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BUREAU OF CHEMISTRY AND SOILS
In cooperation with the North Dakota Agricultural Experiment Station

SOIL SURVEY
OF
CASS COUNTY, NORTH DAKOTA

BY

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and M. F. PEIGHTAL and J. E. CHAPMAN
North Dakota Agricultural Experiment Station

Part 2. THE CHEMICAL COMPOSITION OF THE SOILS OF CASS COUNTY

BY

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North Dakota Agricultural Experiment Station

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This number is the last Soil Survey Report for the Year 1924

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SOIL SURVEY OF CASS COUNTY, NORTH DAKOTA

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COUNTY SURVEYED

Cass County is in the extreme eastern part of North Dakota. The northern boundary is about 140 miles south of the Canadian border. The county is bounded on the east by Red River, which separates it from the State of Minnesota. It comprises an area of 1,782 square miles, or 1,140,480 acres.

The range in elevation within the county is about 320 feet. The highest point recorded, with an elevation of 1,204 feet, is at Buffalo on the Northern Pacific Railway, and the lowest point recorded is at Argusville, where the elevation is only 884 feet above sea level. The average range in elevation from the main upland to the lower basin of former Lake Agassiz is about 240 feet. The drop is gradual. The elevations[1] at the towns along the Northern Pacific Railway, beginning at the west, are as follows: Tower City, 1,168 feet; Buffalo, 1,204; Wheatland, 991; Casselton, 933; Mapleton, 906; Haggart, 903; and Fargo, 906.

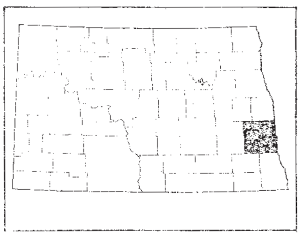

FIGURE 1.—Sketch map showing location of Cass County, N. Dak.

The principal streams, in the order of their importance, are Red, Sheyenne, Maple, and Wild Rice Rivers. The western third of the county is well drained, owing to the surface slope and openness of the subsoil, but the eastern, or lower part of the county, is largely very poorly drained, owing to the flatness of the surface and the heavy texture of the clay soils. (Pl. 1, A.)

For a short time after Lake Agassiz was drained, the streams, like Sheyenne River, flowing across it deposited sediment along their courses, thus building their banks several feet higher than the country lying from one-fourth mile to 2 miles from the main stream channels. These higher accumulations have tended to hold the surface water back from the streams and to keep it from draining freely into the rivers. Moreover, the plastic, impervious surface soils and subsoils of these flat, interstream areas retard the downward movement of surface water, making farming on such areas exceedingly uncertain, especially for those not familiar with the soils in the valley. The higher banks or accumulations and the higher lake terraces are very well drained and constitute the most highly prized farming land in the valley. (Pl. 1, B.)

[1] Gannett, Dictionary of Altitudes.

The area included in Cass County consists of a plain in which there are two slightly different types of relief. The western part of the county is part of an area of undulating or very gently rolling land in which the details have no regular arrangement. It consists of low ridges and hills with intervening low areas, many of which are inclosed by higher land and some of which contain lakes or swamps. It is constructional in origin, having been formed by the deposition of material from glacial ice.

The eastern part of the county is a smooth plain with no differences in surface relief. Creeks have cut very shallow and narrow valleys, in most places little wider than the channel of the stream. This part of the county also is constructional in origin, having been formed by the deposition of silt, sand, and clay in former Lake Agassiz which once covered it. A slight variation of relief was caused by the deposition of a delta in the lake at the mouth of Sheyenne River.

Ditches which have been dug across large areas of the county tend to improve the drainage. Many of the roads cross the drainage ditches by bridges which can not be used for heavy and wide machinery. The first artificial drain northeast of Argusville was constructed about 1900 by man and animal labor, but since that time steam outfits have been used to construct numerous ditches, most of which empty into Maple or Red Rivers. The territory north of Argusville is provided with an east-and-west ditch for each mile. These drain most of the surplus water into Red River. One or two of the ditches which empty into Maple River are not so satisfactory. Some farmers complain that wind-blown snow fills the ditches to such an extent in some years as to make them a detriment rather than a benefit. In other places, as in Noble Township, the soil is so hummocky that the surface water can not drain off and proper lateral drains, which will suffice for the entire area, are very difficult to construct.

Up to the present time about 175 miles of drainage ditches have been dug in the county. These range from about 4 to 10 feet in depth and from 14 to 50 feet in width. The farmers themselves have made numerous smaller ditches on the lower heavy clay soils. On each side of the rather high graded roads small lateral ditches assist in conveying surplus water to the main drainage ditches.

The most poorly drained parts of the county are from 2 to 4 miles south of Argusville, from 1 to 5 miles north of Davenport, and in a strip 2 or 3 miles west of Fargo. In these areas, the fall varies from a few inches to about 2 feet to the mile, whereas in most other parts of the county where drainage ditches are dug the fall varies from 2 to 14 feet to the mile.

Fargo, the county seat, is the largest town in the county and is the metropolis of North Dakota. It is in the eastern part of the county on Red River. The Northern Pacific, Great Northern, and Chicago, Milwaukee & St. Paul Railways extend from Fargo in different directions over the county and afford excellent shipping facilities. Few farms are more than 10 miles from railway stations.

Several automobile trails connect a number of towns in the county. The two most important trails are the Glacier National Park No. 3 and No. 1. Trail No. 1 is well graded and Trail No. 3 is graveled throughout its course in Cass County. The county roads in general are well graded and in excellent condition, although some roads within 6 or 8 miles of Red River or near Davenport become exceedingly rough after heavy rains, owing to the heaviness of the soils.

Many of the farmers have telephones and automobiles, and the radio is increasing in popularity in all parts of the county. Educational facilities are above the average for North Dakota. North Dakota Agricultural College is at Fargo, and North Dakota University is only about 75 miles north of Fargo, in Grand Forks County. In 1924 there were a total of one hundred and one 1-room rural schools, 25 consolidated graded schools, and classified or accredited schools were in the towns of Fargo, Casselton, Kindred, Buffalo, Page, Hunter, and Tower City. A total of 12,878 children was enumerated in districts by the 1924 census. Ninety-two per cent were classed as rural. The average mill rate of taxation was 8.4 on a total of $97,734,002 assessable property.

The principal grain markets for the county are Minneapolis and Duluth, and livestock usually is shipped to South St. Paul or Chicago. Potatoes are shipped to Iowa, Missouri, and as far south as Texas. Most of the grain elevators are owned by large elevator companies, although a few are operated by local farmer organizations.

The county was named in honor of G. W. Cass, of New York, former president of the Northern Pacific Railway Co. This company filed the first plat of a town site January 2, 1874.

The total population of Cass County was 41,477, according to the United States census of 1920. Of this total 21,961 were listed as urban and 15,516 as rural. Of the 19,516 listed as rural dwellers, 4,265 lived in incorporated places of less than 2,500 inhabitants. The United States Census of Agriculture of 1925 gives the farm population of the county as 12,044. The two censuses are, however, not strictly comparable. The Bureau of the Census has made a special study of the farm population, based on the 1920 census.[2] This special study shows that of a total foreign-born white population of 2,624 on the farms, 754 were from Norway, 519 from Germany, 400 from Sweden, 384 from Canada, 97 from Denmark, and fewer from other foreign countries. Of the total farm population of 14,512, 3,738 were born of fathers who lived in the Scandinavian countries and 2,803 of fathers who lived in Germany. Most of the native white farm population came from the West North Central States.

CLIMATE

The climate of Cass County is subhumid, characterized by comparatively long cold winters and short cool summers. According to the records of the Weather Bureau, the climate of the Red River Valley is warm in summer and colder in winter than that of any other section of North Dakota. An occasional hot wind from the southeast causes the tmeperature to rise temporarily to 100° F. or more, and the temperatures of −40° or lower are not unknown. Usually such extremes are of short duration, although occasionally very low tem-

[2] GALPIN, C. J., and LARSON, VEDA B. FARM POPULATION OF SELECTED COUNTIES. Bur. of the Census, U. S. Dept. Com., 1924.

peratures continue for several days. The summer days are warm, usually windy, and rarely cloudy, and nights are invariably cool. The winter days are comparatively short, and, although the thermometer may register far below zero, the cold, owing to the dryness of the air, is far less penetrating than it is farther south where the humidity is higher. The average temperature for the months of June, July, and August is slightly above 66 degrees.

Plant growth, which before May 15 is comparatively slow, after that time becomes very rapid because of the higher temperature and long hours of sunshine. In some years excessive rainfall during the growing season drowns out the crops in many places on the heavier soils. Even in normal years 1 or 1½ inches of rainfall on the lower and more poorly drained areas of Fargo clay is sufficient to cause a large percentage of the young corn to turn yellow and give lower yields. This is especially true on the heavier soils containing alkali. Occasionally, crop growth is retarded by periods of drought, which combined with a hot wind from the southwest, prove very destructive, especially when small grains are in the milk stage. The average damage for wheat and corn resulting from deficient moisture during the years from 1917 to 1923, inclusive, was 23 and 16 per cent, respectively.

The average rainfall recorded at Amenia (1896 to 1920, inclusive) was 20.1 inches. It was slightly less in the western part of the county. The mean rainfall in the critical months of May and June amounts to 6.71 inches. Hailstorms occasionally cause damage in comparatively small areas.

The fall, as a rule, is rather dry. The first or second frost is usually followed by warm mild weather, known as Indian summer. According to the records at Amenia, the average frost-free period is 128 days. The period is slightly shorter to the west. The average date of the last killing frost in spring is May 16 at Amenia, and that of the earliest in fall is September 21. Killing frost has been recorded as late as June 9 and as early as August 18.

Table 1, compiled from the records of the Weather Bureau station at Amenia, shows the normal monthly, seasonal, and annual temperature and precipitation for the county:

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Amenia*

(Elevation, 954 feet)

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1912)
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*
December	12.7	58	−35	0.51	Trace.	0.80
January	4.5	53	−43	.50	0.40	.20
February	7.0	58	−40	.40	.40	.05
Winter	8.1	58	−43	1.41	.80	1.05

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Amenia*—Continued

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1912)
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*
March	23.6	76	−34	0.57	1.42	0.70
April	42.3	96	3	1.88	1.46	2.95
May	54.1	98	14	2.84	.80	4.53
Spring	40.0	98	−34	5.29	3.68	8.18
June	63.5	101	26	3.87	1.22	2.86
July	68.7	106	36	3.01	1.19	3.06
August	66.3	103	32	2.72	.90	4.17
Summer	66.2	106	26	9.60	3.31	10.09
September	57.3	98	20	1.97	1.22	6.54
October	44.3	90	−7	1.29	.76	.02
November	27.3	76	−29	.54	.30	.02
Fall	43.0	98	−29	3.80	2.28	6.58
Year	39.3	106	−43	20.10	10.07	25.90

AGRICULTURE

Agriculture in Cass County is of comparatively recent development. Early in the decade between 1870 and 1880 Cass County and the surrounding country were included in an Indian reservation inhabited by the Sisseton and Wahpeton bands of Sioux Indians. The first white settlers entered the county in 1870 and by December of the following year numbered 53. The protected land along Red, Wild Rice, and Sheyenne Rivers was the first to be settled. Between 1875 and 1880 Red River was used largely to transport grain and supplies. The first post office was Centralia. In 1873 the name of this town was changed to Fargo in honor of Willard G. Fargo, a director of the Northern Pacific Railway Co. and founder of the Wells-Fargo Express Co. The Northern Pacific Railway extended its lines westward in 1871, and in 1870 the St. Paul & Pacific Railroad Co. (now part of the Great Northern) extended its lines to Barnesville, Minn. Settlers then began to enter the county at a rapid rate.

By 1883 practically all the arable land in the county was taken up by settlers. Up to this time large tracts of virgin sod were broken each year and seeded to small grains or more commonly to flax, which was usually followed by wheat. Some barley and oats were grown to provide horse feed and to supplement the crop of prairie hay. Spring wheat provided the first cash crop, and its heavy yield was largely responsible for the rapid settlement of the county.

Table 2 gives the acreage and production of the principal crops of the county in 1879, 1889, 1899, 1909, 1919, and 1924, reported by the United States census.

TABLE 2.—*Acreage and production of principal crops in stated years, 1879 to 1924, inclusive*

Crop	1879		1889		1899	
	Acres	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Wheat	51,727	1,012,565	422,353	4,433,586	570,620	8,873,390
Oats	7,152	310,086	66,506	936,579	81,327	2,529,470
Rye	----------	----------	14	110	585	7,250
Barley	793	22,640	10,502	131,431	22,320	605,640
Flax	----------	----------	281	1,145	74,200	860,980
Corn	306	8,198	867	15,380	8,981	232,540
Potatoes	----------	46,557	1,819	118,762	2,394	250,972
		Tons		*Tons*		*Tons*
Tame hay	----------	----------	----------	----------	15,148	16,601
Wild hay	2,181	3,601	55,510	33,912	49,087	49,609
Forage and silage	----------	----------	----------	----------	10,224	16,497

Crop	1909		1919		1924	
	Acres	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Wheat	423,245	6,419,507	422,756	3,141,890	252,838	4,660,883
Oats	96,521	3,142,748	107,613	1,829,600	130,576	4,409,934
Rye	8,397	164,609	20,383	183,483	42,183	948,159
Barley	78,087	1,818,747	58,468	735,272	80,322	2,116,219
Flax	28,796	254,881	14,231	66,621	70,707	580,394
Corn	39,021	1,039,668	23,423	662,145	108,771	[1] 299,551
Potatoes	3,649	398,961	10,196	601,097	14,965	892,346
		Tons		*Tons*		*Tons*
Tame hay	50,841	59,568	47,163	42,830	55,023	----------
Wild hay	23,820	27,827	20,338	19,339	16,042	(2)
Forage and silage	3,884	12,782	48,385	140,226	(3)	----------

[1] The yield from the 13,217 acres actually harvested for grain. Production data previous to 1924 are based on the probable yield of the entire acreage.
[2] The total production of all hay, including wild hay, was 70,178 tons in 1924.
[3] Included in total acreage of corn.

Table 3 gives the average annual acre yields of the principal farm crops from 1911 to 1927, inclusive, and the 17-year average, the data being furnished by the Bureau of Agricultural Economics of the United States Department of Agriculture.

TABLE 3.—*Average annual yields of the principal crops from 1911 to 1927, inclusive, and 17-year average*

Crop	1911	1912	1913	1914	1915	1916	1917	1918	1919
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Wheat	11.0	19.7	16.2	10.0	17.0	5.0	14.0	23.0	8.0
Oats	31.3	41.4	30.0	21.9	36.9	13.0	26.0	34.0	21.0
Barley	22.3	33.6	24.2	17.4	30.6	13.0	20.0	28.0	14.0
Rye	21.5	21.2	18.0	17.3	14.0	10.0	17.0	18.0	12.0
Flax	8.5	11.2	9.3	9.1	9.8	8.0	7.0	10.0	5.0
Corn	28.2	26.9	31.4	34.3	12.3	30.4	12.0	25.0	39.0
Potatoes	112.0	127.0	92.0	107.0	74.0	70.0	58.0	72.0	65.0
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Tame hay	1.38	1.20	1.17	1.30	1.33	1.53	1.00	1.3	1.9

Crop	1920	1921	1922	1923	1924	1925	1926	1927 [1]	17-year average
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Wheat	10.5	9.0	9.5	7.5	17.4	11.9	14.0	14.7	12.8
Oats	34.0	17.0	31.0	26.0	34.0	33.5	23.0	14.0	27.6
Barley	24.0	14.0	23.0	20.0	26.0	25.5	22.0	26.5	22.6
Rye	14.0	18.0	22.0	12.0	23.0	13.0	11.0	20.0	16.6
Flax	8.0	8.0	11.0	7.5	8.0	8.6	7.5	7.5	8.5
Corn	26.0	35.0	29.0	38.0	23.0	27.0	23.0	25.0	27.4
Potatoes	76.0	95.0	70.0	84.0	80.0	62.0	94.0	102.0	84.6
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Tame hay	1.5	1.6	1.7	1.5	1.4	1.5	1.3	1.8	1.38

[1] Subject to revision.

Spring wheat has consistently been the principal cash crop of the county. It reached its maximum acreage and production in 1909, since which time the total acreage has steadily declined. In 1909, 56 per cent of the total harvested crop acreage in Cass County was in wheat. The census of 1919 showed 54 per cent of the total harvested acreage devoted to wheat, but by 1924 the percentage had declined to 34 per cent. Figure 2, taken from North Dakota Agricultural Experiment Station Bulletin 212,[3] shows the changes which have taken place in the utilization of land in Cass County during the period 1909 to 1924, inclusive.

These changes in the acreage of the various crops have been brought about by a number of conditions, including the necessity of combating weeds and diseases and an increasing tendency toward a diversity of production, including the raising of livestock. The inclusion of

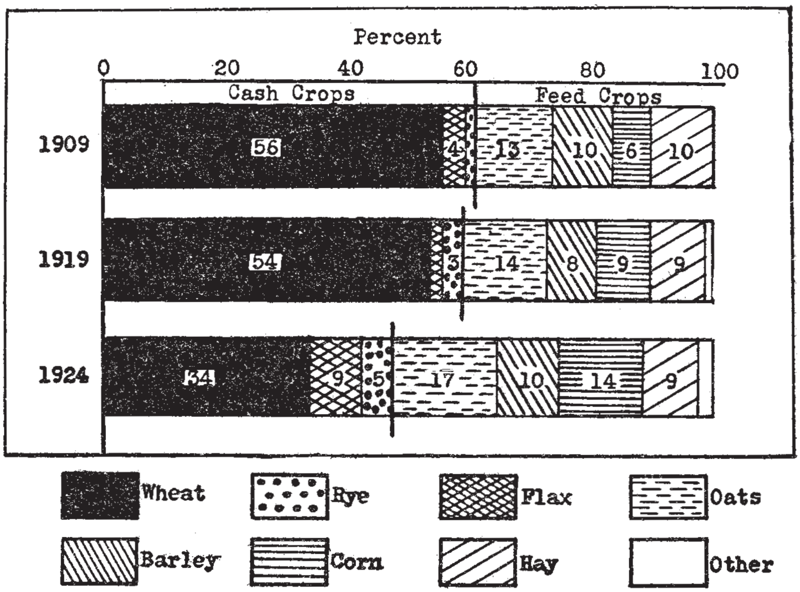

FIGURE 2.—Changes in the percentage of the total harvested crop acreage devoted to each crop, 1909, 1919, and 1924.

livestock in the agricultural program of the county has of necessity increased the relative proportion of land devoted to the production of feed crops.

Although crop rotation practices are not as yet standardized, it will be noted from a study of the percentage of the land in different crops that the acreage of corn is steadily increasing, as is also that of tame hay. These acreages will have to increase at a more rapid rate, however, if hay crops are to occupy the land as frequently as once in five or six years.

During the early years of spring-wheat production, Cass County farmers grew hard red spring wheats exclusively. Fife was grown to the exclusion of all other varieties for many years. Fife was suc-

[3] WILLARD, REX E., and FULLER, O. M. TYPE-OF-FARMING AREAS IN NORTH DAKOTA. N. Dak. Agr. Expt. Sta. Bul. 212. Table 23. 1927. Illus.

ceeded by Bluestem, and finally the Bluestem was succeeded by Marquis. Marquis is still the most popular variety of hard red spring wheat grown in the county, but on account of its susceptibility to black stem rust, it is gradually being replaced by more rust-resistant varieties. Kota, a bearded hard red spring variety having a considerable degree of rust resistance, has been grown recently to a considerable extent, but this is gradually being replaced by Ceres, a new variety of hard red spring wheat having about the same degree of rust resistance as Kota but more nearly resembling Marquis in the milling and baking qualities of the flour made from it. In 1927, Cass County farmers grew 174,000 acres of common spring wheats and 94,000 acres of durum wheats. Durum wheats have been replacing common wheats to a considerable extent during recent years, largely on account of their greater rust resistance. The most important durum varieties grown in Cass County are Kubanka, Nodak, Mindum, and the red durum, Pentad (commonly called D–5). Nodak and Pentad are both highly resistant to rust. Results obtained at the North Dakota Agricultural Experiment Station indicate that Mindum is to be preferred to other varieties of durum wheats to be grown in the eastern part of the State.

The Division of Crop and Livestock Estimates of the Bureau of Agricultural Economics of the United States Department of Agriculture started making annual yield estimates on all the common crops in Cass County in 1911. The average annual yield of wheat from 1911 to 1927, inclusive, was 12.8 bushels to the acre; the highest yield on record, 23 bushels to the acre, was obtained in the very favorable crop year of 1918; and the lowest yield, 5 bushels to the acre, was obtained in the disastrous rust year of 1916. An examination of the annual yields indicates that the character of the season has had a larger effect on the average yield of wheat than any other factor. There is no evidence of a progressive decline in the yield of wheat, in spite of the fact that there is a popular opinion in support of that notion. Willard and Fuller, of the North Dakota Agricultural Experiment Station, have shown that the variability of the yield of wheat in general is high where the yields are low and is low where the yields are high. On the basis of the yields over the period from 1911 to 1926, inclusive, Willard and Fuller have shown that Cass County may be expected to make its average yield of wheat (12.7 bushels to the acre) 47 per cent more frequently than the State average may be expected to be made.

In North Dakota as a whole May and June are considered critical months in grain production, especially in the production of wheat. The average annual rainfall in these months amounts to about 6.7 inches. Willard[4] has shown that there is little relation between May and June rainfall and the yield of wheat in the county. Black stem rust has been a large factor in reducing wheat yields in the county, especially in recent years. The North Dakota Agricultural Experiment Station[5] has reported estimates on the percentage of stem rust infection in Marquis wheat grown on Fargo clay at Fargo.

[4] WILLARD, REX E. AGRICULTURAL REGIONS OF NORTH DAKOTA. N. Dak. Agr. Expt. Sta. Bul. 183. 1924. Illus.

[5] STOA, THEODORE E. VARIETAL TRIALS WITH SPRING WHEAT IN NORTH DAKOTA. N. Dak. Agr. Expt. Sta. Bul. 149. 1921. Illus.

———, SMITH, R. W., and MANGELS, C. E. SPRING WHEAT VARIETIES FOR NORTH DAKOTA. N. Dak. Agr. Expt. Sta. Bul. 209. 1927. Illus.

TABLE 4.—*Percentage of stem-rust infection*[1] *on Marquis wheat at Fargo, N. Dak., 1913–1927*

Year	Per cent	Year	Per cent
1913	15	1921	45
1914	50	1922	80
1915	No trials.	1923	80
1916	73	1924	55
1917	13	1925	80–90
1918	15	1926	75–85
1919	22	1927	70
1920	80		

[1] The percentage figures used are based on the standard charts used by the Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, in estimating the percentage of infection with stem rust.

Records at the North Dakota Agricultural Experiment Station indicate severe rust epidemics previous to 1913. An especially damaging epidemic of black stem rust occurred in 1904.

Farmers of Cass County have found it necessary to gradually replace a considerable proportion of the wheat and other small grains with cultivated crops and with tame hay in order to hold in check and to help eradicate the annual weeds such as French weed, wild oats, wild mustard, and pigeon grass. Certain areas in the county are becoming infested with perennial weeds such as perennial sow thistle, quack grass, and Canada thistle. Farmers, however, who have adopted liberal use of alfalfa and sweet clover in their cropping systems and who are growing a considerable acreage of cultivated crops are finding it possible to keep the more serious perennial weeds under control.

The North Dakota Agricultural Experiment Station, located at Fargo, has been conducting experiments on the management of Fargo clay, one of the principal soil types of Cass County, since 1892. In 1911 experiments were conducted to determine whether or not there was any likelihood of any deficiency of the important fertilizer elements. These experiments show rather definitely that the use of farm manure tends to increase the yields of most of the common crops, even in rotations where leguminous crops such as red clover and sweet clover are being grown. There is abundant unpublished evidence which demonstrates that the yields of common crops on Fargo clay and on certain other soils in the county can be increased through the use of phosphatic fertilizers. The most profitable rates of application, the best methods of application, and the soil types and crops which will respond to the largest degree have not yet been determined. The North Dakota Agricultural Experiment Station is actively engaged on a project aimed at discovering the extent of phosphorus deficiency in this county and in other Red River Valley counties. Evidence accumulated to date indicates that phosphate applications are not likely to prove profitable unless good farming methods are practiced, the best varieties of seed used, and full precautions taken to prevent injury from disease.

In preparing land for wheat fall plowing is almost universally practiced. It is practically impossible to produce a favorable seed bed for any of the small grains with spring plowing on the heavier soils in the county. The usual depth of plowing is from 4 to 6 inches on the heavier soils and somewhat less on the lighter soils. The

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land is usually disked in the spring, harrowed, and then seeded at the rate of 4 or 5 pecks to the acre for the hard spring wheats and slightly more for the durum wheats. The seed is sown as early as weather conditions are favorable, or in April and May. Late-seeded wheat rarely yields well.

Summer fallowing is practiced to some extent on many farms, especially on fields heavily infested with quack grass or other perennial weeds. There is a decided tendency on the better-managed farms to abandon summer fallowing as a method of weed control and to substitute the growing of intertilled crops and of sweet clover and alfalfa for the purpose of smothering weeds and gradually rotting their seeds. Alfalfa growing has been found to be particularly helpful in sow-thistle control, owing to the fact that the crop is cut several times a year.

The oats crop is the second largest crop in point of acreage. The United States census data show that the acreage of oats in Cass County in 1909 was 96,000 acres, in 1919 was 108,000 acres, and in 1924 was 131,000 acres. In 1909 oats occupied 13 per cent of the harvested-crop acreage; in 1919, 14 per cent; and in 1924, 17 per cent. The average yield during the 17-year period 1911 to 1927, inclusive, was 27.6 bushels to the acre. The highest yield reported, 41.4 bushels, was of resistant White Russian oats. The seed bed for oats as a rule receives less attention than that for wheat, and seeding is usually delayed until the last possible date for seeding wheat is past. In general, earlier seeding of both oats and barley could profitably be practiced. It should be emphasized that the early seeding of the feed crops is especially desirable when these crops are being used to help hold weeds in check.

Barley is the crop third in acreage and production. It will be noted from Table 2 that there was an increase in the acreage of barley in 1924 over that of 1919, when it reached its low point. Barley occupied 10 per cent of the harvested-crop acreage in 1909, 8 per cent in 1919, and 10 per cent in 1924. The average yield of barley from 1911 to 1927, inclusive, was 22.6 bushels to the acre. The highest yield, 33.6 bushels to the acre, was obtained in 1912, and the lowest yield, 13 bushels to the acre, was obtained in the disastrous rust year of 1916. Barley is seeded a little later than oats and is usually considered valuable in the control of wild oats and other annual weeds. The farmers of the county look on barley primarily as a feed crop, although it has been used to some extent as a cash crop. It is considered valuable in this county because of its early maturity, which permits the harvesting of a part of the total grain acreage before the main wheat crop comes on, thus effecting better distribution of labor. Manchuria, a standard 6-row variety, is most commonly grown. Trebi, recently introduced, is yielding very well.

In certain parts of the county, emmer (commonly called spelt) is a competitor for some of the barley acreage. The greater disease resistance of emmer has apparently tended to increase its popularity in recent years.

Flax, according to the United States census, reached its maximum acreage in 1899. Cass County farmers grew 29,000 acres of flax in 1909, 14,000 acres in 1919, and 71,000 acres in 1924. The flax crop occupied 4 per cent of the harvested crop acreage of all crops in 1909, approximately 2 per cent in 1919, and 9 per cent in 1924. There has been a distinct increase in the relative acreage of flax since 1919. The North Dakota Agricultural Experiment Station has devoted an unusual amount of attention to the improvement of flax and to the standardization of better methods for its production. The crop has been found to be especially useful as a companion or nurse crop for alfalfa and on the lighter soils for sweet clover. The two most serious hazards in flax production are weeds, especially the annual weeds, so-called green and yellow foxtail (or pigeon grass) and wild oats. If the flax is seeded early on soils infested with pigeon grass, the flax usually holds the pigeon grass in check, but in late-seeded flax the pigeon grass usually dominates. Fields badly infested with wild oats are not considered suitable for flax production. The flax crop should usually follow a sod crop, such as sweet clover or alfalfa, or a cleanly cultivated crop, such as potatoes or corn. Practically all of the soils in the county are infested with the wilt disease of the flax crop, and for this reason only wilt-resistant varieties should be grown. North Dakota resistant No. 114 is being commonly grown but is gradually being replaced by the higher-yielding Linota and Buda (North Dakota resistant 119), wilt-resistant varieties. Flax is commonly seeded on spring-plowed land, and there is a general tendency to delay its seeding until too late. The crop is usually seeded at the rate of about 2 pecks to the acre.

Corn is becoming a very important crop in Cass County. Cass County farmers grew 43,000 acres of corn in 1909, 72,000 acres in 1919, and 109,000 acres in 1924, according to the United States census. Corn occupied 6 per cent of the harvested crop acreage in 1909, 9 per cent in 1919, and 14 per cent in 1924. The average yield of corn in Cass County during the period 1911 to 1927, inclusive, was 27.4 bushels to the acre; the highest yield of 39 bushels to the acre was obtained in 1919, and the lowest yield, 12 bushels to the acre, in 1917. From a practical point of view the farmers of the county find that practically all of the soils are well adapted to the production of corn. The corn crop occupies an important key position in the development of a balanced system of agriculture for the county. The cultivation of the crop serves to eradicate weeds and to make available an early, firm seed bed for the succeeding grain crops. Most of the cornfields of the county are prepared for the succeeding grain crop by disking in the spring. As Cass County farmers are devoting a large part of their energy to the production of beef cattle and dairy cattle, hogs, and sheep, the supply of available fodder and silage made possible through the production of corn is of great importance. In so far as farm manure is available, it is usually applied to land intended for the corn crop. Corn does best if it is planted in checkrows. The early tillage of the fields with harrows, weeders, or rotary hoes is highly advisable, as this treatment kills the weeds before they reach a great size. Fields which have been treated in this way can usually be kept clean with three or four cultivations. The farmers of the county find that early strains of Minnesota No. 13, Northwestern dent, and Rustler white dent are the most dependable general-purpose varieties of corn for the county. Where silage alone is needed, Mercer flint is considered the best. For hogging off, Gehu and

Dakota white flint are considered the best varieties. In 1924 of the 108,771 acres of corn, 13,217 acres were harvested for grain, 77,461 acres were cut for fodder, 5,925 acres were cut for silage, and 12,168 acres were hogged off. The relative proportion of the acreage being hogged off is increasing each year.

Rye serves a useful purpose in the county by providing an early-maturing cash crop and a crop useful in the control of weeds. Cass County farmers grew 8,000 acres of rye in 1909, 20,000 acres in 1919, and 42,000 acres in 1924 according to the United States census. Rye occupied 4 per cent of the harvested crop acreage in 1909, 3 per cent in 1919, and 5 per cent in 1924. The average yield of rye during the period 1911 to 1927, inclusive, was 16.6 bushels to the acre. The highest yield, 23 bushels to the acre, was obtained in 1924, and the lowest yield, 10 bushels to the acre, was obtained in 1916. Considerable rye is "stubbled" in or disked on wheat-stubble land between the middle of August and the middle of September. Other growers find that rye is successfully grown if it is seeded rather early on summer-fallowed land.

Potatoes are increasing somewhat in acreage. Cass County farmers grew 4,000 acres in 1909, 10,000 acres in 1919, and 15,000 acres in 1924. The average yield of potatoes to the acre during the period 1911 to 1926, inclusive, was only, however, 84 bushels to the acre. The highest yield, 127 bushels to the acre, was obtained in 1912 and the lowest yield, 58 bushels to the acre, was obtained in 1917. It should be recognized that the county statistics for potatoes include yields from many small acreages where, because the grower is not equipped for potato production, the yields are likely to be low. Potatoes do best where they are grown in a rotation including sweet clover or alfalfa. Many of the soils which in physical condition are best adapted to potatoes are likely to return larger yields if they are treated with phosphatic fertilizers. On account of the high cost of production of potatoes and the long distance from the market for table stock, it is not likely that the acreage of potatoes will increase at a very rapid rate. The Early Ohio is the most popular variety in the county. There is evidence, however, that the popularity of the Early Ohio as table stock is waning in the United States, and that round, white potatoes such as the Irish Cobbler are growing in popularity. The late varieties of potatoes do not occupy an important place in Cass County.

According to the United States census there were 11,980 acres of sweet clover in Cass County in 1924. A conservative estimate would place the present (1928) acreage of sweet clover at about twice that figure. Sweet clover is grown primarily for pasture and soil-improvement purposes. As a soil improver it is looked upon as of value for two reasons: (1) Because of its ability to add nitrogen and organic matter and (2) because of its ability to smother weeds. On some of the larger holdings considerable sweet clover is cut for seed. Sweet clover has not been particularly successful for hay in this county, on account of the fact that it is very difficult to cure. Moldy sweet-clover hay is likely to be poisonous to cattle. The first crop of sweet clover is usually ready during the first two weeks in June when the rainfall is at its peak. More or less successful attempts are being made to make hay from the crop by cutting it with a binder and loosely shocking three or four bundles in a shock so as to assure abundant ventilation. Even under these conditions mold is apt to develop inside the bundle, but with favorable weather a fair quality of hay may be made. As a practical method of farm management the Cass County farmer usually finds it safer to grow alfalfa for hay purposes and use sweet clover for other purposes. Sweet clover has a higher pasturing capacity than any other crop which can be grown in the county. Ordinarily an acre of sweet clover will carry two mature cattle from about the middle of May to the middle of August, or later if the season is favorable. Since the sweet-clover crop, in its second year of growth, begins to fail in August and provides little pasturage in September and October, it has been found advisable to have available an acreage of sweet clover in its first year of growth into which the animals may be turned in the fall. Care should be taken, however, not to graze this 1-year-old sweet clover too closely. Sweet clover is seeded at the rate of 10 or 12 pounds of scarified seed to the acre, usually with a nurse crop. If unhulled or unscarified seed is used, nearly double this amount is necessary.

On all fields where sweet clover has been grown for pasture or cut for seed, volunteer seed will fill the soil. As this is hard seed, such fields will carry sweet-clover plants for many years following the initial seeding. Care must be taken in the management of such fields to avoid young sweet-clover plants appearing in crops where they are not wanted. The 2-year-old sweet clover plant can always be killed by late spring plowing after the growth from the winter bud has reached a height varying from 4 to 6 inches. Such fields can then be put into corn, potatoes, or flax. The 1-year-old clover plant or seedling plant can not be killed by fall plowing after the winter bud has formed. Very early fall plowing or late summer plowing will eradicate such seedlings. Two varieties of sweet clover are commonly grown in the county. The common white sweet clover is most widely favored for pasturing purposes. In certain parts of the county the early strains of white sweet clover, such as the Grundy County sweet clover, are being grown. Grundy County sweet clover matures earlier, usually sets a little heavier seed crop, and consequently is looked upon with favor by those engaged in seed production. The seed crop can be harvested in time for early fall plowing. There is, however, less national demand for the early strains of white sweet clover than for the common strains.

Alfalfa is the most popular hay crop grown in the county. Cass County farmers grew 15,902 acres of alfalfa in 1924, according to the United States census; the acreage has steadily increased since that time, and the present (1928) acreage is nearly double that figure. The hardy Grimm variety is grown to the exclusion of almost all others. Alfalfa is usually seeded with a nurse crop, preferably flax, although wheat and barley are used to a certain extent. Under average conditions two cuttings can be obtained. A third cutting is frequently available but it is usually better to leave a heavy growth on the field in the fall as then there is less likelihood of winterkilling. Special attention should be given to the preparation of the seed bed for alfalfa. Evidence being accumulated indicates that in certain areas of the county maximum alfalfa yields can not be expected unless phosphatic fertilizers are used. The alfalfa crop seems to be particularly sensitive to a phosphate deficiency. It is suggested that the alfalfa grower ascertain the extent of phosphate deficiency on his alfalfa field by fertilizing a small part of it, thereby determining whether or not it is likely to be profitable to fertilize the entire area.

Timothy is grown by a few farmers, but the stands are usually too thin and too uncertain to make it a very profitable crop. The United States census shows 8,867 acres of timothy in the county in 1924.

Brome grass (*Bromus inermis*) is more drought resistant than timothy and makes hay of excellent quality. Many farmers object to the sowing of brome grass on account of the difficulty of obtaining seed free from quack grass. Seed should be purchased only under guarantee of its freedom from quack-grass seed. Some farmers are using brome grass successfully as an admixture with alfalfa and timothy in permanent pastures.

Wild hay is still being used in the county to a small extent. Most of the areas from which wild hay is cut are poorly drained or rolling and not well suited to cultivation.

Sugar beets have recently been introduced into the county and are being found particularly adapted to soils of intermediate texture and of high fertility. All of the sugar beets are grown under contract with the beet-sugar company. On most of the soils on which the sugar beet is being grown, moderate applications of phosphatic fertilizers increase the yields.

Vegetables such as tomatoes, cabbage, onions, beans, peas, turnips, carrots, and beets do well in the county, but with the exception of small areas close to the larger towns they are grown only for home use. The department of horticulture of the North Dakota Agricultural Experiment Station has developed and disseminated several early-maturing varieties of tomatoes and an especially valuable canning variety of sweet corn. Watermelons and cantaloupes can be grown successfully in most parts of the county and are especially well adapted to the warm, sandy soils. Only the early-maturing varieties should be grown. The department of horticulture of the North Dakota Agricultural Experiment Station has obtained unusually heavy yields of squash. Asparagus thrives throughout the county, especially on the heavier, more fertile soils.

Small fruits such as raspberries, currants, and gooseberries thrive but should ordinarily be grown within the protection of a shelter belt of trees. Although raspberries have not as yet been commercially exploited there seems to be a possibility of increased production of this crop. Strawberries do well but should have some winter protection.

The hardier varieties of apples and plums do well in the more protected places. Any farmer who will make provision for an adequate shelter belt can have a small orchard. The sand-cherry hybrid varieties of plums are especially well adapted to the county. Wild plums and grapes are common along Maple and Sheyenne Rivers. The United States census shows that in Cass County in 1924 there were 3,279 apple trees of bearing age and 1,428 not of bearing age. There were 3,528 plum trees.

That this county has certain possibilities in the way of producing firewood is evidenced by the fact that the 1925 census reports 2,309 cords cut on Cass County farms in 1924.

Livestock production is steadily increasing. The United States census shows that in 1909 the farmers marketed an average of 102 pounds of butterfat to the farm; in 1919, 250 pounds; and in 1924, 521 pounds. In 1924, 14,440 cows, of which 10,128 are classified by the census as dairy cows, were milked. The Division of Crop and Livestock Estimates of the United States Department of Agriculture summarizes the 1928 livestock situation in Cass County in Table 5.

TABLE 5.—*Livestock in Cass County, 1928*

Kind	Number	Value
All cattle	37,000	$1,887,000
Milk cows	17,500	1,198,750
Sheep	12,000	129,600
Swine	47,000	606,300
Horses	21,000	1,327,000

To show the changes that have taken place in the livestock population of the county, the following statistics, based on the livestock population on January 1, 1919, as estimated by the Division of Crop and Livestock Estimates of the United States Department of Agriculture, are quoted: All cattle, 32,855; milk cows, 13,640; sheep, 12,085; swine, 21,635; and horses, 31,135.

There has been a notable decrease in the number of horses and a notable increase in the number of hogs and milk cows, as well as in the total number of cattle. The North Dakota Agricultural Experiment Station[6] has shown that in Cass County 6 per cent of the gross farm income comes from dairy products, 7 per cent from beef cattle, 15 per cent from hogs, 2 per cent from sheep and wool, and 3 per cent from poultry, making a total of 33 per cent, or one-third, of the farm income from livestock and livestock products. Hog production is common throughout the county. Most of the hogs are marketed in the late fall or early winter. A number of excellent herds of purebred beef cattle are being raised at widely scattered points. The county extension agent's office compiled a list of the breeders of purebred livestock in the county in 1926. At that time there were 3 breeders of purebred Aberdeen-Angus cattle, 40 breeders of Shorthorn, 4 breeders of Guernsey, 13 breeders of Holstein, 6 breeders of Jersey, 4 breeders of Red Poll, and 2 breeders of Brown Swiss. There were also at the same time 4 breeders of purebred Shropshire sheep. More farmers were breeding purebred hogs than any other purebred livestock. There were 2 breeders of purebred Berkshire, 30 breeders of Duroc-Jersey, 18 breeders of Chester White, 3 breeders of Hampshire, 20 breeders of Poland China, and 3 breeders of Yorkshire. It should be pointed out that many farmers having purebred sires are not listed as breeders of purebred livestock.

The poultry industry is rapidly increasing in importance in the county. The United States census reports 203,956 chickens in the county in 1920 and 265,386 in 1925. The total value of the eggs produced in 1924 in the county was $191,710, and the total value of the chickens was $164,539. A number of hatcheries produce baby chicks. Turkey production is also on the increase.

[6] See footnote 3.

As far as possible the land is plowed in the fall. Plowing begins immediately after harvest and continues until the ground freezes. Both tractors and horses are used. Tractors are very commonly used for midsummer plowing for summer-fallowing purposes. From four to six horses are commonly hitched to a gang plow. The Percheron and the Shire are the more common draft horses. During the earlier years of development of the county the large steam outfits and large gasoline outfits were in common use for plowing, but in more recent years the smaller tractors capable of pulling two or three plow bottoms are the more popular. Tractors are also being used for propelling other forms of farm machinery, such as binders, mowers, and cultivators.

The farm equipment as a whole is good. On the farm of average size there is a granary, large barn, frequently a silo, manure spreader, tractor, automobile, and enough grain drills, cultivators, binders, plows, and harrows to carry on farm operations. The best farmers have a machine shed, but probably the greater number of them leave their farm machines in a corner of a yard near a grove.

Each farmstead is marked by the characteristic grove of willow, cottonwood, ash, or boxelder trees. (Pl. 1, C.) According to the 1923 State census there were in that year 5,351 acres of planted forest in the county. All the remainder of the county is treeless, save along the bends of Red, Sheyenne, Wild Rice, and Maple Rivers. Since many land sections have only one homestead, it is suggested that the starting of a grove on another part of the section which might ultimately be set off as another farm would tend to increase land values. New farmers coming into the county are likely to pay a little more for land with a grove well started than for land without trees.

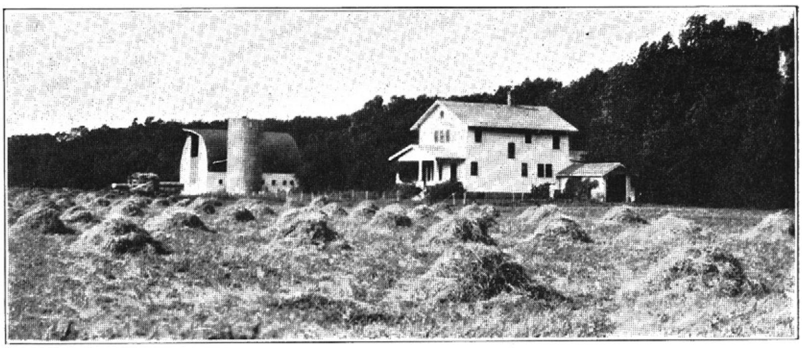
The average size of farms in Cass County in 1900 was 468 acres, according to the census. This had increased to 495 acres in 1910 but declined to 421 acres in 1920 and to 403 acres in 1925.

In 1925, according to the United States census, there were 2,469 farms in Cass County; in 1920 there were 2,374 farms; and in 1910 there were 2,046 farms. Of these, 1,169 farms included from 260 to 499 acres; 508 farms from 500 to 999 acres; 353 farms from 100 to 174 acres; 224 farms from 175 to 259 acres; and 75 farms 1,000 or more acres. There has been a general tendency toward decrease in the number of the larger farms since 1910.

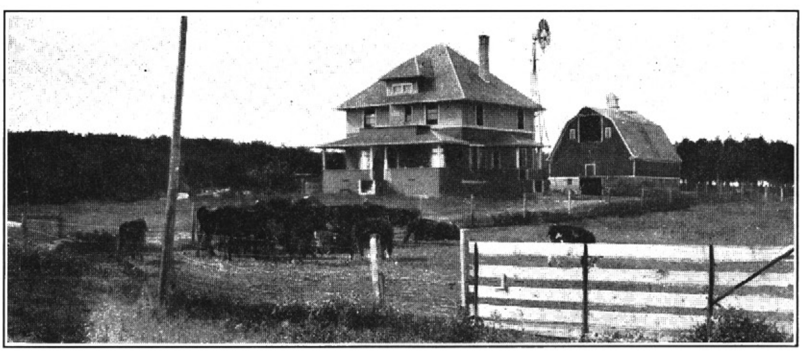
According to the 1925 census, 88.3 per cent of the land in the county is in farms. In 1925 there were 995,832 acres in farms. Of this total, 848,218 acres were in crops, 99,868 acres in pasture land, 2,788 acres in woodland not used for pasture, and 44,958 acres in other land. The value of land and buildings to the farm, according to the United States census, was $47,273 in 1910; $88,202 in 1920; and $57,711 in 1925.

The water supply of the county is plentiful and in general is very good. In a few of the low places the water contains more or less alkali or magnesium sulphate. The water supply comes from three sources, surface wells, rain water caught in cisterns, and artesian wells. The artesian-well supply is most dependable, especially where much livestock is raised. Ordinarily the water is obtained at

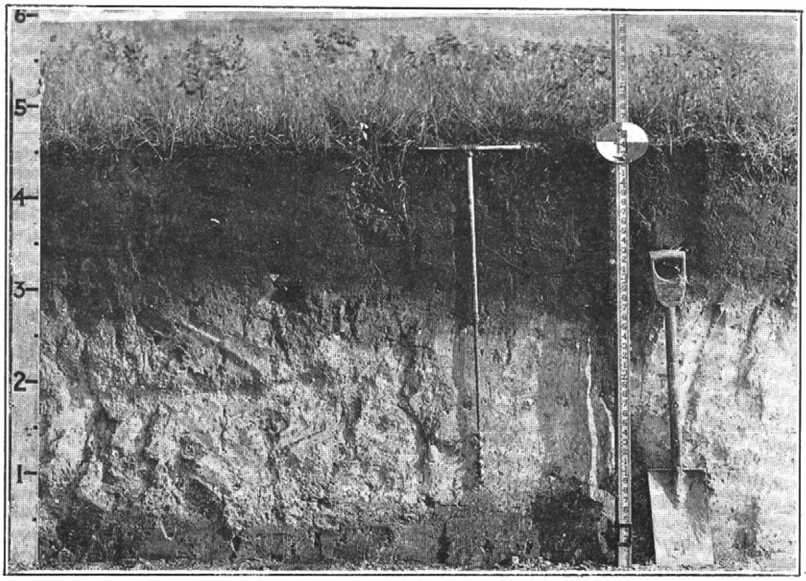
A, Bird's-eye view of part of North Dakota Agricultural College and Experiment Station, showing the dark color and the prevailing flat surface of Fargo clay



B, Modern farmstead along Sheyenne River, showing natural forest in background and alfalfa in foreground



C, Well-improved farm site, showing artifical grove or windbreak in background



A, Profile of Barnes loam, showing the highly calcareous subsoil

B, Profile of Bearden loam, showing zone of high lime accumulation

The left half shows the wet soil.

a depth ranging from 200 to 600 feet, although the shallowest well in the county, located at Fargo, is 90 feet and the deepest, at Page, is 1,150 feet. The average depth of 24 artesian wells in the vicinity of Amenia is 379 feet; of 31 wells at Casselton, 400 feet; of 27 wells at Leonard, 397 feet; of 10 wells at Tower City, 639 feet; of 6 wells at Page, 785 feet; of 19 wells at Buffalo, 639 feet; of 33 wells at Alice, 550 feet; of 46 wells at Wheatland, 422 feet; and of 5 wells at Hunter, 361 feet. There are about 600 artesian wells in the county.

A large number of drainage ditches may be seen on the accompanying soil map. These ditches are on Fargo clay, the heaviest and lowest-lying soil in the county. The first ditch was built with horses in 1889, at a cost of $40,996. It drained the Argusville flat into Red River. According to the map there are about 175 miles of ditches in Cass County. As a rule these ditches are very satisfactory, as they provide a means of draining the land of surface water, which the exceedingly heavy texture of Fargo clay, especially the alkali phase, causes to stand until some damage is done. Excessive rains make it necessary to suspend important farm operations for weeks on these poorly drained areas.

An examination of the tables of crop acreages and yields reveals the trend which agriculture has taken in its development in the county. Facts presented in these tables indicate that agriculture in Cass County has been undergoing very rapid changes in the last 10 years. As evidence of the increasing diversity of agriculture in the county Table 6, compiled from the United States Census of Agriculture, 1925, and giving a detailed record of the land utilization in Cass County in the crop year of 1924 is presented:

TABLE 6.—*Acreage and production of principal crops in Cass County in 1924*

Crop	Acres	Yield
Grain and forage crops:		*Bushels*
Corn, total acreage	108,771	
Harvested for grain	13,217	299,551
		Tons
Cut for silage	5,925	29,939
Cut for fodder	77,461	----------
Hogged off	12,168	----------
		Bushels
Wheat, total acreage and yield	252,838	4,660,906
Oats threshed for grain	130,576	4,409,934
Cut and fed unthreshed	1,038	----------
Barley	80,322	2,116,219
Rye	42,183	948,159
Flaxseed	70,707	580,394
Buckwheat	1,719	14,127
Sorghums, for silage, hay or fodder	87	----------
Dry edible beans (navy, etc.)	14	----------
		Tons
Hay crops, total acreage	71,065	70,178
Timothy alone	8,867	----------
Timothy and clover mixed	9,164	----------
Clover, red, alsike, and mammoth	3,798	----------
Clover, sweet, crimson, and Japan	11,980	----------
Alfalfa	15,902	----------
Other tame grasses	3,829	----------
Small grains cut for hay	1,357	----------
Annual legumes cut for hay	126	----------
Wild grasses cut on farms	16,042	----------
Miscellaneous crops:		
Sugar beets for sugar	75	323

TABLE 6—*Acreage and production of principal crops in Cass County in 1924*—Continued

Crop	Acres	Yield
Miscellaneous crops—Continued.		*Bushels*
Potatoes	14,965	892,346
Strawberries	2	
Vegetables grown for sale:		
Cabbages	6	
Cantaloupes and muskmelons	2	
Lettuce	1	
Onions (dry)	15	
Sweet corn	15	
Tomatoes	2	
Watermelons	1	
Orchard fruits:		
Apples, harvested		3,897
	Trees	
Not of bearing age	1,428	
Of bearing age	3,270	
Pears, trees of all ages	117	
Plums and prunes, trees of all ages	3,528	
	Vines	
Grapevines of all ages	121	
Forest products:		
		Cords
Firewood cut on farms		2,309

The Federal census of 1925 enumerated the livestock on all Cass County farms on January 1, 1925, and also reported the livestock products produced during 1924, comparing them with the products produced five years previously, in 1919. Tables 7 and 8 give these data:

TABLE 7.—*Livestock census of Cass County, January 1, 1925*

Animal	Number	Value	Animal	Number	Value
All livestock		$4,169,518	Goats	13	$91
Horses	24,677	1,716,212	Swine	59,822	733,515
Mules	238	14,599	Chickens	218,785	148,774
Cattle	46,168	1,439,420	Other livestock [1]		26,639
Sheep	8,414	90,268			

[1] Estimated.

TABLE 8.—*Livestock products produced in 1919 and 1924*

	Quantity		Value, 1924
	1919	1924	
	Gallons	*Gallons*	
Dairy products			$754,839
Milk produced	4,202,355	5,833,760	
Cream sold		76,030	
Whole milk sold		499,270	
	Pounds	*Pounds*	
Butter made on farms		669,139	
Butterfat sold		930,026	
Wool produced	45,161	48,641	17,024
	Dozens	*Dozens*	
Eggs produced	741,979	766,841	191,710
Chickens raised			164,539

SOILS

The well-drained soils of Cass County owe their most striking characteristics to the influence of climate. The comparatively low moisture supply of the region has not been sufficient to support a general forest vegetation, but has been favorable to the growth of numerous grasses. These grasses have been the source of the humus which imparts the black color to all the soils of the region. Although the moisture supply is sufficient to allow the accumulation of large quantities of black organic matter in the surface soil, it is not sufficient to leach the soil to any great depth. Carbonates occur either sparingly or not at all in the surface soil, but are present in such great abundance in the subsoil as to indicate a concentration from other horizons.

The characteristics resulting from climatic influences have been imparted to the soil by the great soil-forming processes, such as leaching, oxidation, and the accumulation of organic matter; but account must also be taken of the characteristics resulting from the composition and manner of accumulation of the material from which the soils have developed. The classification of soils into series involves, in addition to consideration of the characteristics of the upper part of the soil, a consideration of the parent material.

The soils of Cass County are derived from glacial drift, either weathered where it was left by the ice or transported and redeposited in the beds of glacial lakes, on terraces along glacial streams, or, in later times, on the flood plains of existing streams. The glacial drift of this region was deposited by the Dakota lobe of the great continental ice sheet during the Wisconsin stage of ice invasion. It varies in thickness from several feet to possibly more than 200. It is composed chiefly of silt, clay, sand, gravel, and bowlders, and is derived from such rock materials as granite, limestone, shale, sandstone, basalt, schist, and gneiss, the various granites apparently being most abundant.

So little time has elapsed, geologically, since the last ice sheet withdrew and since glacial Lake Agassiz was drained, that the drift surface and lake bed have been only slightly affected by erosion and are still very much the same as they were at the close of this glacial period.

The soils of Cass County, with respect to the mode of accumulation of the material, may be classed in four main groups—namely, glacial soils, glacial-lake soils, lake and river terrace soils, and river flood-plain soils.

The glacial soils are those developed on glacial drift. They have not been disturbed since being deposited by the last ice invasion. These soils occur on the higher elevations in the western third of the county. They contain a noticeable quantity of gravel and granite bowlders. The surface is, in general, moderately undulating, although a few of the areas near drainage ways are rolling. Lime carbonate is scarce in the surface soil but is very abundant in the subsoil.

The glacial-lake group comprises the soils on terraces along old lake beds. The soils of the eastern two-thirds of the county, or that part east of the Herman Beach, belong to this group. Geologically, this area was once a part of glacial Lake Agassiz, but is now a part of Red River Valley. The surface is gently undulating or almost level. A number of irregular, depressed areas are northwest and southwest of Page. These have a poorly defined shore line, indicating that glacial waters covered these areas for a much shorter period than in the case of former Lake Agassiz. These glacial-lake soils are grouped in the Fargo and Bearden soil series.

The lake and river-terrace soils were derived from material laid down during the various stages of stream overflow and from material that had been reworked more or less by wave action and deposited along the edge of the melting glacier. Such soils occur in narrow strips or immense wavelike swells along the shore lines of old Lake Agassiz or as terraces along streams. The soils are open and are underlain by sand and gravel beds ranging from 1 to 12 feet in thickness. Such soils constitute the Sioux series.

The river flood-plain soils have developed from alluvial sediments deposited largely after glacial Lake Agassiz had receded. Most of the poorly drained areas west of Leonard in the southern part of the county are in the condition of wet meadow. These areas mapped in irregular and poorly drained positions have light-gray calcareous surface soils and subsoils, and are grouped in the Maple series. Originally, before Lake Agassiz had receded, the entire area west from Leonard to Maple River was formed as a delta between Maple and Sheyenne Rivers through the deposition of the heavier sedimentary material. The better-drained and more distinctly defined bottom-land soils having black surface soils and olive-gray subsoils, and occurring along Maple River above its entrance into old Lake Agassiz, are mapped in the Lamoure series. Although, prior to the complete recession of Lake Agassiz, many sediments were laid down along Sheyenne, Maple, and Red Rivers, the sediments at the present time do not form any well-established first bottoms and are thus included in the glacial-lake soils.

The soils of the well-drained upland of the western part of the county have reached a fairly uniform stage of development and one that may be regarded as mature under the prevailing climatic conditions. The typical profile to the depth to which the soil-weathering processes have acted shows several characteristic layers or horizons. The upper layer or surface soil, which is commonly about 12 inches thick, is very dark grayish brown or almost black and is the darkest well-drained soil in the United States. To a depth varying from 4 to 6 inches the soil is commonly looser and mellower than is the lower part of the surface layer, and there is in places a distinct lamination or succession of thin horizontal layers which show fairly distinct cleavage lines. The soil material has undergone two important changes during its development. The soluble materials, particularly the carbonates, have largely been removed by leaching, and organic matter has been accumulated through the influence of the grass vegetation. The next lower layer typically continues to a depth ranging from 15 to 25 inches. It grades from the dark color of the surface soil to moderately dark brown. In texture it is heavier than the surface soil, but in no place is there any hardpan. The material, when dried, assumes a columnar form, but when broken it crumbles into granules. This layer is underlain by grayish-yellow or grayish-olive silty clay loam, heavier in texture and less compact than the material in the layer above. The columnar arrangement has disappeared and the material has no regular structure. This layer is strongly calcareous throughout and in most places is streaked and spotted by sufficient white lime carbonate to constitute a zone of lime carbonate accumulation. This layer continues to a depth of 30 or more inches. The exact boundary between it and the next lower layer is difficult to determine, as the materials are similar except in the percentage of lime carbonate present, and in some places this difference is slight. The material is usually firm when in position, but it breaks easily, forming soft, irregular clods. The next lower layer is the parent material, unchanged by the soil-forming process. The color varies according to the color and composition of the original rock. Grayish brown, brown, grayish yellow, and gray predominate, but nearly everywhere a faint olive color is noticeable. The colors indicate good drainage and thorough oxidation. Lime carbonate is disseminated through the material, and some spots and concretions of lime carbonate are present. There is not, however, the evidence of concentration that may be seen in the layers above.

The profile described is characteristic of the greater part of the upland area, and, although a considerable range is found in the thickness of the several layers, exceptions are not extensive. The intermediate layer is variable in thickness, and in places is absent, so that the almost black surface soil is immediately underlain by the light olive-gray material.

In this county the soils which have reached the stage of development just described belong to the Barnes and the Bearden series. The parent material of the Barnes soils is glacial drift which is commonly mellow and friable and which contains glacial gravel and bowlders. The Bearden soils occur on the better-drained terraces and higher positions in old lake beds and have developed largely over alluvial materials. The Pierce and Sioux soils may also be regarded as belonging to the well-drained group. The Pierce soils cover glacial knolls and ridges built up of coarse material laid down at the margins of the ice sheets. The surface soils are similar to those of the Barnes soils, but they are immediately underlain by beds of gravel and bowlders. Profiles of the Sioux soils are similar to those of the Pierce soils, but these soils occur on old glacial or lake terraces.

Other soils have developed under conditions of more or less restricted drainage. These soils comprise a large area on the flat lake terraces in the eastern part of the county and occur in narrow strips along streams in all parts of the county. The surface soils are black, in most places being a darker shade than the soils of the well-drained upland. The structure ranges from finely granular to silty or single grained. The dark surface layer ranges in thickness from 12 to 18 inches, the greater thickness being found in the areas where drainage is least effective. Below the surface soil, the color grades downward into dark olive gray or drab, and the texture commonly becomes heavier. This transitional layer may reach a depth ranging from 24 to 30 inches. The next lower layer is gray, light olive-gray, or dark-gray heavy silt loam or silty clay. Lime carbonate is found immediately below the surface soil, and in places even the surface soil is highly calcareous. Where the water table is deep enough to permit its development, there may be a zone of lime carbonate accumulation below the dark surface soil, but in most places it is lacking or is imperfectly developed.

The profiles of the poorly drained soils vary considerably depending on the depth to which drainage and oxidation have been active. In places both surface soil and subsoil have developed under a permanently wet condition, but in other places, the saturation of the soil has been intermittent. At the present time, the soils may be undrained or they may be artificially drained, but where artificially drained, sufficient time has not elapsed since drainage has been established for any appreciable change to have taken place in the character of the soil.

The soils developed under the influence of excessive moisture on the lower lake-bed areas have been grouped in the Fargo series and on the low flood plains in the Maple and Lamoure series.

In the system of mapping employed in all detailed surveys, the soils are grouped into series on the basis of similarity in color, structure, and origin or mode of accumulation. Each series consists of closely related soil types that are differentiated from one another on the basis of texture or the size of the grains of which the soils are composed, that is, the relative proportion of sand, silt, and clay in the surface soil.

The soils of the Barnes series have at least three distinct layers above the parent material. The surface soil is dark grayish brown or almost black, and is loose, single-grained, or finely granular in structure. It is underlain by a heavier-textured layer which grades in color from dark grayish brown into brown. The next lower layer is grayish-yellow or grayish-olive, friable, structureless, highly calcareous material. (Pl. 2, A.) Lime carbonate concretions are abundant and lime carbonate is disseminated throughout the material. This is apparently a zone of lime carbonate accumulation. The parent material which underlies this layer is similar to it except that the lime carbonate, instead of being accumulated, occurs in smaller quantities and is disseminated more uniformly through the soil material. This material is glacial drift little altered by the soil-forming processes. Bowlders are found in the underlying glacial till. Barnes loam, with a rolling phase, and Barnes fine sandy loam have been mapped.

The soils of the Bearden series are, in their principal features, very similar to the Barnes soils of the upland. They have essentially the same number and arrangement of layers. The surface soil, which ranges in thickness from 8 to 14 inches, is very dark grayish brown or almost black and has a loose, finely granular structure. The heavier layer below is not commonly so heavy as in the Barnes soils. It continues to a depth varying from 15 to 18 inches. The lime zone immediately below this is distinctly marked. The color is light gray, and in places, almost white. At a depth ranging from about 25 to 30 inches the light olive-gray drift material occurs. (Pl. 2, B.) The fine sand, fine sandy loam, with a rolling phase, very fine sandy loam, loam, silt loam, silty clay loam, and silty clay members of this series have been mapped.

The Pierce series includes soils having dark-brown or black surface soils varying in thickness from 8 to 15 inches, underlain by light-brown or yellowish-brown layers, from 3 to 6 inches thick, beneath which are yellowish-brown sandy or gravelly subsoils. The subsoil material is stratified or cross-bedded in many places and the gravel is more or less rounded and waterworn. These soils occur on rather rounded hills, lateral moraines, eskers, and kames in glaciated territory. The surface features insure free drainage. Pierce loam was mapped in Cass County.

The soils of the Sioux series have dark-brown or black surface soils, ranging in thickness from 6 to 15 inches, underlain by brown or light-brown material 3 or 4 inches thick. The next lower layer is composed of a mixture of calcareous sand and gravel, commonly stratified, which varies in thickness from 1 to 12 feet. (Pl. 3, A.) The soils occur on beach lines and river terraces and are well drained. The loam, sandy loam, and fine sandy loam members of the series were mapped.

The Valentine soils have brown or rather dark-brown surface soils. The underlying material, usually sand or very fine sandy loam, is brown or grayish brown. In some places, the surface soils are lighter in color, and no marked change in color or texture takes place to a depth of several feet. These soils have developed over wind-laid sands by a very slight weathering of the parent material. In this county only Valentine fine sand is mapped.

A profile of the Fargo soils shows two distinct horizons. The surface soil ranges in thickness from 15 to 20 inches, but in places the thickness may be 3 feet. The underlying lighter-colored subsoil continues to a depth ranging from 6 to 10 feet with very little change. The subsoil is exceedingly plastic and has a characteristic olive-gray color. It contains numerous lime concretions. (Pl. 3, B.) The clay, with a hummocky phase and an alkali phase, the silty clay, with a slope phase, silty clay loam, silt loam, loam, clay loam, and very fine sandy loam members of the series are mapped.

The soils of the Lamoure series consist of a dark-gray or black layer, ranging in thickness from 14 to 18 inches, underlain by a layer, 3 or 4 feet thick, of heavier-textured material of various shades of drab or olive gray. The subsoil is consistently highly calcareous and in many places lime is present from the surface downward. The soil material was laid down as overflow or alluvial deposits. Lamoure loam was mapped in Cass County.

The soils of the Maple series are characterized by dark-gray or grayish-brown surface soils and gray or light-gray subsoils. These soils occur along small streams, sloughs, or elongated and irregular low, wet areas. Little leaching has taken place and lime is present in both the surface soil and subsoil. These soils differ from the Lamoure soils in that they are poorly drained and have lighter-colored subsoils. Maple silt loam, Maple very fine sandy loam, and Maple silty clay were mapped.

In the following pages of this report the various soils are described in detail and their agricultural importance is discussed; the accompanying soil map shows their distribution; and Table 9 gives their name, acreage, and proportionate extent:

TABLE 9.—*Acreage and proportionate extent of soils mapped in Cass County, N. Dak.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Fargo clay	244,032		Bearden loam	66,752	5.9
Hummocky phase	20,160	24.3	Bearden very fine sandy loam	80,768	7.1
Alakali phase	12,288		Bearden fine sandy loam	47,296	4.4
Fargo silty clay	121,920	11.2	Rolling phase	3,136	
Slope phase	6,016		Bearden fine sand	1,600	.1
Fargo silty clay loam	51,008	4.5	Sioux loam	6,528	.6
Fargo silt loam	12,864	1.1	Sioux sandy loam	2,496	.2
Fargo very fine sandy loam	4,224	.4	Sioux fine sandy loam	2,560	.2
Fargo loam	4,736	.4	Pierce loam	960	.1
Fargo clay loam	640	.1	Maple very fine sandy loam	9,664	.8
Barnes loam	252,160	22.5	Maple silt loam	4,928	.4
Rolling phase	4,224		Maple silty clay	2,368	.2
Barnes fine sandy loam	4,544	.4	Lamoure loam	5,952	.5
Bearden silty clay loam	112,064	9.8	Valentine fine sand	1,280	.1
Bearden silty clay	12,032	1.1			
Bearden silt loam	41,280	3.6	Total	1,140,480	

FARGO CLAY

The surface soil of Fargo clay, locally known as "gumbo," is black clay, plastic when wet and either coarse, granular, or cubelike when dry. In most places this grades, at a depth ranging from 14 to 20 inches, into dark grayish-drab or olive-gray clay, although in some places the material is almost as dark at a depth of 30 or 40 inches as it is at the surface, and a trace of bluish black is present. The lower subsoil layer of dark olive-gray clay continues to a depth of several feet with little variation. (Pl. 3, B.) In many places the subsoil at a depth of about 20 inches, is olive gray or rather light olive gray, very similar in color to the corresponding layer of Bearden silty clay. Such areas occur in close proximity to Bearden silty clay but differ from the Bearden soil in that the lower part of the subsoil is heavy plastic clay rather than the friable silty clay loam or silty clay of the Bearden soils. In many fields, dark-gray or black rather irregular streaks are present in the subsoil 3 or 4 feet from the surface. Such streaks, which gradually diminish in size with depth and are most conspicuous in the lighter-colored subsoils, are caused by the washing of the surface soil into the large cracks after long droughty periods.

Lime carbonate occurs at a depth varying from 8 to 24 inches, commonly at an average depth of about 15 inches, but in a few places along sharp slopes at the surface. A few of the very poorly drained areas are indicated by marsh symbols. In several such areas southwest of Fargo the surface soil, to a depth ranging from 6 to 12 inches, has a consistence closely approaching muck. These areas, however, are small and are included in mapped areas of Fargo clay.

This soil is stone free, although a few scattered bowlders were noticed in fields or along the road, mainly south of Hickson.

The principal areas of Fargo clay occur north and west of Davenport, east of Hunter, southwest of Casselton and Mapleton, and in a strip about 6 miles wide along Red River. This soil predominates on the lower levels of the valley, where it was laid down through the slow accumulation of the fine particles held in suspension in the more quiet waters of former Lake Agassiz.

The surface of Fargo clay is prevailingly flat. The fall varies from 1 foot to several feet to the mile. The land has a general slope to the north or northeast, but one area southeast of Casselton drains southward for some miles and then eastward. The surface drainage, although rather poor on the flatter areas, is ample to take care of the surplus rainfall since drainage ditches have been constructed. About 175 miles of ditches have been dug, and in places more are needed. The flatter areas occur north and south of Davenport and northeast and southwest of Argusville. The underdrainage is very inadequate. In wet years, the surplus water has a natural tendency to accumulate on the lower areas of Fargo clay, and when thoroughly saturated the heavy plastic subsoil retards percolation to such an extent that, where surface drainage is lacking, water stands along graded roads for weeks after rains. Sometimes a crop can not be harvested because of the length of time before the farmer can get into the field. Tile drainage has not been provided except in a very few places. The surface water is generally disposed of by a few small, lateral ditches leading to the main ditches.

This soil is the most extensive in the valley. It is estimated that about 90 per cent is in cultivation in average years. There is no timber other than that which has been planted. All of the crops common to the region can be grown, although wheat, barley, flax, rye, alfalfa, sweet clover, and corn grow best. Corn is frequently injured by frost on account of the low position and coldness of the soil, which makes it difficult for the crop to get an early start. Corn makes excellent fodder and an abundance of silage in almost any season, but it can not be depended on to mature grain as on the lighter-textured soils. Of late years, however, a large proportion has matured. On a large part of the soil the continuous growing of small grains has resulted in the land becoming infested with noxious weeds. Early fall plowing is always advantageous, as by this means weed growth is checked, the decay of vegetable matter is facilitated, and the tilth of the soil is greatly improved by the severe freezing which follows. Sweet clover is being grown more and more to improve the soil and eliminate weed pests. Wheat yields from about 10 to 40 bushels to the acre, oats from 30 to 70 bushels, barley from 20 to 60 bushels, and corn from 12 to 65 bushels. Potatoes do fairly well on the better-drained areas, especially in rather dry years. Flax does well some years, but weeds often damage it. (Pl. 4, A.)

More livestock is being raised each year in order to use sweet clover, alfalfa, and corn, which are being grown to help control the weeds. Many farms which have been devoted almost exclusively to the growing of small grains are badly infested with wild oats, French weed, and yellow mustard. These weeds are annuals and are comparatively easy to control under good diversified farming conditions. Quack grass and perennial sow thistle are serious perennial weeds. The growing of intertilled crops and of alfalfa is, however, proving beneficial in the control of both these pests. Special tillage machinery is of value in the control of perennial weeds.

Investigations conducted at the North Dakota Agricultural Experiment Station, which is located on Fargo clay, show that this soil responds favorably to the application of farm manure. Evidence accumulated indicates that Fargo clay will return larger yields if

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it is fertilized with phosphatic fertilizers, but it can not become profitable to use the phosphatic fertilizer to increase yields until other limiting factors, such as weeds and poor drainage, have been put under control. The growing of sweet clover on this soil in the course of the rotation has been found beneficial. It improves the physical condition of the soil and increases its permeability to water.

Current values of Fargo clay range from about $30 to $100 an acre, depending on general improvements, distance from railroads and towns, and drainage conditions.

Fargo clay, alkali phase.—Fargo clay, alkali phase, consists of exceedingly heavy, very dark gray or black clay underlain, at a depth ranging from 12 to 20 inches, by dark-gray or dark olive-gray clay. The soil differs from typical Fargo clay in that numerous alkali spots are scattered over its surface. These spots range in diameter from 15 to 30 feet and are from 20 feet to more than 300 feet apart. The material is exceedingly waxy when thoroughly wet, so that it is very difficult to go over these spots with a binder, mower, or other implement. In droughty years this soil is very hard and cracks from 1 to 4 feet deep are numerous. In most places lime is present in different quantities at a depth ranging from 14 to 24 inches.

This soil occurs just west and northwest of Fargo in an area about 2½ miles wide and 9 miles long. The surface is either flat or sufficiently hummocky to prevent good surface drainage, even if a drainage ditch is close by. The soil immediately between these very low swells, although dark, is noticeably lighter than typical in color and texture. In most places it consists of gray or dark-gray silty clay loam underlain, at a depth ranging from 4 to 10 inches, by the characteristic impervious black clay which probably contains a rather high percentage of colloidal material. The alkali spots are more numerous on the higher swells associated with the heavy black clay. As a whole, drainage is inferior to that of any other soil mapped in the county.

This is not an important soil agriculturally. Possibly 75 or 80 per cent is in cultivation in average years, and the remainder is used for pasture or hay land. The small-grain crops are most commonly grown, together with some corn and a few potatoes. The land can best be utilized for pasture and hay, as it is the least dependable of all the Fargo soils for cultivated crops. The fact that only stunted isolated groves and no houses mark the sites of the first homesteads is sufficient evidence to prospective settlers that this is an undesirable soil for farming, especially for intertilled crops.

The prices asked for this land range from $30 to $100 an acre.

Fargo clay, hummocky phase.—The surface soil of Fargo clay, hummocky phase, consists of black clay which is stiff when wet and coarse, granular, and crumbly when dry. In the slightly lower areas it is silty clay loam from 4 to 10 inches thick and is distinctly lighter in color than in areas on the slightly higher levels. The subsoil, below a depth ranging from 10 to 15 inches, is dark grayish drab or olive gray and continues to a depth of several feet with very little change, except to become lighter in color. In a few places the soil is black to a depth of 30 or 40 inches. Where the soil is gray at the surface it is more difficult to plow than typical Fargo clay, unless the moisture conditions are just right to allow the plow to scour. These slightly lighter-textured and lighter-colored areas are so intricately mixed and occur in such narrow and patchy areas that it was impossible to separate them as a soil type for mapping. In extremely dry weather the soil is very hard and compact, with wide cracks from 1 to 4 feet deep. In well-cultivated corn or potato fields a loose mulch is easily produced and maintained.

This soil occurs in the northeastern part of the county in a single area covering about 31 square miles. The surface is faintly billowy or broken by rather long irregular hummocks almost imperceptible to the eye but very conspicuous immediately after a heavy rain. At the present time a drainage ditch to Red River extends east on each section line. Through these and many small lateral ditches made by the farmers and the rather high-graded roads which act as laterals, the soil is fairly well drained. A few sections are still imperfectly drained, and heavy rains cause crops to be drowned out in many small patches.

Fargo clay, hummocky phase, is a fairly important soil, and about 90 or 95 per cent is, or has been, in cultivation. All the crops common to the region are grown, and the yields are about the same as on typical Fargo clay. The farmers are raising more corn and livestock than formerly. The more imperfectly drained areas are left in pasture.

Current prices of this land range from about $30 to $90 an acre, depending on general improvements, drainage, and distance from towns and railroads.

Table 10 gives the results of mechanical analyses of samples of the surface soil and subsoil of typical Fargo clay:

TABLE 10.—*Mechanical analyses of Fargo clay*

No.	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*
351946	Surface soil, 0 to 15 inches	0.2	1.3	0.6	2.6	6.2	43.7	45.5
351947	Subsoil, 15 to 22 inches	.4	2.0	.8	2.8	4.2	44.0	45.6
351948	Subsoil, 22 to 50 inches	.0	.2	.0	.4	1.1	20.8	77.5

FARGO SILTY CLAY

The dark-gray or black silty surface soil of Fargo silty clay is underlain, at a depth ranging from 8 to 20 inches, by heavy clay of the same color. In most places the clay begins at a depth varying from 10 to 14 inches. It is underlain by dark olive-gray clay which gradually merges with lighter-gray material, which, at a depth ranging from 28 to 36 inches, has a distinct olive-gray tint. This material continues downward for several feet with little change, except the presence of numerous white lime concretions. In many places the lower part of the subsoil is rather yellowish gray, especially in areas adjacent to Bearden silty clay or Bearden silty clay loam.

This soil represents the first texture lighter than Fargo clay and is widely distributed over Red River Valley. The largest areas are on the higher rises immediately bordering Fargo clay south of

Grandin, northeast and southeast of Casselton, south of Davenport, and bordering Red, Sheyenne, and Maple Rivers in either small or rather large belts.

Areas slope slightly toward areas of Fargo clay or occur on gently rounded or flat ridges from 6 inches to about 10 feet above these lower areas. The underdrainage, although slightly better than that of Fargo clay, is far inferior to that of the Bearden soils. The generally good surface drainage makes the underdrainage a matter of less importance. Probably the most undependable areas of this soil are associated with the Barnes soils, and as they receive the run-off of the Barnes soils, in wet years they are too poorly drained to permit cropping. Such areas in this county are of small extent.

Fargo silty clay is a fairly important as well as a uniformly good soil, and 95 per cent or more is in cultivation. A small strip of forest borders Maple and Sheyenne Rivers.

Crop yields on this soil are comparable to those obtained on any soil in the valley. Wheat yields from 12 to 40 bushels, oats from 20 to 60 bushels, flax from 10 to 18 bushels, barley from 15 to 45 bushels, and corn from 20 to 50 bushels to the acre. Alfalfa always produces two crops, and in some years three. The growing of sweet clover to free the land of weeds and provide summer and fall pasturage is increasing.

Corn is commonly cut for fodder or silage, as a large number of farmers on this soil are livestock farmers. Potatoes do well, but not so well as on the lighter-textured Bearden soils.

Farms are well improved. As this soil occurs largely in belts bordering streams or rivers or on rather flat ridges, it makes desirable home sites, and a comparatively larger number of homes are built on it than on Fargo clay. A large homestead, barn, grove, granaries, and, on many farms, a silo, constitute the chief improvements. Probably about 75 per cent of the farmers on this soil practice diversified farming and own more or less livestock.

Current values of this soil range from $50 to $125 an acre, depending on the distance from towns, railroads, and rivers and on general improvements.

Fargo silty clay, slope phase.—Fargo silty clay, slope phase, has a gray or rather dark-gray surface soil which varies more or less in some of the larger river bends. In many places the same color and texture continue downward 3 or 4 or more feet; however, below a depth of about 20 inches the texture is slightly heavier as a rule, and the color is fairly uniform olive gray. Near the bends of the rivers slight color variations occur, owing to the various accumulations as a result of former occasional overflows of Red River.

Soil of this phase occurs chiefly along the bends of Red River, though a few narrow strips border Wild Rice and Sheyenne Rivers. In many places the surface slopes to such a degree that cultivation is not attempted. Some areas are hummocky, and in others small mounds are so numerous that cultivation is impractical. Some of the larger and more level areas, however, are well suited to cultivation, as the natural drainage is good. The presence of lime in the surface soil makes this soil well adapted to legumes, especially alfalfa. Bluegrass thrives and provides an abundance of pasturage, except where the forest growth is dense.

This soil is used primarily for pasturing livestock. It is especially desirable for livestock farmers because it provides an abundance of shade and water in summer and, to a certain extent, shelter from the north winds in winter. (Pl. 4, B.) Probably about 90 per cent of it is covered with a dense forest growth, consisting of white elm, ash, boxelder, basswood, and bur oak, and a scantier growth of willow, cottonwood, ironwood, hackberry, and dogwood. In places, a few red and black haw, wild plum, and chokecherry trees were noticed.

This land is sold in connection with the associated typical Fargo silty clay and, owing to its desirability for livestock raising, is held at prices ranging from $60 to $100 or more an acre, depending on general improvements and distance from Fargo.

Table 11 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and subsoil of typical Fargo silty clay.

TABLE 11.—*Mechanical analyses of Fargo silty clay*

No.	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*
351940	Surface soil, 0 to 8 inches	0.0	0.8	0.3	1.9	9.0	61.6	26.4
351941	Subsurface soil, 8 to 16 inches	.0	1.3	.5	2.2	6.9	52.8	36.9
351942	Subsoil, 16 to 36 inches	.0	.9	.4	1.4	6.2	53.4	37.6

FARGO SILTY CLAY LOAM

Fargo silty clay loam has a surface soil of very dark gray or black silty clay loam which commonly breaks into coarse clods. However, if it is broken under the right condition of moisture it pulverizes and forms a fine, granular mass. At a depth of 6 or 8 inches, this layer is underlain by dark-gray silty clay which continues to a depth ranging from 16 to 24 inches. The next lower layer is the zone of lime accumulation and consists of olive-gray clay containing streaks and concretions of lime. All the soil material of this layer is calcareous. Dark streaks and tongues, which result from the filling of cracks with dark soil from the surface layer, extend downward into this layer in many places. Below this is the substratum of grayish-yellow clay or silty clay loam. This material is calcareous, but the lime is not so highly concentrated as in the layer above.

The lower part of the subsoil, although it is clay, is in many places considerably lighter gray than is the corresponding material in Fargo clay, and it may be olive gray. This soil, as mapped along Sheyenne River, is underlain by stiff, plastic, black clay at a depth ranging from about 2½ to 4½ feet, and the surface soil has a slightly lighter gray color than soils away from streams.

This soil is commonly associated with the silt loam and silty clay members of the series and in many places represents material in the transitional stage. Thus the exact line of separation is exceedingly difficult to locate. In several sections, particularly secs. 1, 2, 10, 11, and 12, T. 138 N., R. 49 W., the subsoil contains a layer of lighter material similar to that underlying Bearden silty clay loam. This layer, which is from 4 to 10 inches thick and which occurs at a depth ranging from 18 to 30 inches, consists of olive-gray silty clay loam. In a few places two or three layers occur within a depth of 3 feet. Lime is present at the surface along Sheyenne River and is everywhere present within 14 inches of the surface.

Fargo silty clay loam is mapped in widely separated areas and is an important soil. Where associated with Barnes loam it occurs in lower positions and has an imperfectly drained subsoil and, in many places, a poorly drained surface soil. Possibly not more than half of these areas are in cultivation, and very few farmers attempt to produce a grain crop when the growing season is abnormally wet. In the areas in the bed of former Lake Agassiz surface drainage, as a rule, is good. The underdrainage is everywhere imperfect, yet this characteristic has little significance in normal years, provided the surface drainage is good. The larger areas occur west and northwest of Gardner, east of Arthur, between Arthur and Amenia, northeast and southwest of Wheatland, around Mapleton and Prosper, southwest of Fargo, and about 23 miles along Sheyenne River where it enters the county on the south.

Practically all of this soil in the Agassiz Lake bed is in cultivation, except a strip lying mainly within the oxbow bends of Sheyenne River. Such areas support a natural forest growth, in some places the largest and thickest growth in the county. The trees are white elm, ash, boxelder, basswood, bur oak, and scattered cottonwood, willow, ironwood, hackberry, dogwood, and wild plum.

The surface relief of Fargo silty clay loam is variable. The areas associated with Barnes loam are flat, whereas most of those within the valley proper are gently undulating, with a slight slope. Areas occurring northeast and south of Arthur have a distinct slope in different directions, depending on which direction Fargo clay lies. A rather large area northwest of Casselton appears to be perfectly flat, but in detail consists of numerous almost imperceptible low swells with very slight depressions or strips intervening. In ordinary seasons these depressions do not interfere with cropping, but in wet seasons such places are so soft that horses and implements frequently bog on the fields. This condition exists over most of the principal areas of this soil. The long strip mapped along Sheyenne River has a rise, beginning at the river bank, of from 2½ to about 5 feet, and it gradually slopes out toward Fargo clay on both sides. On these slopes, in general, surface drainage is good. The soil as a whole occurs at lower levels than either Bearden silt loam or Fargo silt loam, but in sec. 16, T. 139 N., R. 53 W., Fargo silty clay loam occurs on the highest part of the ridge, with the Fargo silt loam next highest, and Bearden silt loam and Bearden very fine sandy loam at still lower levels in sec. 17, to the west.

All the crops commonly grown in the Red River Valley do well on this soil. Wheat, the most important crop, yields from 12 to 40 bushels to the acre; oats from about 20 to 60 bushels; and flax from 10 to 15 bushels. If the ground is exceptionally clean and the season is favorable, yields of flax varying from 18 to 22 bushels are not uncommon, but if wild oats get a good foothold, which is not unusual of late years, the yield is often so reduced as to make the crop barely worth harvesting. Corn, in average years, can be depended on to produce a crop. Although this soil lies only a few feet higher than Fargo clay, it is much better corn soil because it is better drained, can be worked earlier in the spring, is easier to cultivate, and is less subject to damaging frosts late in spring or early in fall. This soil retains moisture well, so that when corn is once started it makes a vigorous growth. Yields range from about 25 to 60 bushels to the acre. Potatoes do well where surface drainage is good. They yield from 75 to 150 bushels to the acre, depending on the season and the general care given the crop.

Most farms on this soil are well improved. Small grains are the leading crops although corn is almost as important on the better-drained areas bordering streams. Along Sheyenne River the natural forest growth, which affords excellent shade in summer and a windbreak or shelter in winter, makes this land desirable for livestock raising and dairying. The fact that there is an average of five farmsteads to the mile on this soil along the river is sufficient proof of its desirability. The farms, as a whole, are well improved, with a barn, silo, windmill, granaries, and an excellent windbreak or grove.

Current land values range from about $40 to $100 an acre, depending on improvements, lay of the land, and distance to elevators and towns.

FARGO SILT LOAM

Fargo silt loam has a surface soil of dark-gray or black silt loam ranging in thickness from 8 to 18 inches. This is underlain by dark-gray or brownish-gray silty clay loam which gradually becomes heavier and more plastic with increasing depth and which, at a depth ranging from 16 to 22 inches, grades into rather dark-gray plastic silty clay or clay. The color grades into lighter olive gray or grayish drab which prevails to a depth varying from 36 to 40 inches. Although lime is present in considerable quantities in the subsoil and rather sparingly at the surface, the soil has not the characteristic zone of high lime accumulation found in Bearden silt loam and Bearden loam. The lower part of the subsoil is very impervious to surface water, and the only places where it is slightly friable is in close proximity to the line of demarcation between this soil and the Bearden soils.

Fargo silt loam occurs at higher levels than the other Fargo soils. The more important areas are slightly southeast, southwest, and northeast of Arthur. A few areas are east of Alice, southwest of Page, and southwest of Wheatland. The occurrence of this soil on comparatively higher positions than the heavier members of the series naturally makes surface drainage better. In the smaller areas associated with the Barnes soils, the most important of which are east of Alice and southwest of Page, natural surface drainage is inadequate.

This soil is not extensive, but the most important areas, which are in the old Lake Agassiz bed, show a high state of improvement. Practically all the soil is in cultivation, except some of the smaller areas associated with Barnes loam. When the precipitation is heavy in early spring these small areas are left idle unless good surface drainage is provided, but when the precipitation is very slight in fall and spring they frequently produce much higher yields than the higher and better-drained Barnes loam. However, these patches can not be depended upon every year for small-grain or corn crops and they are largely left in pasture.

All the farm crops commonly grown in this region are or can be produced on this soil east of Herman Beach or within the old lake bed. The yields are about the same as on Fargo silty clay loam. The soil becomes dry and warm early in the spring, and as it is mellow and seldom cracks or bakes it is well suited to corn and potatoes as well as to small grains and leguminous crops. Fall plowing is usually practiced, and as this soil is earlier than the heavy members of the series, cultivation on it usually begins from a week to 10 days earlier than on them.

In view of the fact that the various noxious weeds have become exceedingly aggravating on this, as well as on all other soils in the valley, farmers should raise more livestock in order that corn, clover, alfalfa, and sweet clover may profitably be grown and the weed pests held in check. The more successful farmers in the valley are gradually coming to the raising of more livestock, and with the elimination of a large part of the weeds, flax, a very important cash crop, can be depended upon. Many of the old wheat-growing areas are so infested with wild oats and other noxious weeds that the production of flax is very precarious. The incorporation of organic matter through the growing of clovers adds much to the value of any soil.

This soil, although usually held in connection with other soils, sells at prices ranging from $40 to $100 an acre, depending on improvements and distance to elevators and towns.

FARGO VERY FINE SANDY LOAM

The surface soil of Fargo very fine sandy loam consists of dark-gray or dark brownish-gray very fine sandy loam from 8 to 15 inches thick. This is underlain by dark-brown very fine sandy loam which grades in color to olive gray or olive yellow at a depth ranging from 15 to 20 inches. The subsoil is very abruptly underlain by heavy olive-gray clay at a depth ranging from 18 to 32 inches. Lime concretions are common in the lower part of the subsoil.

Although Fargo very fine sandy loam is rather inextensive in Cass County, practically all of it is in cultivation and is well improved. The larger areas are 3 miles west of Gardner and from 1 to 3 miles southwest of Arthur. This soil occurs at about the same level as areas of Bearden very fine sandy loam and Bearden silty clay loam.

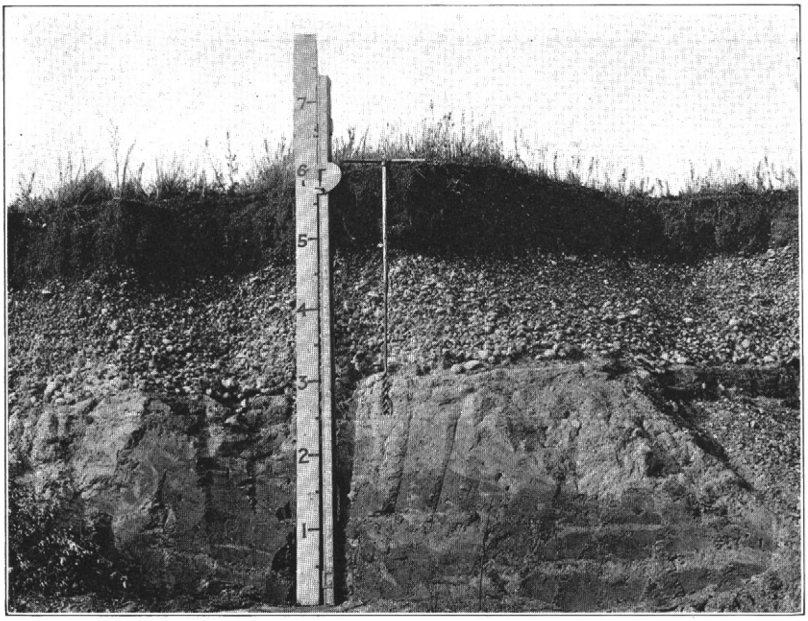
Fargo very fine sandy loam in most places has sufficient slope to insure good surface drainage. The underdrainage is not so good, on account of the stiffness and plasticity of the subsoil, but this does not affect the soil agriculturally. This soil really consists of a thin sandy layer over a Fargo clay subsoil, a very desirable combination.

All the crops common to the valley do well. Yields vary considerably but are as good as on the associated Bearden very fine sandy loam or Bearden silt loam. This is a more dependable soil than the heavier members of the Fargo series.

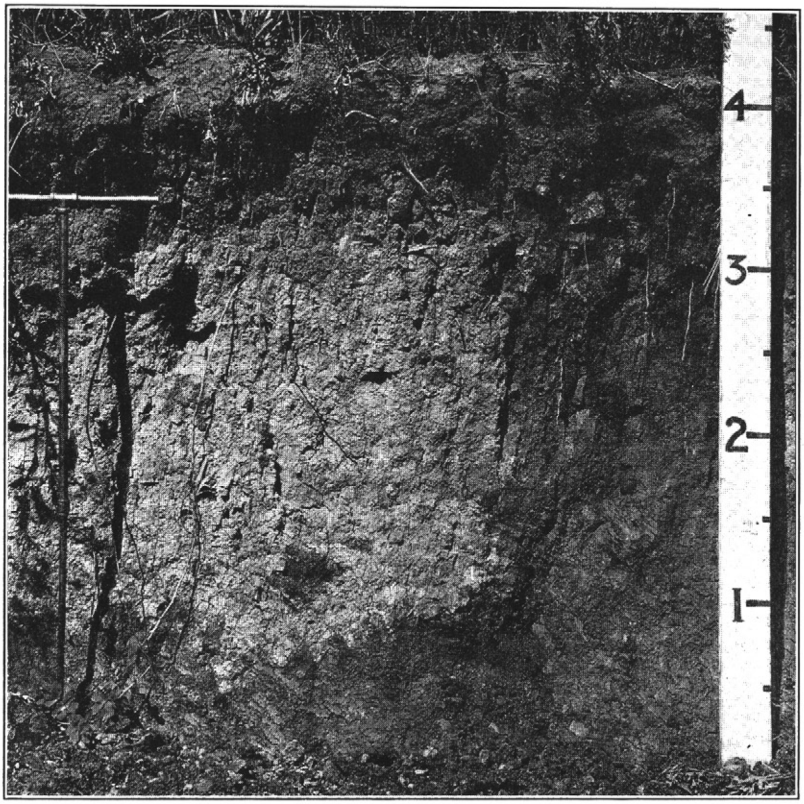
Current land values range from $50 to $90 an acre. Owing to its small extent this land usually is held in connection with other soils.

FARGO LOAM

In Fargo loam the dark grayish-brown or almost black loam surface soil, similar in general appearance to that of Barnes loam,

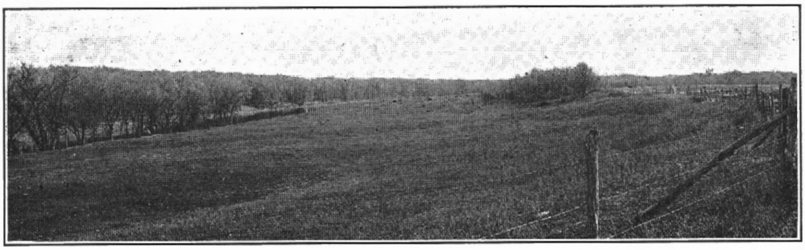


A, Profile of Sioux loam

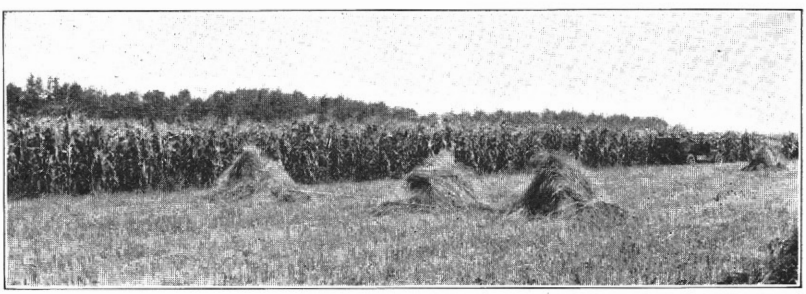


B, Profile of Fargo clay
The dark color on the right side shows the soil in a moist condition.

A, Flax on Fargo clay



B, Grazing land on Fargo silty clay, slope phase



C, Corn and rye on Barnes loam

D, Good growth of corn on Bearden fine sandy loam gradually becomes heavier with increasing depth and grades into clay or clay loam at a depth ranging from 16 to 24 inches. As the texture approaches clay, the color generally becomes more dark olive drab or olive gray, although in some places the color varies little from the surface downward. In a few areas there are traces or slight accumulations of alkali. Lime is everywhere present in the subsoil, at a depth ranging from 8 to 16 inches. The highest concentration of lime is just below the dark surface soil.

Areas of this soil are more or less scattered. Most of them occur in the lower flats immediately bordering the Bearden soils in the vicinity of the McCauleyville Beach Line. The largest areas are north and south of Arthur and north of Hunter.

This soil is not extensive. It is used for the same crops as the adjoining soils. In wet seasons crops in the lower areas are more subject to injury than on the Bearden soils owing to the longer time it takes surplus water to drain off or penetrate through the heavy subsoil.

The surface of Fargo loam is almost flat, with a slope to the southeast. A few very slight swells are noticeable, but these do not affect crops unless the season is unusually wet.

Current values for this soil are about the same as for the adjoining soils with which it is usually sold.

FARGO CLAY LOAM

Fargo clay loam has the characteristic dark-gray or black surface soil which grades into slightly heavier clay loam at a depth of about 8 or 10 inches. Beneath this, at a depth ranging from 15 to 20 inches, is grayish-drab or dark olive-gray clay. The texture of Fargo clay loam is distinctly unlike that of any other soil mapped in the county. The material is mainly clay, with an appreciable content of fine sand.

This soil occurs on rather distinct rises or as depositions laid down in the early formation of the valley. It is associated with the lighter members of the Fargo series and occurs from 1½ to 5 miles south of Horace. It is the least extensive soil mapped in the county. Its texture and occurrence make it desirable in that it is not difficult to work and is fairly well drained naturally. All of it is in cultivation.

BARNES LOAM

Barnes loam, to an average depth of 7 inches, is very dark grayish-brown loam having a loose or very finely granular structure. It is underlain by a layer of somewhat heavier and more compact dark grayish-brown loam or clay loam which continues to a depth ranging from 12 to 15 inches. The next lower layer is light grayish-yellow, grayish-brown, or olive-brown clay loam or silty clay loam. A large quantity of lime in this layer is the result of concentration or accumulation from other layers. The material has a nut structure but breaks into soft, irregular clods. This layer continues to a depth ranging from 20 to 24 inches and is underlain by the parent material of glacial drift which continues downward to a depth of many feet with little variation. The substratum is grayish yellow with a slight olive tinge. Lime is abundant but is more uniformly disseminated

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through the material than in the layer above. A few lime concretions and spots of lime may be seen where calcareous material occurred in the drift. (Pl. 2, A.) White spots and splotches of lime occur throughout the soil material. A few small bowlders and gravel are present on the surface and throughout the soil.

Knobs, knolls, or rather sharply sloping areas are covered with material lighter in color than typical. These areas in many places show the presence of lime at or near the surface, but in lower areas the calcareous material is 15 or more inches below the surface. Some areas, such as one covering almost a square mile 4 miles west of Page and several sections south and southeast of Ayr, were recognized as silt loam but were too inextensive to justify separate mapping. The material in several rather low areas west of Maple River ranges in texture from clay loam to silty clay loam, but these areas also were too small to map. Some of these patches of heavier soils show indications of the presence of alkali. Several small areas of fine and very fine sandy loam, mostly small isolated patches on hill or mound crests northwest of Page, are included in mapped areas of Barnes loam.

Small depressions are common over a large part of this soil. They range from about 20 to 100 feet in diameter and from 1 to 4 feet in depth and have a flat surface. The more prominent depressions are shown on the map by symbols. In average years their presence interferes but little with crops, but when heavy snows or rains cause an excessive amount of surface water their presence is undesirable. When the precipitation has been very light in the fall, winter, and spring, these depressions are plowed and seeded, and yields on them are heavy owing to the extra moisture present.

The surface of Barnes loam is flat, gently undulating, or moderately rolling. The country south and southeast of Ayr appears almost flat, though in reality it is very gently undulating, and a number of sections south of Alice are moderately rolling. A number of permanent and intermittent lakes are south of Alice.

This soil is easy to plow and cultivate and does not bake or crack upon drying, except in a few low areas that are inclined to be slightly alkaline. Its porousness allows free percolation of surplus rainfall, and in dry years considerable moisture is made available to crop growth through capillary attraction. Drainage is sufficient but not excessive. The greater part of the run-off enters either Red River or Maple River. In other places the surface water accumulates in the depressions or areas of Fargo soils.

Barnes loam is the most extensive soil in the county. It has developed from glacial till which has been so little altered in surface features that it is now almost exactly as it was when deposited at the close of the glacial period. This soil occurs only in a belt in the western part of the county, 6 miles wide at the south and from 12 to 15 miles wide in the central and northern parts. This is an excellent soil, and it is estimated that at least 95 per cent of it is under cultivation. No native forest is found on this land.

The crops grown are wheat, rye, barley, corn, and flax. Of these, wheat is the most important. Corn is grown largely for forage and silage (pl. 4, C), but more is being husked than formerly was. The average yield of corn is less than on some of the Bearden soils in the valley, owing largely to the lighter rainfall on this soil. Alfalfa, of the more hardy strains, has been grown successfully in recent years, especially on well-prepared seed beds. Some brome grass, timothy, and red clover are grown with fair success, yields ranging from 1 to 2 tons to the acre. Sweet clover does exceedingly well and is used for summer pasture.

Diversified farming involving the raising of livestock and the production of feed crops and their by-product of manure is rapidly increasing on this soil. The more progressive farmers use all the available farm manure, and some of them are beginning to experiment in a small way with the use of commercial fertilizers. Sweet clover is commonly grown in the rotation and is used either as hay, pasture, or green manure. The homes and barns are well built and well cared for and in general indicate prosperity. The characteristic cottonwood or willow groves afford an abundance of shade and are excellent windbreaks.

The better-improved land currently sells for prices ranging from $50 to $75 an acre, and a few highly improved farms are held at $100 an acre. Unimproved land can be bought for about $40 or $50 an acre. Land values depend on the distance from railroad stations, trails, schools, and towns.

Barnes loam, rolling phase.—Barnes loam, rolling phase, differs from typical Barnes loam in its shallower surface soil which typically ranges in thickness from 4 to 7 inches. On very steep hillsides and on the tops of sharp knolls, the black surface soil may be entirely removed by erosion and a small patch of the brown drift exposed. The underlying heavier layer is thinner than on the more level areas and in places is very thin or entirely absent. The layer of lime accumulation below this is commonly thin but very distinct and almost white. The substratum is grayish-yellow, structureless, calcareous glacial drift which does not differ from the substratum of the typical soil except in the larger proportion of glacial bowlders and gravel present.

Rolling Barnes loam occurs mainly in the southwestern part of the county, chiefly along the slopes of Maple River. A rather prominent area is mapped west of Erie Junction. This soil covers but a small area in the county. The surface is steep, the slopes rising from 50 tc 100 or more feet above the narrow valley, yet erosion has been slight, owing to the light rainfall.

Agriculturally this soil is unimportant, and it is estimated that not more than 10 per cent is in cultivation. It is used for grazing, as it supports a luxuriant and highly succulent growth of native grasses, such as cord grass, porcupine grass, slender wheatgrass, pigeon grass, blue grama or buffalo grass, and other grasses and weeds.

The value of this soil ranges from $20 to $35 an acre, but as it occurs in small strips it is necessarily sold in conjunction with typical Barnes loam, which has a tendency to increase the price.

Table 12 gives the results of mechanical analyses of samples of the surface soil and subsoil of typical Barnes loam:

TABLE 12.—*Mechanical analyses of Barnes loam*

No.	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*
351913	Surface soil, 0 to 14 inches	0.9	5.1	4.6	23.9	17.2	40.8	7.6
351914	Subsoil, 14 to 20 inches	1.1	4.4	4.2	31.3	16.5	28.5	13.8
351915	Subsoil, 20 to 55 inches	1.5	3.6	2.9	19.6	21.6	34.2	17.1

BARNES FINE SANDY LOAM

Barnes fine sandy loam has a surface soil of dark grayish-brown fine sandy loam which ranges in thickness from 8 to 20 inches, but which is ordinarily about 14 inches thick. This is underlain, at a depth ranging from 20 to 26 inches, by slightly heavier fine sandy loam which grades in color from dark grayish brown in the upper part of the layer to brown in the lower part. The layer below is grayish-yellow or grayish-olive fine sandy loam which continues downward more than 4 feet. This soil material is calcareous throughout, but a very noticeable concentration of lime carbonate can be seen.

A rather prominent area 2 miles west of Page consists of very fine sandy loam very similar to that described except that the lower part of the subsoil, below a depth of about 22 inches, has a more distinctive pale-yellow or faint olive-yellow color. Another such area is about 1 mile west of Erie. Although these areas may be extensive enough for a type differentiation, their agricultural difference is so slight that it was considered advisable to combine them with Barnes fine sandy loam in mapping.

The larger areas of Barnes fine sandy loam are northeast and northwest of Page, the largest single area being about 4 miles northwest of Page. Another rather conspicuous area is about 2 miles north of Erie. This area was possibly partly covered by glacial Lake Agassiz for a short period, although it has the surface features and color characteristics of the Barnes soils.

The surface of this soil is undulating or faintly billowy. The soil is porous, sandy, and comparatively level, and all rainfall is rapidly absorbed. Probably the most undesirable feature of the soil is its tendency to drift, although this does not seriously impair its agricultural value.

All crops common to this region can be successfully grown on Barnes fine sandy loam. Rye is one of the best crops, as it can be seeded on stubble land in the fall on fields which are more susceptible to drifting. Crop yields are probably slightly inferior to those obtained on Barnes loam, especially in dry years.

As this soil is associated with Barnes loam, it is usually sold in connection with that soil at prices ranging from about $35 to $50 an acre.

BEARDEN SILTY CLAY LOAM

The surface soil of Bearden silty clay loam, to a depth of 7 inches, commonly consists of very dark grayish-brown or black silty clay loam. Between depths of 7 and 18 or 20 inches the color changes gradually to dark gray, and the texture becomes slightly heavier. Under this layer is a very distinct zone of lime accumulation. This material is light gray or almost white and is lighter in color than the layers above or below it. Below a depth ranging from 24 to 28 inches and continuing to a depth of many feet is pale olive-gray or grayish-yellow silty clay loam or friable silty clay. No distinct mottling is noticeable at any depth, but faint gray and brown splotches or stains are present in the lower areas where drainage is less perfect.

As a rule, this soil is more silty and more open with increasing depth where it is associated with other Bearden soils, but where it is in close proximity to the Fargo soils the lower subsoil material is somewhat stiff. The material is commonly calcareous at the surface, but in places is leached out to a depth of 10 or 15 inches and is highly calcareous in the subsoil. Alkali spots are rare, and where they occur the concentration is not of such intensity as to interfere seriously with the growing of crops.

Bearden silty clay loam occurs at lower levels than the lighter members of the Bearden series but above the adjoining Fargo soils. The largest area is northeast of Casselton and occupies a large, flat-topped ridge from 4 to 8 miles wide and about 18 miles long, terminating about 2 miles west of Gardner. About 6 miles west of Gardner a continuation of this ridge extends northward into Traill County. Beginning about a mile north of Prosper, this ridge takes a slightly southeasterly direction on the Minnesota side, where, although rather broken and disconnected, it varies little from the 930-foot level and is believed to be the beach of the last stage of recession of glacial Lake Agassiz in Cass County.

Another rather prominent area, averaging about 2 miles in width, is below the Sheyenne delta, in the southern part of the county, extending from Maple River to the county line about 2 miles west of Kindred. A number of areas occur along Maple River and the old Sheyenne River channel. These apparently were formed by sediments deposited by overflow waters before the lake bed fully receded. In such areas the material is calcareous from the surface downward. In the old Sheyenne River channel, which extends north of Warren, the surface has a gradual slope on both sides toward the lower Fargo soils. As the main channel is treeless, with gently sloping banks, it does not interfere with cultivated crops in average years.

The surface of this soil, in general, is almost level, with sufficient fall to insure good surface drainage. The underdrainage is good because of the friability of the subsoil and substratum. A large part of the surface water escapes by percolation into the subsoil.

This soil is not only one of the most extensive but one of the most important and highly prized farming soils in the valley. It is used generally for the production of small grains, although diversified farming is in common practice along Maple River and several of the small intermittent streams. Wheat, the most extensively grown small grain, yields from about 12 to 40 bushels to the acre, oats from 25 to 60 bushels, barley from 18 to 40 bushels, flax from 10 to 24 bushels, rye from 14 to 40 bushels, corn from 20 to 65 bushels, and potatoes from 75 to 200 bushels. Clover and timothy mixed are now more commonly grown and are excellent for hay as well as for soil improvement and weed eradication. Alfalfa and sweet clover are more extensively grown than any other crop except corn to eradicate noxious weeds and conserve moisture for the succeeding crop. The weeds have been responsible in a large measure for a steady decline in wheat and flax yields. This decrease has resulted in a more diversified system of farming, in which dairying and livestock raising are more commonly practiced. The cultivation of potatoes eliminates a large proportion of the weeds. Corn is proving an exceptionally good crop on this soil. It is seldom killed by frosts, and a crop may be counted on. A heavy rain will not drown out a good stand or cause it to turn yellow, as is the case on some of the low areas of the Fargo soils.

This soil currently sells at prices ranging from $50 to $100 an acre, depending on general improvements, distance to railroads and stations, and the abundance of wild oats or quack grass on the soil.

As this is an excellent soil for general farming, it could be much more thickly settled. The groves are more dense, and cottonwood trees invariably attain a greater height than on Fargo clay. It would probably be a paying investment to start a grove on part of many of the larger farms, as it is believed the ground required, the cost, and the trouble would be compensated generously within 10 years by the increased sale value of the land.

BEARDEN SILTY CLAY

Bearden silty clay consists of dark-gray or black silty clay which grades, at a depth ranging from 15 to 20 inches, into gray material that may vary in texture from heavy silty clay to rather light friable clay. The subsoil ordinarily begins at a depth ranging from 20 to 24 inches, though in places it may begin at a depth of 30 inches. It has the light-gray, light olive-gray, or olive-yellow color of the zone of lime accumulation. The subsoil material is, as a rule, more friable and open than the material between depths of 12 and 20 inches. The lower part of the subsoil is grayish-yellow or light grayish-olive silty clay. In many places, especially in depressions, it contains some grayish mottles and a few brownish stains. It is uniformly lighter in texture and color where it is adjacent to the Bearden soils than where it is in close proximity to the Fargo soils.

This soil occurs at slightly lower levels than Bearden silty clay loam but above Fargo clay, although this may not mean a difference of more than a foot or two in elevation. As it has the same surface appearance as Fargo silty clay, its separation was not possible until numerous borings into the lower part of the subsoil had been made. It differs from Fargo silty clay only in that, to a depth of 3 feet, it is friable silty clay loam or silty clay whereas the Fargo soil consistently has a darker and heavier clay subsoil. The larger areas are southeast and northeast of Davenport and north and south of Prosper. Small strips are scattered about more or less wherever Bearden silty clay loam occurs.

The surface of this soil is almost level, with only a slight fall toward the associated Fargo clay. The drainage, which is mainly effected by percolation into the subsoil, is usually sufficient to absorb ordinary rains, except in places where water collects from higher soil. The excess surface water is largely removed either through drainage ditches or by the side ditches along graded roads.

The position of the areas, the level surface, and the character of the surface soil and subsoil material indicate that this soil is of alluvial origin. The finer materials of which it is formed were carried farther into the lake and modified by deposits of lacustrine origin.

Bearden silty clay, although not very extensive, is practically all in cultivation and in a high state of agricultural development. It is used most extensively for the production of wheat, although oats, barley, flax, spelt, corn, potatoes, timothy, clover, alfalfa, and millet are grown to some extent. The yields are about the same as on Bearden silty clay loam.

This soil is easily kept in good physical condition. It is rather rich in organic matter, although leguminous crops are always beneficial in increasing crop yields. Little fertilizer other than the available barnyard manure is used. Farms, in general, are well improved, and large houses and barns with well-established groves similar to those on other Bearden soils prevail.

Current land values range from about $40 to $100 an acre, depending on general improvements and distance to towns or shipping points.

BEARDEN SILT LOAM

The surface soil of Bearden silt loam is very dark-gray, very dark grayish-brown, or black silt loam from 12 to 15 inches thick. This grades into dark-gray, heavy silt loam or silty clay loam, which gradually becomes lighter in color with increasing depth. Below a depth ranging from 18 to 22 inches is yellowish-gray or olive-gray silty clay loam containing a few brownish stains, especially in slightly lower areas. Where drainage is exceptionally good and the areas are higher than adjoining soils, this lower subsoil material, from a depth of about 24 inches to a depth of several feet, is characteristically pale greenish-yellow or light olive-yellow, highly calcareous, friable material which varies in texture from silty clay loam to silty clay. In several places Bearden silt loam is so closely associated with Bearden silty clay loam, and the texture change is so gradual, that the line of demarcation is more or less arbitrary. In many places, the upper subsoil layer is sharply underlain by a pale yellowish-gray or gray layer which contains a high concentration of lime.

This soil is widely distributed over the county. As a rule it is found along small intermittent streams, on slightly higher elevations than the associated Bearden silty clay loam. The larger areas are west and southeast of Amenia, northwest and southwest of Casselton, east and northeast of Kindred, southeast of Mason, southwest of Gardner, west of Hunter, and southeast of Chaffee along Maple River.

The areas are almost flat, with a gentle slope on the low, rather flat, rounded ridges or along both sides of the intermittent coulees which were formed at the time the lake had almost receded. Drainage is excellent, owing to the friability of the subsoil.

About 95 per cent of the Bearden silt loam is cultivated every year and is in a high state of productiveness. A little timber is found along Rush Creek, along the creek 5 miles south of Wheatland, and along the bends of Sheyenne River, but the most abundant virgin tree growth in 1924, the year in which the survey was completed, was along the bends or meanderings of Maple River.

Bearden silt loam is one of the most highly prized soils of the Red River Valley. It is used for the production of all the staple crops common to this section of the country and is excellent for diversified farming. Dairying and hog raising are practiced more or less in connection with small-grain farming, especially along the forested areas.

Wheat yields from 12 to 35 bushels, oats from 25 to 60 bushels, barley from 18 to 40 bushels, flax from 10 to 22 bushels, rye from 14 to 40 bushels, corn from 20 to 65 bushels, and potatoes from 75 to 200 bushels to the acre. Alfalfa, red clover, and timothy grow well on this land, and yields range from 1 to 2 tons to the cutting. It is often difficult to secure a good stand of red clover, although farmers who have had many years' experience on this soil minimize the difficulty. Red clover does not stand the competition of nurse crops and weeds so well as alfalfa and sweet clover and is more likely to be injured by winter exposure or by alternate freezing and thawing in the spring. Sweet clover is commonly grown as pasturage for livestock, or the first crop is cut for hay and the second crop is grown for seed or green manure. When plowed under as a green-manure crop, the main object is to eradicate the wild oats, French weed, quack grass, and other pests and to follow up with a corn or flax crop. Corn does exceedingly well, as the soil is easy to cultivate and does not crack or bake on drying, and the friable subsoil does not allow water to remain on the surface long enough to drown out the corn or cause it to turn yellow. Potatoes do remarkably well, and the tubers are smooth, of uniform size, and of excellent quality. The high content of organic matter and the smooth, fluffy consistence of the soil make conditions ideal for raising this crop.

The ease with which this soil can be plowed and cultivated, its earliness, its capacity for absorbing and holding moisture, and its good drainage make it most desirable. The assurance of a good crop every year is reflected in the well-improved farms and prosperous appearance of the farmers.

Little commercial fertilizer is used, although barnyard manure has in late years been generally applied to cornland. Manure assists very materially in increasing not only the corn yields but yields of the crops following. Fall plowing is generally practiced.

This land ranges in value from $60 to $100 an acre, depending on the distance from towns and railroads and on general improvements.

Table 13 gives the results of mechanical analyses of samples of the surface soil and subsoil of Bearden silt loam:

TABLE 13.—*Mechanical analyses of Bearden silt loam*

No.	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*
351920	Surface soil, 0 to 12 inches	0.0	0.8	0.8	18.6	29.6	39.7	11.0
351921	Subsoil, 12 to 22 inches	.0	.0	.6	16.6	29.0	35.0	18.8
351922	Subsoil, 22 to 40 inches	.0	.4	.8	15.8	36.2	30.5	16.3

BEARDEN LOAM

The surface soil of Bearden loam consists of very dark gray, dark brownish-gray, or black loam containing a comparatively large proportion of either fine or very fine sand. Below a depth ranging from 8 to 14 inches is dark-gray or brownish-gray clay loam or silty clay loam which gradually merges with lighter-gray material. Commonly, at a depth of 16 or 18 inches, there is a very sharp line of demarcation indicating a zone of high concentration of calcareous material. (Pl. 2, B.) This light-gray zone is particularly noticeable when the soil is dry. At a depth of about 26 inches, the light-gray silty clay loam or silty clay typically grades in color into rather light olive gray which predominates to a depth of 36 inches. In a number of places the lower part of the subsoil, at a depth of about 30 inches, grades abruptly into greenish-yellow or olive-yellow very fine sandy loam or silt loam. In places the lower part of the subsoil, which is everywhere friable within a depth of 3 feet, contains a very noticeable quantity of crystalline gypsum.

Bearden loam, as it is mapped north and northwest of Leonard, represents the border of the Sheyenne delta, and the land is more sloping than typical, and in some places is almost silt loam in texture. It differs from the other Bearden soils in that it is more retentive of moisture, no doubt largely as a result of underground seepage from the higher and very porous substratum of Bearden very fine sandy loam. Not only is this area inclined to be moist, it is also rather cold in the spring and in places is rather boggy.

Stones and some bowlders were formerly present in Bearden loam, and a few are still found here and there on the surface and in the subsoil.

The greater part of the Bearden loam occurs in rather irregular areas from about 1 mile east to 3 or 4 miles west of the McCauleyville Beach. A few areas occur just below the Herman Beach, about 5 miles southeast of Alice, and east and southeast of Buffalo. A large number of elongated irregular areas are in the northwestern part of the county along Maple River and in the vicinity of Page.

The surface of this land is almost flat, with a gradual slope to the southeast. A number of included ridges from 10 to 40 yards in width and from 1 to 3 feet in height are mapped as Sioux loam. Smaller ridges or large wavelike swells are common, but these do not contain noticeable gravel or sand as do the typical Sioux soils.

Drainage is sufficient to care for the surface run-off, and the friability of the subsoil does not permit water to remain on the surface for any length of time.

This soil is rather important. It is estimated that about 95 per cent is in cultivation, and practically all of it can be cultivated. There are no forested areas.

All of the crops common to the valley do well. Oats do best on areas inclined to be rather cold and wet in the early spring, whereas corn does best on the higher areas where the proportion of fine sand is greater. Wheat yields from 10 to 35 bushels to the acre, rye from 12 to 40 bushels, barley from 12 to 45 bushels, flax from 8 to 20 bushels, oats from 20 to 60 bushels, potatoes from 75 to 175 bushels, and corn from 20 to 50 bushels. Alfalfa and sweet clover are grown more extensively each year as the interest in dairying and livestock raising increases. Alfalfa yields from 1 to 1½ tons to the acre and at least two and sometimes three cuttings are harvested. Timothy and clover are grown to some extent and yield from three-fourths to 1½ tons to the acre. Sweet clover produces an abundance of feed but is commonly utilized as summer pasturage, is cut for seed, or is plowed under as a green-manure crop. On many farms alfalfa, clover and timothy, or sweet clover is allowed to stand for several years, the sod is then turned under, and the land is seeded to flax or planted to corn or potatoes.

Of late years, farms are being more generally stocked, more fields are fenced, and a more diversified type of farming is practiced. Farms are well improved and indicate prosperity, but most of the farms are larger than can properly be cared for, especially where highly diversified farming is practiced.

Current land values range from about $50 to $100 an acre, depending on general improvements and distance from trails, railroads, and towns.

BEARDEN VERY FINE SANDY LOAM

The surface soil of Bearden very fine sandy loam consists of dark-gray or dark brownish-gray very fine sandy loam. At a depth ranging from 16 to 20 inches this is underlain by rather dark-brown very fine sandy loam which continues to a depth ranging from 22 to 26 inches. The subsoil varies from light brownish gray to light olive gray in most places, although in areas closely associated with Bearden loam or Bearden silt loam the lower part of the subsoil and the material for several feet below it may have an olive-yellow or pale-yellow color. In the country west of Leonard, the surface soil seems to contain less organic matter than in the country west of Arthur and Hunter, at least it is more susceptible to drifting. The lower part of the subsoil, in general, is distinctly more sandy and contains less lime carbonate. The soil west of Leonard shows no trace of lime carbonate to a depth of 3 feet except in the areas close to the lower-lying Maple very fine sandy loam.

This is a fairly extensive and important soil. It occurs just below Bearden fine sandy loam in the lake bed and is most extensive in the country west of Leonard and west of Arthur and Hunter. It occurs at elevations ranging from 980 feet at Hunter to 1,047 feet at Leonard. Practically all of the soil occurs west of or above McCauleyville Beach. It is estimated that about 97 per cent of it is under cultivation, but all of it could be cultivated. It supports no native forest growth except along Maple River, in the southeastern part of the county, and along Rush Creek, about 4 miles northeast of Absaraka.

The surface of this soil is level or slightly billowy. The slope is sufficient to insure good surface drainage, although the loose and porous structure insures the rapid absorption of rain water. In the southern part of the county, an area which is more variable than the average is mapped along Maple River between the two strips of Bearden fine sandy loam, rolling phase. The surface is rather hummocky, and numerous old channels, many of which are barely recognized, give it a very irregular appearance. The variability in relief is caused by the action of overflow water, probably at the time that glacial Lake Agassiz was receding toward the Canadian border. At present this area is not subject to overflow, except along a few of the lower river bends. This strip is from 20 to 80 feet lower than the adjoining areas of the rolling phase of Bearden fine sandy loam.

All the crops common to the region do well. Rye, wheat, barley, corn, potatoes, oats, and flax are the principal crops. Red and sweet clover are grown more extensively than formerly. Such legumes not only afford an abundance of hay and pasturage but assist very materially in eradicating weed pests and incorporating organic matter in the soil.

This is considered one of the best, if not the best, potato soil in the county, and the acreage of potatoes is comparatively large. Yields range from 75 to 200 bushels to the acre, depending on the season, condition of the soil, and tillage methods. Potatoes grown on this soil are clean, smooth, uniform in size, high in quality, and very desirable for seed in the Central and Southern States. The varieties grown are Early Ohio, Irish Cobbler, Triumph, and Green Mountain.

Corn yields from 30 to 60 bushels of grain to the acre and from 2½ to 4 tons of fodder and silage. When it is hogged down, a flint or early dent variety is most desirable. Corn is an almost certain crop, because the sandy soil warms up early in the spring and the porous subsoil prevents too much rain from causing any loss by drowning. Corn invariably ripens earlier than on the heavier Fargo soil.

Winter rye is a good crop, and in areas where the soil is inclined to be rather light and susceptible to drifting, rye is frequently drilled in on stubble land with or without previous disking. It is sown between the last of August and the middle of October, depending on the season. Yields range from about 12 to 25 or more bushels to the acre.

Wheat is grown very extensively, but as it is seeded in the spring care must be taken to prevent soil drifting. Rye, having an earlier start, is seldom affected by drifting. Flax yields average between 8 and 10 bushels to the acre, but when weeds are largely eliminated yields ranging from 15 to 20 bushels are not unusual. The French weed and wild oats are, on most farms, the most serious pests to contend with in raising flax. On many farms it is a question whether the weeds will overcome the flax or the flax get the better of the weeds.

Although weeds of many kinds grow in great abundance they are not so troublesome as on the heavier soils, owing largely to the fact that moisture conditions do not interfere with cultivation to such an extent as on the heavier types. The more common weeds are the Russian thistle, wild oats, tumbling mustard, French weed, yellow and green pigeon grass, corn cockle, pink cockle, wild rose, king head, bindweed, lamb's-quarters, quack grass, and nettle. The sow thistle is making its appearance in a few spots. The early recognition and prompt destruction of sow thistle before it goes to seed will save future trouble. As the plant spreads by means of an underground root structure, it will be necessary to practice either crop smothering or tillage methods to eradicate it when it makes an appearance.

On a rather large number of farms sheep are becoming popular. The sandy soil is especially favorable to sheep raising, because there is no mud to contend with and little chance for foot diseases to get started in the flocks.

Current land values range from about $40 to $75 an acre, although the highly improved farms are valued between $80 and $100 an acre. Land values west of Hunter and Arthur are higher than those west of Leonard, largely because of the slightly less sandy soil and subsoil and because the areas are associated with soils that are not so low and imperfectly drained.

BEARDEN FINE SANDY LOAM

The surface soil of Bearden fine sandy loam consists of dark-gray fine sandy loam. At a depth of about 18 or 20 inches, this is underlain by dark-brown or brownish-gray fine sandy loam, which grades downward, at a depth ranging from 22 to 26 inches, into lighter-brown or yellowish-brown fine sand or fine sandy loam. Below this layer the material varies in color from light olive gray or light brownish gray to grayish brown or light gray in slightly lower areas where more surface water penetrates the lower part of the subsoil. Both surface soil and subsoil are free of stones and gravel. In several places, this soil has an unusually sandy subsoil and other characteristics similar to Bearden fine sand. These have made separation in mapping rather arbitrary. In these places the soil is leached of lime carbonate so that no effervescence is noticed with hydrochloric acid above a depth of 3 feet.

This soil occurs in the western third of the county, in a long strip from 1 to 4 miles wide lying just east of the Herman Beach Line, or Sioux soil. Several other areas, the largest of which is 4 miles west of Hunter, are mapped in the glacial Lake Agassiz basin.

The surface of this soil is almost level, with ample slope to the east to insure good surface drainage. The wave action, by which this land apparently was largely formed, caused the fine sand to be deposited at a higher level than the very fine sand. Some areas take the shape of large wavelike swells similar to areas of Sioux soils.

This soil is used for the same general crops as Bearden very fine sandy loam, but ordinarily the yields are slightly less. Corn yields from 30 to 40 bushels to the acre, potatoes from 75 to 175 bushels, wheat from 10 to 15 bushels, oats from 20 to 35 bushels, barley from 20 to 25 bushels, rye about 15 bushels, and flax about 10 bushels. Corn, sweet clover, alfalfa, and potatoes do remarkably well. (Pl. 4, D.) Small grains are grown in excess of other crops. It is estimated that at least 95 per cent of this soil is in cultivation and practically all of it is tillable. It does not support any virgin forest.

Owing to its openness and porosity, Bearden fine sandy loam has a tendency to drift. This danger is more common when the fields have little or no snow protection or when the soil is unusually dry in early spring at the time crops are getting started. This difficulty is minimized by the application of manure or straw on fields or spots most susceptible. Crop rotations in which alfalfa or sweet clover are prominent are recommended, as these crops afford valuable cover, add organic matter to the soil, and assist in the eradication of a large proportion of the noxious weeds.

Bearden fine sandy loam is generally well improved. Its agricultural value is slightly lower than that of Bearden very fine sandy loam and slightly in excess of that of Bearden fine sand. Current land values range from about $30 to $60 an acre.

Bearden fine sandy loam, rolling phase.—Bearden fine sandy loam, rolling phase, includes more variations than any other soil of the same area in the county. The more common soil profile shows a layer of gray or dark-gray fine sandy loam grading, at a depth of about 10 or 15 inches, into brown or yellowish-brown fine sandy loam which continues to a depth ranging from 20 to 24 inches. This is underlain to a depth of 36 inches, by lighter-gray or brownish-gray fine sand or fine sandy loam. In places at a depth ranging from 2½ to 4 feet the characteristic glacial till of greenish-yellow silty clay loam or clay loam occurs in the lower part of the subsoil. Along the steeper slopes numerous gravelly pockets are found and in some places the yellowish glacial till is exposed.

In sections 8, 9, and 16, T. 137 N., R. 53 W., the soil on most of the slopes is loamy in texture and supports a virgin growth of grasses and plants. In sections 7, 8, 18, and 19, T. 137 N., R. 53 W., the slopes are covered with very fine sandy loam from the adjoining areas of Bearden very fine sandy loam.

Soil of this phase occurs inextensively in the southern part of the county in the Lake Agassiz basin. A small, irregular strip is on both sides of Maple River, beginning about 4 miles south of Chaffee and extending in a southwesterly direction to the county line.

The slopes on areas of this soil are steep, rising from 20 to about 80 feet above the Maple River Valley, but the effects of erosion are very slight. About 90 per cent of the land is in virgin pasture, with only a few patches of native forests along the lower slopes. The remainder can be cultivated.

Land values are difficult to determine as the soil is sold in connection with other soils. When it is utilized as pasture land, the grass cover not only affords protection from wind in summer and winter but affords valuable grazing. With an abundance of running water flowing from springs near Enderlin, farmers find the Maple River bottom between these slopes a very suitable location for livestock farming.

BEARDEN FINE SAND

In Bearden fine sand the dark-gray surface layer is loamy fine sand underlain, at a depth ranging from 15 to 20 inches, by brownish or yellowish-brown loose fine sand. Below this material the color is more variable, but a shade of light brown or grayish brown commonly predominates to a depth of several feet. The zone of lime accumulation, which occurs in other soils of this series below the dark-colored surface soil, is not noticeable in this soil although it may be seen in a few localities where conditions are more favorable for its development.

This soil is mapped in the northern part of the county, the larger areas occurring in rather long strips about a quarter of a mile wide. Two large areas are 8 miles west and 4 or 5 miles northwest of Hunter. This is an inextensive and unimportant soil.

Areas of Bearden fine sand are inclined to be rather hummocky and, although the soil was originally formed largely by wave action, its surface appears to have been shifted about more or less by the wind. Surface water is rapidly absorbed and percolates through the loose surface soil and subsoil.

This soil is cultivated or can be put into cultivated crops. Its most undesirable feature is its tendency to drift. Care must be taken to prevent crops from being blown out, especially on the higher and more exposed areas. Manure and straw are frequently spread over wheat or rye fields in early spring to minimize drifting. Crop rotations in which alfalfa or sweet clover are used are effective in checking drifting and also add considerable organic matter to the soil. Corn or potatoes are seldom affected by soil drifting and can be grown very successfully, especially when a liberal quantity of barnyard manure is applied.

The various noxious weeds common to the region grow with great vigor and are exceedingly troublesome. Crop yields in normal years are slightly inferior, and land values are slightly lower than those of Bearden fine sandy loam.

SIOUX LOAM

The surface soil of Sioux loam is dark-brown or dark-gray loam containing a comparatively small proportion of rather coarse sand and gravel. Below a depth ranging from 8 to 15 inches is lighter-brown heavy loam or light clay loam. In this layer coarse sand and gravel become more abundant, and at a depth ranging from 10 to 26 inches gravelly material is so abundant that the material can not be penetrated with the soil auger. This gravelly subsoil or substratum consists chiefly of granite, gneiss, basalt, schist, and limestone, all in the form of sand, pebbles, gravel, and small rounded stones some of which are as large as coconuts. A concentration of white lime carbonate is found below the dark surface soil, and incrustations of lime carbonate are very noticeable on the rounded gravel and stones, particularly on the lower side. These beds range from about 1 foot to 12 or 15 feet in thickness. (Pl. 3, A.) About 1 mile west of Absaraka, along the Great Northern Railway, immense quantities of the gravelly substratum have been removed for ballast. This sand and gravel are excellent road-building materials and are being used in large quantities for this purpose.

This soil occurs along the several old beach lines of glacial Lake Agassiz and has the appearance of immense, smooth, gracefully rounded, wavelike swells. The productive capacity of the soil varies with its power to hold moisture, hence crop yields are higher on the lower areas where the gravelly subsoil is thinner. In dry seasons this soil is more seriously affected by drought than the associated Barnes and Bearden soils. A large part of the Sioux loam occurs along the Herman Beach Line at an elevation of about 1,100 feet.

At least 90 per cent of this soil is in cultivation. Areas along small drainage ways where the slopes are rather sharp are used for pasture. Small-grain crops are generally grown, and yields are less than on the associated Barnes and Bearden soils. Land values are also less, but as the soil occurs in small strips it is necessarily sold in conjunction with the adjoining soils.

SIOUX SANDY LOAM

Sioux sandy loam is dark-brown sandy loam grading, at a depth of 6 or 8 inches, into slightly lighter-brown sandy loam which is underlain by gravelly material at a depth ranging from 10 to 20 inches. The higher crests of these beach lines are lighter brown in color, are more droughty, and contain a higher proportion of sand and small gravel.

This soil, which is of small extent in Cass County, occurs chiefly along the Herman Beach Line southeast of Alice and northwest of Chaffee. It occupies long narrow ridges ranging in width from a rod or two to a quarter of a mile. The sandy and porous surface soil and the gravelly subsoil below make this soil more droughty probably than the other Sioux soils mapped. The surface soil has a tendency to drift, although crops are seldom damaged by being blown out.

Practically all this soil is in cultivation. Yields compare favorably with those on other Sioux soils but are less than on the adjacent Barnes loam and Bearden fine sandy loam. The productive capacity of Sioux sandy loam varies according to its power to hold moisture, so that the higher or wider areas in which the gravelly subsoil is thicker produce lower yields than the very narrow ridges in which the gravelly subsoil is from 10 to 20 inches thick. Owing to the large content of gravel in the subsoil a very small quantity of moisture is made available to crop growth by capillary attraction, and surface water from rain or snow evaporates very quickly.

Land values are lower than for contiguous soils. As this soil occurs in small strips it is sold in conjunction with the Barnes or Bearden soils.

SIOUX FINE SANDY LOAM

The surface soil of Sioux fine sandy loam is dark-gray or dark-brown fine sandy loam grading into brown fine sandy loam at a depth varying from 9 to 12 inches. This layer is underlain, at a depth ranging from 16 to 26 inches, by a gravelly subsoil which is similar to the subsoil of Sioux loam and Sioux sandy loam although the proportion of sand and fine gravel is considerably greater, owing to the fact that most of this soil occurs on a lower beach line, known as the McCauleyville Beach Line, where stones and gravel were apparently less abundant during the period in which glacial Lake Agassiz receded. Also, this beach line is of less depth and width than the older Herman Beach Line, indicating that the period of its formation was of shorter duration geologically.

This soil is not extensive. The larger areas occur north and south of Arthur along McCauleyville Beach and south of Absaraka and Ripon.

Practically all of the soil is in cultivation. Corn, oats, rye, barley, and potatoes are the principal crops. The yields are smaller than those on the associated Barnes and Bearden soils, although when the spring months are abnormally wet very favorable yields of small grain are produced. Wild rye, wild oats, pigeon grass, Russian thistle, wild rose, and French weed are the most common noxious weeds.

As this soil occurs in small strips, it is difficult to determine a land value. Its presence on a farm, however, has a tendency to lower the value of the adjacent Bearden soils.

PIERCE LOAM

Pierce loam has a dark-brown or brown surface soil, commonly grading, at a depth varying from 4 to 8 inches, into brown or rather light-brown loam which in many places contains some small gravel. The subsoil, at a depth ranging from 10 to 15 inches, grades into light-brown sand and gravel in varying proportions which continue downward to a depth ranging from 3 to 12 or more feet. A few of the steeper slopes and sharply rounded knolls show quantities of exposed sandy or gravelly material. The subsoil is either gravelly, stratified, or cross-bedded with varying quantities of sand, gravel, and glacial till. The gravel is more or less rounded and waterworn. The gravelstones usually have an incrustation of highly calcareous material on their lower surface.

Pierce loam has developed over material laid down by the melting glacier in the shape of irregular crests, ridges, or hills, or in the form of lateral moraines. The relief is such that free drainage is insured, and this factor, combined with a porous and leachy subsoil, makes this soil rather undependable for general farm crops. When in cultivation Pierce loam is probably best suited to small grains, such as wheat and rye. The more uneven areas are in pasture.

Pierce loam occurs in small, widely separated areas associated with areas of Barnes loam. The larger areas are about 5 miles west and 5 miles slightly southwest of Alice in the southwestern part of the county.

Crop yields are less than on Barnes loam but are about the same as on the Sioux soils. As the areas are small it is difficult to determine land values. Pierce loam is sold in conjunction with Barnes loam, but its presence does not enhance the value of that soil.

MAPLE VERY FINE SANDY LOAM

The surface soil of Maple very fine sandy loam is dark-gray calcareous very fine sandy loam. It is underlain, at a depth ranging from 8 to 14 inches, by gray or light-gray very fine sandy loam or silty clay loam which grades, at a depth ranging from 24 to 30 inches, into light-gray or slightly olive-gray very fine sandy loam. The olive-yellow lower subsoil material, which continues downward for several feet, may be silty clay loam, very fine sandy loam, or very fine sand containing light-gray or rust-brown mottles. In small areas which have been included in mapping the soil is gray or dark-brown loam underlain, at a depth ranging from 10 to 15 inches, by light-gray loam or silt loam. At a depth ranging from 18 to 26 inches the material becomes rather heavy loam or silty clay loam, and at a depth of 30 inches it grades into brown or olive-gray silty clay loam or silty clay. Where the soil is associated with areas of the Bearden soils in the Lake Agassiz basin, this lower subsoil material is brown, olive-gray, or olive-yellow loam or fine sandy loam.

This soil occurs largely in the southern part of the county west of Leonard and 6 miles west and southwest of Hunter. It is found in poorly drained places such as sloughs, depressions, and first bottoms of sluggish creeks. At present the surface water escapes largely by percolating into the sandy substratum and by gradual evaporation.

Areas not too wet are utilized for hay or pasture land, and the better-drained areas are sown to small grain. In exceptionally wet years it is necessary to use the greater part of these areas for pasture and hay, but in exceptionally dry years the yields of small grain are larger than those on the associated Bearden very fine sandy loam. The areas indicated with marsh symbols on the map are used for hay or pasture every year, as they are low and poorly drained.

The bulk of the hay consists of various native grasses such as wild timothy (*Muhlenbergia racemosa*, Mich.), hollow stem or sprangle top (*Scolochloa festucacea*), false redtop or fowl meadow grass (*Poa triflora* Gilib.), switch grass (*Panicum variegatum*), Indian grass or bushy bluestem (*Andropogon nutans avenaceus*, Mich.), slough sedge (*Carex trichocarpa*), bulrush (*Scirpus fluveatilis*), witch grass (*Panicu meapillare* Linn.), and such weeds as wormwood (*Artemisia biennis*), tall white aster (*Aster paniculatus*), water horehound (*Lycopus americanus*), long-rooted smartweed (*Polygonum emersium*), and many others. Yields vary from one-half to 1 ton to the acre. In some seasons one cutting is made and in others two, depending on the quantity of moisture in the soil and the kind of grass. The hay is used locally.

This land is usually sold in connection with Bearden very fine sandy loam. It tends to lower somewhat the value of farms, especially if the areas are large. It sells at prices ranging from $15 to $25 an acre, depending on improvements and the distance from railroads.

MAPLE SILT LOAM

The surface layer of Maple silt loam consists of gray, brownish-gray, or dark-gray silt loam containing varying quantities of organic matter. This grades, at a depth ranging from 1 to 4 inches, into gray silt loam which in many places has a slight bluish tinge. This material is underlain, at a depth varying from 15 to 26 inches, by light-gray silty clay loam. In some places, below a depth varying from 18 to 24 inches, there is a layer of very light or almost white, strongly calcareous silty clay loam, representing a zone of lime accumulation.

This soil occurs in poorly drained areas along small streams and in sloughs or depressions, and its use is restricted to pasture or the production of hay crops. The surface is nearly flat, but in a few areas are the characteristic depressions known as buffalo wallows.

Hay yields from 1 to 2½ or more tons to the acre. The vegetation includes a large variety of grasses, and this characteristically moist soil affords excellent grazing throughout the summer. A few of the more common plants are wild timothy, hollow stem, false redtop, switch grass, Indian grass, slough sedge, bur reed, various sedges, tall manna grass, and many others.

This soil is inextensive, the more prominent areas occurring about 6 miles southwest of Page and about 6½ miles west or slightly southwest of Hunter. The latter area is cultivated when the season is favorable, but as a rule it is used either for hay or pasture.

Current land values range from about $12 to $25 an acre.

MAPLE SILTY CLAY

Maple silty clay is dark brownish-gray or dark-gray silty clay or silty clay loam grading, at a depth varying from 4 to 6 inches, into faintly bluish-gray silty clay which in turn, at a depth varying from 18 to 26 inches, grades in color into olive gray or light olive gray.

Maple silty clay is not extensive. The largest area occurs along Maple River about 3 miles west and southwest of Page. Practically all the soil is used for hay or pasture land. Areas occur at slightly lower levels than Maple silt loam, and for this reason hollow stem is one of the most common grasses available for hay.

Current values range from $15 to $25 an acre.

LAMOURE LOAM

The surface soil of Lamoure loam is dark-gray or dark grayish-brown loam containing variable quantities of sand, fine sand, silt, and clay. At a depth ranging from 14 to 18 inches this layer is underlain by olive-gray or drab silty clay loam which grades into olive-gray, light olive-gray, or rather light-gray silty clay loam or clay, continuous to a depth of 3 or 4 feet. The many meanderings of Maple River have given rise to considerable variations in surface relief, and it is not uncommon to find soils of loam, silty clay, and in a few places of clay texture in the same area. Likewise, the subsoil varies greatly in texture and color. In view of the fact that these areas are used exclusively for pasture or hay land and are too inextensive for separate mapping, they were included with mapped areas of this soil.

Lamoure loam occurs along the first bottom of Maple River in the western part of the county. It supports no forest growth, but isolated patches of rose and buckbush are common. This is considered an excellent soil for pasturing livestock, as water is available in the creek bends all summer, except in abnormally dry seasons.

Current land values range from about $15 to $25 an acre.

VALENTINE FINE SAND

To a depth ranging from 15 to 20 inches, Valentine fine sand consists of brown or grayish-brown fine sand or loamy fine sand. Beneath this is light-brown or yellowish-brown fine sand which continues downward to a depth of 8 and in places to 15 or more feet with very little variation. The darker surface color results from the presence of decayed organic matter and is more noticeable in the lower areas. Other places show little difference in color from the surface downward. Lime carbonate occurs in but few places in either surface soil or subsoil.

The areas of Valentine fine sand mapped in Cass County are small and occur only in that part of the county east and west of Leonard.

The surface is characteristically billowy or sharply billowy, with differences in relief ranging from 2 to 6 feet. Part of the modification by wind has taken place since the sod was first broken. Abandoned fields now support an abundance of various weeds and grasses, and the soil affords fair grazing in spring and summer. Close grazing by sheep is not advisable, as this practice makes drifting possible. Cultivated areas are best adapted to such crops as rye and sweet clover. In general, it is best to utilize this soil for pasture only.

Current land values range from about $10 to $15 an acre.

SUMMARY

Cass County is in the southeastern part of North Dakota, bordering Red River. It has an area of 1,782 square miles, or 1,140,480 acres.

The land is almost flat in the eastern two-thirds of the county. This area is known geologically as glacial Lake Agassiz and is commonly known as the Red River Valley. The western third is gently undulating and constitutes the glaciated upland.

In the greater part of the county surface drainage is good, although some imperfectly drained areas are in the eastern part. Underdrainage is good in the western part of the county and rather poor in the eastern part. The county drains to the north and northwest, chiefly through Red, Sheyenne, and Maple Rivers.

The highest elevation recorded is 1,204 feet at Buffalo and the lowest is 884 feet at Argusville.

The first permanent settlement was made in 1871. Most of the arable land was homesteaded by 1883. The present population is of various origins, but a large proportion is of Scandinavian descent. The population of the county was 41,477 in 1920. Twenty-one thousand nine hundred and sixty-one were classed as urban and 19,516 as rural. The largest town is Fargo, located at the middle of the eastern border of the county, adjoining Red River.

Several railroads cross the county and furnish good connections with St. Paul and Chicago. The public-road system is good; well-graveled trails cross the county from east to west and from north to south. Other graveled roads are being provided for.

The climate is subhumid. The mean annual rainfall is 20.1 inches; the mean annual temperature is 39.3° F.

The agriculture consists chiefly of the production of small grains, principally wheat. In recent years corn, potatoes, sweet clover, alfalfa, poultry, hogs, and dairy products have become more important. There has been a steady decrease since 1909 in the percentage of farm land devoted to wheat production and a steady increase in the percentage devoted to corn and other crops. Although crop rotation was not practiced during the early days of farming in the county, good rotation practices are rapidly being adopted throughout the county.

The proportion of farms operated by owners in 1920 was 57.7 per cent, by tenants 39.7 per cent, and by managers 2.6 per cent. The average size of the farms was reported as 421.2 acres.

The current selling price of land ranges from about $15 to $125 an acre. The average assessed value in 1920 was $75.62 an acre.

The soils of Cass County fall into four natural divisions, namely, glacial, glacial lake, lake and river terrace, and flood-plain soils. They are grouped in 8 series, which comprise 25 soil types and 5 phases.

The Fargo soils have very dark surface soils and heavy, waxy, calcareous subsoils. The surface drainage is fair or good, but the underdrainage is poor. These soils are extensive in the Red River Valley.

The Barnes soils, including three soil types, occur in the western third of the county. The surface soils are dark brown or black, the subsurface layers are brown, and the subsoils are highly calcareous yellow or olive-yellow material.

The Bearden soils have black surface soils and light grayish-yellow or olive-yellow friable subsoils. Drainage is good. These are good agricultural soils.

The Sioux soils occur on high river and lake terraces and have gravelly subsoils. They are droughty and are not of high agricultural value.

The Pierce series includes one type, of small extent and minor importance. Pierce loam is rolling and is characterized by a gravelly subsoil. It is a droughty soil.

The Maple soils are mapped near sluggish streams and on depressed areas where the first bottoms have not been distinctly formed. The subsoils are very light gray. These soils are not of high agricultural value.

Lamoure loam is a fairly well-drained first-bottom soil but is used largely for pasture.

The Valentine soils are wind formed and drift easily. They have a billowy or hummocky surface. Valentine fine sand has a low value and is used principally for grazing.

PART 2. THE CHEMICAL COMPOSITION OF THE SOILS OF CASS COUNTY [7]

By T. H. HOPPER, *Agricultural Chemist*, and H. L. WALSTER, *Agronomist and Director of Soil Survey, North Dakota Agricultural Experiment Station*

INTRODUCTION

Chemical analyses have been made of soil samples taken from 74 Cass County fields. These samples represent all the soil series, except the Pierce, and 26 of the 30 soil types and phases. Each field was sampled separately for the surface soil, subsurface soil, and subsoil, in such a manner as to avoid all possible contamination of the sample. The sample was a composite of the portion from five separate and equidistant borings. The surface soil is arbitrarily defined as the top layer to a depth of 7 inches, the subsurface as the layer between 7 and 20 inches, and the subsoil as the layer between 20 and 40 inches. From one to nine fields of each soil type were sampled. The larger the extent of the soil the larger was the number of fields sampled.

All samples were analyzed for total nitrogen, phosphorus, calcium, magnesium, silicon, sulphur, total carbon, and carbonate carbon. The moisture was determined by drying at 110° C. to constant weight; the nitrogen was determined by the Gunning-Hibbard method; the phosphorus by the magnesium nitrate method; the calcium, magnesium, silicon, and sulphur by the sodium carbonate fusion method; and the potassium by the J. Lawrence Smith method. The silicon determinations are somewhat high, owing to the necessity of using porcelain and glass in their determination and to the lack of facilities for volatilization of silica to correct for occluded impurities. These methods were taken and adapted from the official and tentative methods of analysis of the Association of Official Agricultural Chemists and from United States Geological Survey Bulletin No. 700, The Analysis of Silicate and Carbonate Rocks by W. F. Hillebrand. The total carbon was determined by the dry oxygen combustion method and the carbonate carbon by liberation with dilute hydrochloric acid, purification, and final absorption by ascarite in an apparatus which was developed in the agricultural chemical laboratory of the North Dakota Agricultural Experiment Station. The details of the methods followed are to be published elsewhere.

All samples were prepared for analysis by being passed over a 20-mesh sieve. Only the fine soil particles passing through the sieve were used for analysis. This fine portion was reduced to pass through a 100-mesh sieve by means of a flint pebble mill and an agate

[7] The soil samples were taken in the field by J. E. Chapman, assistant in soils, and T. H. Hopper, agricultural chemist, North Dakota Agricultural Experiment Station. All chemical analyses were made by the department of agricultural chemistry of the North Dakota Agricultural Experiment Station under the direction of T. H. Hopper, assisted by L. L. Nesbitt and A. J. Pinckney. The tables of chemical composition were prepared by T. H. Hopper.

mortar. The percentage of material not passing through the 20-mesh sieve, by soil types and average for the series, is set forth in Tables 14 and 15. The amounts coarser than 20 mesh are comparatively small in most cases, except in the case of the very gravelly Sioux soils.

The legal description of each of the fields sampled is given in Table 16. By referring to the soil map the reader can locate each area sampled. Maple loam (soil type No. 29) has been mapped as Maple very fine sandy loam (soil type No. 28). As each soil type bore a number instead of a name in the actual field mapping, these numbers are added in parentheses after each soil type. These numbers may be ignored in reading the report.

TABLE 14.—*Portion larger than 20-mesh in surface, subsurface, and subsoil layers of soil types*

Field No.	Soil type	Soil type No.	0 to 7 inches	7 to 20 inches	20 to 40 inches
			Per cent	*Per cent*	*Per cent*
5	Barnes loam	9	2.04	2.86	7.26
6	do	9	2.40	2.53	6.87
20	do	9	1.75	2.32	4.54
23	do	9	2.34	3.50	6.75
24	do	9	6.52	4.25	3.72
29	do	9	2.87	3.27	2.62
44	do	9	5.06	4.50	5.17
45	do	9	1.06	3.44	4.50
52	do	9			
	Average		3.00	3.33	5.18
30	Barnes fine sandy loam	6	.43	.94	1.12
11	Bearden silty clay	51	0	0	0
50	do	51	.21	T.	T.
	Average		T.	T.	T.
1	Bearden silty clay loam	44	T.	1.79	1.20
26	do	44	T.	T.	.10
38	do	44	.13	.29	.18
49	do	44	T.	T.	.56
64	do	44	0	0	0
68	do	44	T.	T.	T.
69	do	44	0	T.	T.
	Average		T.	.30	.29
7	Bearden silt loam	43	T.	T.	T.
15	do	43	T.	T.	T.
	Average		T.	T.	T.
2	Bearden loam	49	2.78	6.78	9.50
18	do	49	3.38	8.49	10.26
32	do	49	1.92	3.28	7.79
46	do	49	T.	1.55	1.05
56	do	49	T.	.90	2.00
	Average		1.62	4.20	6.12
3	Bearden very fine sandy loam	42	.69	1.29	3.01
25	do	42	0	.31	.35
34	do	42	0	T.	.30
36	do	42	.72	1.37	2.24
51	do	42	0	0	0
57	do	42	.87	.85	6.76
58	do	42	0	T.	T.
	Average		.33	.55	1.81
8	Bearden fine sandy loam	40	.67	1.42	2.03
16	do	40	2.70	1.58	5.35
35	do	40	1.40	2.57	10.47
55	do	40	0	.79	1.72
	Average		1.19	1.59	4.89

TABLE 14.—*Portion larger than 20-mesh in surface, subsurface, and subsoil layers of soil types*—Continued

Field No.	Soil type	Soil type No.	0 to 7 inches	7 to 20 inches	20 to 40 inches
			Per cent	*Per cent*	*Per cent*
54	Bearden fine sandy loam, rolling phase	24	1.67	1.00	0.80
31	Bearden fine sand	47	.27	.85	.48
12	Fargo clay	14	0	0	0
33	do	14	0	0	0
60	do	14	0	T.	T.
65	do	14	0	0	T.
66	do	14	0	T.	T.
70	do	14	0	0	0
	Average		0	T.	T.
74	Fargo clay, alkali phase	53	0	0	0
14	Fargo silty clay	15	0	0	0
37	do	15	0	0	0
41	do	15	0	0	0
59	do	15	0	0	0
67	do	15	T.	T.	T.
73	do	15	T.	0	0
	Average		T.	T.	0
13	Fargo silty clay loam	17	T.	0	0
39	do	17	.26	T.	T.
63	do	17	0	0	0
72	do	17	.33	T.	T.
	Average		.15	T.	T.
61	Fargo clay loam	57	.31	.27	T.
9	Fargo silt loam	12	T.	0	T
19	do	12	.35	1.42	4 84
40	do	12	0	0	.19
	Average		.12	.47	2.52
62	Fargo loam	13	T.	0	0
71	do	13	1.62	1.20	2.69
	Average		.81	.60	1.34
10	Fargo very fine sandy loam	18	.25	T.	.18
42	Lamoure loam	20	3.94	3.06	7.48
43	do	20	T.	T.	1.66
	Average		1.97	1.53	4.57
22	Maple silty clay	30	T.	T.	2.38
28	Maple silt loam	27	0	0	0
27	Maple very fine sandy loam	28	0	0	.23
47	do	28	0	0	T.
	Average		0	0	.12
4	Sioux loam	38	20.41	53.69	80.31
17	Sioux fine sandy loam	11	9.72	29.92	53.03
53	Sioux sandy loam	32	17.91	49.36	68.41
48	Valentine fine sand	31	0	T.	T.

TABLE 15.—*Portion larger than 20-mesh in surface, subsurface, and subsoil layers*

[Average by series]

Series	Fields	Types	Surface soil	Subsurface soil	Subsoil
	Number	*Number*	*Per ct.*	*Per ct.*	*Per ct.*
Barnes	10	2	2.72	3.07	4.73
Bearden	29	8	.60	1.21	2.28
Fargo	24	8	.13	.12	.33
Lamoure	2	1	1.97	1.53	4.57
Maple	5	4	.23	.50	.98
Sioux	3	3	16.01	43.99	67.25
Valentine	1	1	0	T.	0

TABLE 16.—*Legal description of fields sampled*

Barnes loam (type No. 9):
- Field No. 5: NE. ¼ NW. ¼ sec. 3, T. 140 N., R. 54 W.
- Field No. 6: NW. ¼ SW. ¼ sec. 22, T. 139 N., R. 54 W.
- Field No. 20: E. ½ sec. 21, T. 141 N., R. 55 W.
- Field No. 23: NW. ¼ NE. ¼ sec. 11, T. 142 N., R. 55 W.
- Field No. 24: SW. ¼ SE. ¼ sec. 1, T. 143 N., R. 54 W.
- Field No. 29: SW. ¼ SW. ¼ sec. 9, T. 142 N., R. 53 W.
- Field No. 44: NW. ¼ SW. ¼ sec. 33, T. 138 N., R. 55 W.
- Field No. 45: SW. ¼ SE. ¼ sec. 24, T. 137 N., R. 55 W.
- Field No. 52: SW. ¼ SW. ¼ sec. 28, T. 138 N., R. 54 W.

Barnes fine sandy loam (type No. 6):
- Field No. 30: SE. ¼ NE. ¼ sec. 33, T. 143 N., R. 53 W.

Bearden silty clay (type No. 51):
- Field No. 11: SE. ¼ SW. ¼ sec. 11, T. 138 N., R. 51 W.
- Field No. 50: SW. ¼ SW. ¼ sec. 22, T. 137 N., R. 51 W.

Bearden silty clay loam (type No. 44):
- Field No. 1: NW. ¼ NW. ¼ sec. 11, T. 140 N., R. 52 W.
- Field No. 26: SW. ¼ SW. ¼ sec. 2, T. 143 N., R. 53 W.
- Field No. 38: NW. ¼ SW. ¼ sec. 5, T. 141 N., R. 50 W.
- Field No. 49: SE. ¼ SE. ¼ sec. 20, T. 137 N., R. 51 W.
- Field No. 64: SE. ¼ SW. ¼ sec. 13, T. 139 N., R. 49 W.
- Field No. 68: NW. ¼ NW. ¼ sec. 21, T. 141 N., R. 51 W.
- Field No. 69: S. ½ NE. ¼ sec. 14, T. 139 N., R. 52 W.

Bearden silt loam (type No. 43):
- Field No. 7: NE. ¼ SE. ¼ sec. 19, T. 139 N., R. 53 W.
- Field No. 15: SW. ¼ SW. ¼ sec. 19, T. 142 N., R. 50 W.

Bearden loam (type No. 49):
- Field No. 2: SW. ¼ SW. ¼ sec. 30, T. 141 N., R. 52 W.
- Field No. 18: SW. ¼ NE. ¼ sec. 9, T. 139 N., R. 53 W.
- Field No. 32: SE. ¼ SW. ¼ sec. 12, T. 143 N., R. 53 W.
- Field No. 46: SE. ¼ SW. ¼ sec. 30, T. 137 N., R. 54 W.
- Field No. 56: SE. ¼ SW. ¼ sec. 30, T. 138 N., R. 53 W.

Bearden very fine sandy loam (type No. 42):
- Field No. 3: SE. ¼ SW. ¼ sec. 26, T. 141 N., R. 53 W.
- Field No. 25: SE. ¼ SE. ¼ sec. 4, T. 143 N., R. 53 W.
- Field No. 34: NW. ¼ NE. ¼ sec. 28, T. 143 N., R. 52 W.
- Field No. 36: SW. ¼ NW. ¼ sec. 20, T. 142 N., R. 52 W.
- Field No. 51: SW. ¼ SE. ¼ sec. 34, T. 137 N., R. 51 W.
- Field No. 57: NW. ¼ SW. ¼ sec. 33, T. 138 N., R. 53 W.
- Field No. 58: NW. ¼ NW. ¼ sec. 10, T. 137 N., R. 53 W.

Bearden fine sandy loam (type No. 40):
- Field No. 8: NW. ¼ NW. ¼ sec. 10, T. 141 N., R. 53 W.
- Field No. 16: NW. ¼ NW. ¼ sec. 30, T. 140 N., R. 53 W.
- Field No. 35: W. ½ NW. ¼ sec. 29, T. 143 N., R. 52 W.
- Field No. 55: NW. ¼ NE. ¼ sec. 36, T. 138 N., R. 54 W.

Bearden fine sandy loam, rolling phase (type No. 24):
- Field No. 54: SW. ¼ SW. ¼ sec. 35, T. 138 N., R. 54 W.

Bearden fine sand (type No. 47):
- Field No. 31: NW. ¼ NE. ¼ sec. 27, T. 143 N., R. 53 W.

Fargo clay (type No. 14):
- Field No. 12: SE. ¼ SE. ¼ sec. 13, T. 138 N., R. 51 W.
- Field No. 33: SW. ¼ SW. ¼ sec. 12, T. 143 N., R. 52 W.
- Field No. 60: W. ½ NW. ¼ sec. 17, T. 137 N., R. 49 W.
- Field No. 65: SE. ¼ SE. ¼ sec. 20, T. 143 N., R. 49 W.
- Field No. 66: S. ½ SW. ¼ sec. 9, T. 143 N., R. 49 W.
- Field No. 70: Center NE. ¼ sec. 6, T. 139 N., R. 52 W.

Fargo clay, alkali phase (type No. 53):
- Field No. 74: SW. ¼ NW. ¼ sec. 26, T. 140 N., R. 49 W.

Fargo silty clay (type No. 15):
- Field No. 14: SE. ¼ SE. ¼ sec. 24, T. 139 N., R. 49 W.
- Field No. 37: SW. ¼ SE. ¼ sec. 36, T. 142 N., R. 50 W.
- Field No. 41: NW. ¼ NW. ¼ sec. 14, T. 143 N., R. 51 W.

TABLE 16.—*Legal description of fields sampled*—Continued

Fargo silty clay—Continued.
- Field No. 59: E. ½ SE. ¼ sec. 27, T. 137 N., R. 49 W.
- Field No. 67: NW. ¼ NW. ¼ sec. 31, T. 143 N., R. 50 W.
- Field No. 73: SE. ¼ SE. ¼ sec. 13, T. 140 N., R. 49 W.

Fargo silty clay loam (type No. 17):
- Field No. 13: SE. ¼ SW. ¼ sec. 24, T. 139 N., R. 50 W.
- Field No. 39: SE. ¼ NE. ¼ sec. 30, T. 142 N., R. 51 W.
- Field No. 63: SW. ¼ NW. ¼ sec. 2, T. 138 N., R. 49 W.
- Field No. 72: SE. ¼ sec. 9, T. 140 N., R. 52 W.

Fargo clay loam (type No. 57):
- Field No. 61: Middle N. ½ sec. 18, T. 137 N., R. 49 W.

Fargo silt loam (type No. 12):
- Field No. 9: NE. ¼ SE. ¼ sec. 15, T. 141 N., R. 52 W.
- Field No. 19: SE. ¼ NW. ¼ sec. 13, T. 140 N., R. 55 W.
- Field No. 40: NE. ¼ SE. ¼ sec. 8, T. 142 N., R. 51 W.

Fargo loam (type No. 13):
- Field No. 62: NE. ¼ NW. ¼ sec. 32, T. 138 N., R. 49 W.
- Field No. 71: NE. ¼ NW. ¼ sec. 32, T. 141 N., R. 52 W.

Fargo very fine sandy loam (type No. 18):
- Field No. 10: SW. ¼ SE. ¼ sec. 34, T. 142 N., R. 52 W.

Lamoure loam (type No. 20):
- Field No. 42: SW. ¼ SE. ¼ sec. 22, T. 140 N., R. 55 W.
- Field No. 43: NE. ¼ NW. ¼ sec. 22, T. 138 N., R. 55 W.

Maple silty clay (type No. 30):
- Field No. 22: SE. ¼ SE. ¼ sec. 4, T. 142 N., R. 55 W.

Maple silt loam (type No. 27):
- Field No. 28: NE. ¼ NW. ¼ sec. 26, T. 143 N., R. 53 W.

Maple very fine sandy loam (type No. 28):
- Field No. 27: NW. ¼ NE. ¼ sec. 26, T. 143 N., R. 53 W.
- Field No. 47: NW. ¼ NW. ¼ sec. 32, T. 137 N., R. 52 W.

Sioux loam (type No. 38):
- Field No. 4: NW. ¼ NW. ¼ sec. 36, T. 140 N., R. 54 W.

Sioux fine sandy loam (type No. 11):
- Field No. 17: S. ½ SE. ¼ of SE. ¼ sec. 29, T. 140 N., R. 53 W.

Sioux sandy loam (type No. 32):
- Field No. 53: NW. ¼ NE. ¼ sec. 3, T. 137 N., R. 54 W.

Valentine fine sand (type No. 31):
- Field No. 48: SE. ¼ SW. ¼ sec. 36, T. 137 N., R. 52 W.

METHOD OF REPORTING ANALYSES

All analyses are reported as percentages of the moisture-free soil. No attempt has been made to convert these percentages to pounds per acre because the writers feel certain that not enough is known about the relative volume weights of these various types of soils to warrant the common, more or less arbitrary, assumptions. All fields sampled have been carefully located so that at some future time it may be possible to make volume weight determinations on special samples to be obtained for that purpose. The analyses are calculated and reported as percentage of the elements determined rather than as percentage of oxides. The analyses are presented in Table 17.

DISCUSSION OF CHEMICAL ANALYSIS

In the discussion which follows, only the average analyses for each soil type will be given in full. Reference will be made to those fields whose analyses depart from the average in any considerable degree.

TABLE 17.—*Composition of Cass County soils (dry basis)*

Field No.	Total nitrogen			Total phosphorus			Total potassium	Total calcium			Total magnesium		
	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
BARNES LOAM (TYPE NO. 9)													
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5	0.366	0.157	0.040	0.0568	0.0483	0.0565	1.760	1.45	2.98	7.15	0.591	0.836	1.700
6	.303	.132	.055	.0591	.0389	.0474	1.335	1.35	2.10	7.21	.566	.709	1.481
20	.356	.162	.055	.0640	.0475	.0458	1.505	1.27	2.17	6.60	.531	.792	1.696
23	.355	.143	.076	.0664	.0515	.0493	1.371	1.45	5.75	7.00	.609	1.061	1.917
24	.221	.099	.053	.0517	.0376	.0369	1.335	1.15	1.20	4.07	.447	.578	1.147
29	.226	.110	.051	.0595	.0420	.0506	1.292	1.17	1.14	3.85	.611	.469	.991
44	.425	.166	.056	.0691	.0522	.0478	1.352	2.78	8.02	8.04	.847	1.369	2.020
45	.336	.205	.088	.0634	.0512	.0474	1.170	1.31	1.24	4.73	.585	.613	1.393
52	.320	.156	.074	.0641	.0480	.0449	1.234	1.50	2.68	4.46	.545	.702	1.166
Average	.323	.148	.061	.0616	.0464	.0474	1,374	1.49	3.03	5.90	.592	.792	1.501
BARNES FINE SANDY LOAM (TYPE NO. 6)													
30	0.349	0.118	0.048	0.0757	0.0462	0.0376	1.296	1.18	0.95	0.99	0.413	0.386	0.420
BEARDEN SILTY CLAY (TYPE NO. 51)													
11	0.311	0.144	0.062	0.0713	0.0646	0.0622	1.630	1.23	2.61	5.75	0.829	1.043	1.772
50	.284	.132	.071	.0601	.0514	.0622	1.424	1.60	5.45	5.51	.826	1.047	1.788
Average	.298	.138	.067	.0657	.0580	.0622	1.527	1.42	4.03	5.63	.828	1.045	1.780
BEARDEN SILTY CLAY LOAM (TYPE NO. 44)													
1	0.239	0.094	0.050	0.0621	0.0420	0.0674	1.431	1.23	1.46	5.80	0.578	0.776	1.897
26	.335	.125	.036	.0705	.0582	.0498	1.338	2.20	9.54	8.46	.833	1.050	.795
38	.242	.105	.049	.0613	.0524	.0644	1.644	1.21	4.07	7.50	.632	1.537	3.076
49	.281	.092	.047	.0681	.0602	.0663	1.289	2.69	3.46	7.31	.751	.845	1.882
64	.304	.166	.079	.0679	.0636	.0609	1.784	2.00	5.25	6.34	1.106	1.770	2.374
68	.200	.094	.040	.0565	.0562	.0762	1.535	1.39	2.43	5.60	.636	.920	1.817
69	.307	.167	.065	.0638	.0597	.0634	1.531	1.19	1.65	5.92	.763	.921	2.092
Average	.273	.120	.052	.0643	.0560	.0641	1.507	1.70	3.98	6.70	.757	1.117	1.990
BEARDEN SILT LOAM (TYPE NO. 43)													
7	0.267	0.125	0.060	0.0566	0.0497	0.0575	1.542	1.30	2.06	6.13	0.551	0.743	1.393
15	.246	.127	.047	.0630	.0605	.0667	1.351	1.36	3.06	7.53	.620	.984	2.556
Average	.256	.126	.054	.0598	.0551	.0621	1.446	1.33	2.56	6.83	.586	.864	1.974
BEARDEN LOAM (TYPE NO. 49)													
2	0.266	0.098	0.054	0.0458	0.0339	0.0451	1.439	1.21	2.41	8.92	0.502	0.802	1.616
18	.302	.134	.056	.0524	.0479	.0453	1.258	1.25	1.78	7.96	.536	.680	1.657
32	.238	.109	.047	.0447	.0373	.0432	1.427	1.20	2.15	5.45	.572	.703	1.405
46	.173	.072	.024	.0494	.0376	.0332	1.194	1.02	1.04	1.22	.386	.432	.374
56	.173	.086	.049	.0385	.0356	.0514	1.370	1.25	1.47	7.46	.410	.498	1.595
Average	.230	.100	.046	.0462	.0385	.0436	1.338	1.19	1.77	6.20	.481	.623	1.329

TABLE 17.—*Composition of Cass County soils (dry basis)*—Continued

Field No.	Total nitrogen			Total phosphorus			Total potassium	Total calcium			Total magnesium		
	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
BEARDEN VERY FINE SANDY LOAM (TYPE NO. 42)													
3	0.174	0.076	0.033	0.0533	0.0410	0.0586	1.628	1.30	1.36	4.57	0.392	0.422	0.972
25	.143	.077	.034	.0427	.0392	.0365	1.273	1.20	1.39	2.36	.378	.396	.571
34	.139	.072	.028	.0336	.0282	.0273	1.743	1.09	1.05	1.14	.376	.402	.394
36	.176	.067	.042	.0349	.0250	.0358	.988	1.12	1.03	4.24	.405	.522	.607
51	.393	.204	.053	.0816	.0709	.0522	1.112	2.04	4.09	4.24	1.137	1.001	.656
57	.141	.089	.040	.0407	.0376	.0426	1.211	1.14	1.40	3.84	.380	.449	.785
58	.133	.078	.031	.0383	.0350	.0349	1.293	1.10	1.43	1.35	.356	.356	.367
Average	.186	.095	.037	.0464	.0396	.0411	1.321	1.28	1.68	3.11	.489	.507	.622
BEARDEN FINE SANDY LOAM (TYPE NO. 40)													
8	0.146	0.070	0.025	0.0440	0.0346	0.0286	1.382	1.25	1.03	1.01	0.352	0.350	0.353
16	.108	.050	.018	.0534	.0279	.0363	1.222	1.22	1.98	3.10	.375	.420	.626
35	.258	.108	.033	.0450	.0283	.0298	1.268	1.10	.95	2.15	.396	.344	.573
55	.245	.113	.045	.0495	.0394	.0483	1.230	2.58	7.44	7.42	.579	.711	1.360
Average	.189	.085	.030	.0480	.0326	.0358	1.276	1.54	2.85	3.42	.426	.456	.728
BEARDEN FINE SANDY LOAM, ROLLING PHASE (TYPE NO. 24)													
54	0.366	0.203	0.061	0.0605	0.0570	0.0591	1.352	1.92	5.12	6.71	0.547	0.956	1.578
BEARDEN FINE SAND (TYPE NO. 47)													
31	0.199	0.113	0.050	0.0472	0.0379	0.0398	1.386	1.14	1.06	2.66	0.384	0.399	0.727
FARGO CLAY (TYPE NO. 14)													
12	0.382	0.162	0.111	0.0702	0.0561	0.0618	1.708	1.44	2.83	4.87	1.152	1.504	1.710
33	.300	.160	.089	.0565	.0487	.0480	1.620	1.40	3.63	5.78	1.136	1.429	1.783
60	.297	.137	.078	.0675	.0609	.0554	1.704	1.61	4.64	6.12	1.055	1.498	1.753
65	.324	.184	.111	.0749	.0690	.0660	1.830	1.50	3.01	5.30	1.244	1.604	2.086
66	.337	.134	.075	.0643	.0598	.0517	1.807	1.00	1.10	3.35	.929	1.274	1.782
70	.305	.177	.104	.0609	.0509	.0530	1.622	1.22	2.04	4.05	1.015	1.364	1.677
Average	.324	.159	.095	.0657	.0560	.0560	1.715	1.36	2.82	4.91	1.089	1.446	1.766
FARGO CLAY, ALKALI PHASE (TYPE NO. 53)													
74	0.389	0.172	0.075	0.0655	0.0540	0.0522	1.680	1.04	2.16	5.99	0.928	1.489	2.137
FARGO SILTY CLAY (TYPE NO. 15)													
14	0.290	0.143	0.088	0.0580	0.0470	0.0555	1.703	0.95	1.86	5.41	0.901	1.319	2.030
37	.288	.134	.090	.0550	.0474	.0562	1.765	1.16	2.29	4.21	.986	1.557	1.893
41	.367	.193	.111	.0704	.0572	.0535	2.057	1.34	2.34	4.78	1.043	1.272	1.643
59	.351	.129	.068	.0706	.0633	.0586	1.659	1.55	4.76	6.76	.888	1.563	2.279
67	.357	.174	.107	.0556	.0619	.0512	1.786	1.04	2.62	6.22	1.065	1.309	1.735
73	.384	.196	.097	.0737	.0492	.0531	1.800	1.09	1.25	4.21	.882	1.345	1.818
Average	.340	.162	.094	.0639	.0543	.0547	1.795	1.19	2.52	5.26	.961	1.394	1.900

Table 17.—*Composition of Cass County soil (dry basis)*—Continued

Field No.	Total nitrogen			Total phosphorus			Total potassium	Total calcium			Total magnesium		
	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
FARGO SILTY CLAY LOAM (TYPE NO. 17)													
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
13	0. 339	0. 138	0. 062	0. 0786	0. 0601	0. 0576	1. 499	2. 59	7. 10	6. 41	1. 248	2. 024	2. 443
39	. 278	. 152	. 083	. 0565	. 0471	. 0466	1. 687	1. 04	1. 57	3. 12	. 648	1. 061	1. 439
63	. 389	. 179	. 090	. 0722	. 0558	. 0561	1. 505	1. 17	2. 44	5. 18	. 900	1. 356	2. 072
72	. 238	. 102	. 070	. 0504	. 0304	. 0515	1. 499	1. 00	. 82	2. 82	. 617	. 714	1, 594
Average	. 311	. 143	. 076	. 0644	. 0484	. 0530	1. 548	1. 45	2. 98	4. 38	. 853	1. 289	1. 887
FARGO CLAY LOAM (TYPE NO. 57)													
61	0. 331	0. 185	0. 080	0. 0656	0. 0540	0. 0597	1. 481	1. 10	2. 72	5. 65	0. 959	1. 166	1. 671
FARGO SILT LOAM (TYPE NO. 12)													
9	0. 278	0. 147	0. 074	0. 0593	0. 0555	0. 0541	1. 520	1. 08	1. 95	5. 52	0. 696	1. 284	1. 809
19	. 588	. 117	. 034	. 0827	. 0668	. 0476	1, 218	4. 01	5. 64	3. 46	1. 042	. 911	1. 093
40	. 226	. 093	. 044	. 0535	. 0322	. 0378	1. 399	1. 10	. 92	1. 59	. 428	. 454	. 759
Average	. 364	. 119	. 051	. 0652	. 0515	. 0465	1. 379	. 06	2. 84	3. 51	. 722	. 883	1. 220
FARGO LOAM (TYPE NO. 13)													
62	0. 245	0. 111	0. 060	0. 0600	0. 0520	0. 5620	1. 468	1. 30	2. 66	5. 71	0. 708	0. 963	1. 659
71	. 317	. 157	. 061	. 0578	0. 464	. 0421	J. 352	1. 45	5. 96	12. 42	. 671	. 989	1. 995
Average	. 281	. 134	. 061	. 0589	. 0492	0492.	1. 410	1. 38	4. 31	9. 07	. 690	. 976	1. 827
FARGO VERY FINE SANDY LOAM (TYPE NO. 18)													
10	0. 168	0. 061	0. 042	0. 0502	0. 0534	0. 0533	1. 330	1. 22	2. 17	4. 89	0. 393	1. 460	1. 533
LAMOURE LOAM (TYPE NO. 20)													
42	0. 298	0. 177	0. 092	0. 0651	0. 0580	0. 0531	1. 317	1. 96	3. 78	7. 67	0. 775	1. 183	1. 897
43	. 406	. 215	. 136	. 0837	. 0696	. 0606	1. 220	1. 88	2. 34	2. 95	. 793	. 919	. 987
Average	. 352	. 196	. 114	. 0744	. 0638	. 0568	1. 268	1. 92	3. 05	5. 31	. 784	1. 051	1. 442
MAPLE SILTY CLAY (TYPE NO. 30)													
22	0. 629	0. 150	0. 040	0. 0803	0. 0510	0. 0572	1. 232	4. 24	9. 67	9. 37	1. 108	1. 307	1. 646
MAPLE SILT LOAM (TYPE NO. 27)													
28	0. 930	0. 343	0. 068	0. 1112	0. 0674	0. 0394	0. 577	11. 76	14. 68	5. 62	2. 382	1. 078	0. 530
MAPLE VERY FINE SANDY LOAM (TYPE NO. 28)													
27	0. 330	0. 067	0. 023	0. 0743	0. 0484	0. 0477	1. 545	1. 88	1. 97	2. 91	1. 144	0. 665	0. 826
47	. 319	. 057	. 023	. 0460	. 0330	. 0408	1. 117	1. 34	1. 95	2. 96	. 434	. 438	554
Average	. 324	. 062	. 023	. 0602	. 0407	. 0442	1. 331	1. 61	1. 96	2. 94	. 789	. 552	. 690

TABLE 17.—*Composition of Cass County soils (dry basis)*—Continued

SIOUX LOAM (TYPE NO. 38)

Field No.	Total nitrogen			Total phosphorus			Total potassium	Total calcium			Total magnesium		
	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4	0.336	0.197	0.030	0.0650	0.0664	0.0391	1.046	1.33	2.36	7.40	0.503	0.792	1.609

SIOUX FINE SANDY LOAM (TYPE NO. 11)

17	0.218	0.109	0.031	0.0554	0.0418	0.0394	1.316	1.16	1.24	3.68	0.407	0.517	0.989

SIOUX SANDY LOAM (TYPE NO. 32)

53	0.265	0.181	0.019	0.0584	0.0584	0.0272	1.305	1.46	5.19	6.59	0.468	1.086	1.297

VALENTINE FINE SAND (TYPE NO. 31)

48	0.096	0.076	0.053	0.0338	0.0371	0.0375	1.216	1.00	1.52	2.24	0.299	0.383	0.299

BARNES LOAM (TYPE NO. 9)

Field No.	Total sulphur			Total silicon			Organic carbon			Carbonate carbon		
	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5	0.0796	0.1371	0.8408	36.16	33.39	29.32	4.206	1.732	0.472	0.056	0.657	2.109
6	.0636	.0581	.1756	34.81	35.06	29.81	3.705	1.475	.620	.011	.290	2.191
20	.0773	.2107	.4984	34.69	34.41	29.45	4.318	1.813	.594	.030	.325	1.980
23	.0787	.1909	.9519	34.20	30.99	28.53	4.303	1.558	.872	.054	1.526	1.943
24	.0608	.0512	.0298	35.73	36.49	32.98	2.595	1.036	.544	.016	.076	1.284
29	.0459	.0571	.0325	36.33	35.61	34.12	3.088	1.159	.545	.026	.064	.994
44	.0811	.4146	.3468	31.62	27.16	27.32	4.959	1.893	.581	.480	2.316	2.773
45	.0802	.0543	.0411	34.27	35.33	31.80	4.359	2.669	1.014	.020	.028	1.559
52	.0684	.0532	.0479	34.24	33.93	32.17	3.585	1.990	.814	.557	.587	1.353
Average	.0706	.1364	.3294	34.67	33.60	30.61	3.902	1.703	.673	.139	.652	1.798

BARNES FINE SANDY LOAM (TYPE NO. 6)

30	0.0833	0.0328	0.0420	35.14	37.46	38.10	4.256	1.269	0.473	0.007	0.003	0.006

BEARDEN SILTY CLAY (TYPE NO. 51)

11	0.0598	0.0114	0.0145	32.17	31.28	28.27	4.153	1.726	0.625	0.016	0.623	1.989
50	.1467	.3889	.2117	32.25	31.87	28.74	3.500	1.658	.757	.163	.349	1.746
Average	.1032	.2002	.1131	32.21	31.58	28.51	3.826	1.692	.691	.090	.486	1.868

TABLE 17.—*Composition of Cass County soils (dry basis)*—Continued

Field No.	Total sulphur			Total silicon			Organic carbon			Carbonate carbon		
	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
BEARDEN SILTY CLAY LOAM (TYPE NO. 44)												
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1	0.0724	0.0549	0.0829	35.04	35.61	29.57	2.944	1.123	0.562	0.022	0.194	2.054
26	.1124	.1199	.0739	32.87	27.15	30.29	3.802	1.395	.422	.268	2.680	2.384
38	.0486	.0281	.0351	34.54	31.29	25.65	2.975	1.223	.568	.029	1.312	3.164
49	.1272	.0956	.1124	33.08	33.53	28.19	3.381	1.089	.517	.456	.814	2.525
64	.0893	.0462	.0508	31.11	28.06	25.52	3.786	1.936	.845	.297	1.766	2.388
68	.0592	.0410	.0475	35.64	34.85	30.70	2.554	1.130	.461	.093	.591	2.045
69	.0703	.0597	.0493	33.13	33.46	28.14	4.030	2.184	.727	.017	.218	2.264
Average	.0282	.0636	.0646	33.63	31.99	28.29	3.353	1.440	.586	.169	1.082	2.403
BEARDEN SILT LOAM (TYPE NO. 43)												
7	0.0596	0.0644	0.1155	34.63	34.57	30.14	3.335	1.447	0.719	0.010	0.284	1.807
15	.0352	.0180	.0241	35.36	33.77	27.62	3.109	1.510	.601	.043	.795	2.845
Average	.0474	.0412	.0698	35.00	34.17	28.88	3.222	1.479	.660	.026	.540	2.326
BEARDEN LOAM (TYPE NO. 49)												
2	0.0743	0.0861	0.6842	35.54	34.93	26.94	2.991	1.057	0.564	0.010	0.501	2.702
18	.0636	.0943	.7678	35.28	35.83	28.19	3.782	1.601	.646	.017	.233	2.419
32	.0745	.1297	.8573	35.36	34.99	30.79	3.040	1.281	.504	.017	.336	1.396
46	.0441	.0624	.0531	37.49	37.90	40.12	2.097	.727	.266	.006	.002	.156
56	.0976	.0545	.4146	37.27	39.75	28.97	2.165	1.000	536	.016	.106	2.196
Average	.0708	.0854	.5554	36.18	36.68	31.00	2.815	1.133	.503	.013	.236	1.774
BEARDEN VERY FINE SANDY LOAM (TYPE NO. 42)												
3	0.0528	0.0509	0.0511	37.16	37.74	34.26	1.986	0.814	0.392	0.014	0.063	1.281
25	.0345	.0254	.0317	37.30	37.78	36.49	1.729	.916	.363	.006	.080	.489
34	.0326	.0322	.0148	37.39	38.12	38.34	1.574	.798	.279	.006	.018	.059
36	.0427	.0425	.6198	36.96	37.59	32.82	2.121	.766	.389	.008	.010	.950
51	.0935	.0715	.0504	33.46	33.13	34.96	4.619	2.471	.690	.265	1.017	1.097
57	.0473	.0415	.0365	37.72	37.62	35.00	1.661	1.036	.468	.009	.121	.999
58	.0588	.0563	.0311	38.20	38.57	38.84	1.631	.953	.346	.010	.117	.113
Average	.0517	.0458	.1193	36.88	37.22	35.82	2.189	1.108	.418	.045	.204	.713
BEARDEN FINE SANDY LOAM (TYPE NO. 40)												
8	0.0351	0.0503	0.0394	38.00	38.94	39.88	1.730	0.761	0.264	0.010	0.004	0.006
16	.0255	.0952	.3384	38.38	38.01	36.62	1.253	.550	.212	.026	.296	.640
35	.0569	.0724	.0298	36.59	38.22	37.61	3.177	1.303	.359	.008	.002	.463
55	.1871	1.9474	.3502	35.43	32.51	29.68	2.701	1.219	.571	.405	1.356	2.268
Average	.0762	.5413	.1894	37.10	36.92	35.95	2.215	.958	.352	.112	.414	.844
BEARDEN FINE SANDY LOAM, ROLLING PHASE (TYPE NO. 24)												
54	0.0610	0.1648	0.7215	33.69	31.01	29.57	4.285	2.221	0.743	0.196	1.437	1.944
BEARDEN FINE SAND (TYPE NO. 47)												
31	0.0674	0.0560	0.0430	37.30	37.94	35.95	2.330	1.260	0.506	0.013	0.016	0.686

TABLE 17.—*Composition of Cass County soils (dry basis)*—Continued

FARGO CLAY (TYPE NO. 14)

Field No.	Total sulphur			Total silicon			Organic carbon			Carbonate carbon		
	Surfrce	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12	0.0749	0.0353	0.1508	28.26	27.17	25.46	4.629	1.948	1.295	0.063	0.595	1.363
33	.0530	.0227	.0284	27.60	27.40	25.53	3.784	1.838	.945	.097	.908	1.738
60	.0777	.0496	.0532	29.56	26.68	25.21	3.684	1.524	.809	.140	1.223	1.904
65	.0584	.0426	.0355	31.46	28.28	26.18	4.166	2.291	1.309	.138	.872	1.879
66	.0569	.0600	.0655	31.59	31.58	29.10	3.919	1.459	.811	.018	.119	1.086
70	.0648	.0478	.0551	28.86	28.45	26.32	4.177	2.319	1.228	.017	.315	1.093
Average	.0643	.0430	.0648	29.56	28.26	26.30	4.060	1.896	1.066	.079	.672	1.510

FARGO CLAY, ALKALI PHASE (TYPE NO. 53)

74	0.0853	0.1049	0.2087	30.93	29.70	25.84	5.088	2.167	0.772	0.015	0.487	2.053

FARGO SILTY CLAY (TYPE NO. 15)

14	0.0654	0.0329	0.2056	31.88	30.46	26.43	3.678	1.691	0.960	0.008	0.444	1.799
37	.0873	.0361	.0596	30.94	29.28	27.60	3.608	1.496	.951	.040	.602	1.407
41	.0812	.0462	.0409	29.13	28.78	27.01	4.694	2.339	1.265	.009	.437	1.378
59	.0797	.0604	.0514	31.58	28.56	25:12	4.277	1.534	.645	.107	1.505	2.457
67	.0634	.0452	.0513	30.34	28.79	25.72	4.518	1.951	1.114	.011	.647	1.968
73	.0503	.0640	.0472	29.48	29.80	27.38	4.736	2.205	.997	.010	.076	1.302
Average	.0712	.0475	.0760	30.56	29.28	26.54	4.252	1.869	.989	.031	.618	1.718

FARGO SILTY CLAY LOAM (TYPE NO. 17)

13	0.1072	0.0347	0.0788	30.57	26.61	26.03	4.126	1.719	0.601	0.507	2.414	2.495
39	.0607	.0313	.0303	33.23	31.12	29.36	3.414	1.793	.902	.012	.256	.823
63	.0697	.0698	.1530	31.11	29.97	26.34	5.111	2.148	.998	.019	.687	1.750
72	.0817	.0572	.0464	33.98	34.83	28.84	2.947	1.119	.699	.011	.005	.853
Average	.0798	.0482	.0771	32.22	30.63	27.64	3.900	1.695	.800	.137	.840	1.480

FARGO CLAY LOAM (TYPE NO. 57)

61	0.0538	0.0319	0.0244	30.13	29.18	25.65	4.309	2.283	0.834	0.024	0.597	1.788

FARGO SILT LOAM (TYPE NO. 12)

9	0.0583	0.0914	0.3922	33.57	30.88	25.49	3.640	1.654	0.751	0.0	0.370	1.695
19	.1169	.0711	.0570	29.36	30.82	33.44	6.287	1.200	.303	.910	1.589	1.132
40	.0729	.0141	.0223	35.94	36.81	35.40	2.642	1.027	.476	.0	.0	.231
Average	.0827	.0589	.1572	32.96	32.84	31.44	4.190	1.294	.510	.303	.653	1.019

FARGO LOAM (TYPE NO. 13)

62	0.0395	0.0310	0.3030	33.86	33.34	27.54	3.018	1.188	0.576	0.073	0.628	1.755
71	.0978	1.4337	3.9442	33.63	29.05	46.32	3.883	1.747	.681	.087	1.169	2.534
Average	.0386	.7324	2.1236	33.75	31.20	36.93	3.450	1.468	.628	.080	.898	2.144

FARGO VERY FINE SANDY LOAM (TYPE NO. 18)

10	0.0297	0.0255	0.0708	36.41	36.21	30.72	2.009	0.673	0.425	0.009	0.381	1.582

TABLE 17.—*Composition of Cass County soils (dry basis)*—Continued

LAMOURE LOAM (TYPE NO. 20)

Field No.	Total sulphur			Total silicon			Organic carbon			Carbonate carbon		
	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
42	0.0870	0.0904	0.1020	33.42	31.67	27.33	3.924	2.099	1.147	0.240	0.990	2.455
43	.0861	.0720	.0666	32.94	34.09	35.06	4.777	2.444	1.598	.258	.494	.784
Average	.0866	.0812	.0843	33.18	32.88	31.20	4.350	2.272	1.372	.249	.742	1.620

MAPLE SILTY CLAY (TYPE NO. 30)

22	0.5032	2.0528	1.7545	27.76	24.85	26.48	7.234	1.706	0.530	0.549	2.128	2.366

MAPLE SILT LOAM (TYPE NO. 27)

28	0.1499	0.1002	0.0389	19.10	21.64	34.08	10.168	4.113	0.762	3.203	4.203	1.457

MAPLE VERY FINE SANDY LOAM (TYPE NO. 28)

27	0.0807	0.0302	0.0318	35.07	37.39	36.73	3.441	0.802	0.254	0.195	0.305	0.616
47	.1365	.0699	.0796	36.51	37.91	36.70	3.443	1.657	.267	.048	.299	.695
Average	.1086	.0500	0.557	35.79	37.65	36.72	3.442	1.230	.260	.122	.302	.656

SIOUX LOAM (TYPE NO. 38)

4	0.0703	0.0735	0.0447	35.17	35.14	29.60	3.982	2.011	0.319	0.031	0.503	2.530

SIOUX FINE SANDY LOAM (TYPE NO. 11)

17	0.0609	0.0338	0.0319	36.83	37.40	35.13	2.699	1.201	0.289	0.015	0.148	1.229

SIOUX SANDY LOAM (TYPE NO. 32)

53	0.0893	0.0570	0.0426	36.05	32.30	32.13	3.141	1.741	0.167	0.050	1.569	2.204

VALENTINE FINE SAND (TYPE NO. 31)

48	0.0440	0.0526	0.0593	39.41	38.73	37.69	1.100	0.821	0.641	0.026	0.188	0.452

BARNES LOAM (TYPE NO. 9)

Field No.	Calcium-magnesium ratio (Ca/Mg)			Lime ($CaCO_3$) equivalent of calcium			Lime ($CaCO_3$) equivalent of carbonate carbon			Lime equivalent of calcium minus lime equivalent of carbonate carbon		
	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
5	2.45	3.56	4.21	3.62	7.44	17.86	0.47	5.48	17.57	+3.15	+1.96	+0.29
6	2.39	2.96	4.87	3.37	5.24	18.01	.09	2.42	18.26	+3.28	+2.82	−.25
20	2.39	2.74	3.89	3.17	5.42	16.48	.25	2.71	16.50	+2.92	+2.71	−.02
23	2.38	5.42	3.65	3.62	14.36	17.48	.45	12.72	16.19	+3.17	+1.64	+1.29
24	2.57	2.08	3.55	2.87	3.00	10.16	.13	.63	10.70	+2.74	+2.37	−.54
29	1.91	2.43	3.88	2.92	2.85	9.61	.22	.53	8.28	+2.70	+2.32	+1.33
44	3.28	5.86	3.98	6.94	20.03	20.08	4.00	19.30	23.11	+2.94	+.73	−3.03
45	2.24	2.02	3.40	3.27	3.10	11.81	.17	.23	12.99	+3.10	+2.87	−1.18
52	2.75	3.82	3.83	3.75	6.69	11.14	4.64	4.89	11.28	−.89	+1.80	−.14
Average	2.48	3.43	3.92	3.73	7.57	14.74	1.16	5.43	14.99	+2.57	+2.14	−.25

TABLE 17.—*Composition of Cass County soils (dry basis)*—Continued

Field No.	Calcium-magnesium ratio (Ca/Mg)			Lime ($CaCO_3$) equivalent of calcium			Lime ($CaCO_3$) equivalent of carbonate carbon			Lime equivalent of calcium minus lime equivalent of carbonate carbon		
	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
BARNES FINE SANDY LOAM (TYPE NO. 6)												
30	2.86	2.46	2.36	2.95	2.37	2.47	0.06	0.02	0.05	+2.89	+2.35	+2.42
BEARDEN SILTY CLAY (TYPE NO. 51)												
11	1.48	2.50	3.24	3.07	6.52	14.36	0.13	5.19	16.57	+2.94	+1.33	−2.21
51	1.93	5.21	3.08	4.00	13.61	13.76	1.36	2.91	14.55	+2.64	+10.70	−.79
Average	1.70	3.85	3.16	3.54	10.06	14.06	.75	4.05	15.56	+2.79	+6.01	−1.50
BEARDEN SILTY CLAY LOAM (TYPE NO. 44)												
1	2.13	1.88	3.06	3.07	3.65	14.48	0.18	1.62	17.12	+2.89	+2.03	−2.64
26	2.64	9.09	10.64	5.49	23.83	21.13	2.23	22.33	19.87	+3.26	+1.50	+1.26
38	1.91	2.65	2.44	3.02	10.16	18.73	.24	10.93	26.37	+2.78	−.77	−7.64
49	3.58	4.09	3.88	6.72	8.64	18.26	3.80	6.78	21.04	+2.92	+1.86	−2.78
64	1.81	2.97	2.67	4.99	13.11	15.83	2.48	14.72	19.90	+2.51	−1.61	−4.07
68	2.19	2.64	3.08	3.47	6.07	13.98	.78	4.92	17.04	+2.69	+1.15	−3.06
69	1.56	1.79	2.83	2.97	4.12	14.78	.14	1.82	18.87	+2.83	+2.30	−4.09
Average	2.26	3.59	4.09	4.25	9.94	16.88	1.41	9.02	20.03	+2.84	+.92	−3.26
BEARDEN SILT LOAM (TYPE NO. 43)												
7	2.36	2.77	4.40	3.25	5.14	15.31	0.08	2.37	15.06	+3.17	+2.77	+0.25
15	2.19	3.11	2.95	3.40	7.64	18.81	.36	6.62	23.71	+3.04	+1.02	−4.90
Average	2.28	2.94	3.68	3.32	6.39	17.06	.22	4.50	19.38	+3.10	+1.89	−2.32
BEARDEN LOAM (TYPE NO. 49)												
2	2.41	3.00	5.52	3.02	6.02	22.28	0.08	4.18	22.52	+2.94	+1.84	−0.24
18	2.33	2.62	4.80	3.12	4.44	19.88	.14	1.94	20.16	+2.98	+2.50	−.27
32	2.10	3.06	3.88	3.00	5.37	13.61	.14	2.80	11.63	+2.86	+2.57	+1.98
46	2.64	2.41	3.26	2.55	2.60	3.05	.05	.02	1.30	+2.50	+2.58	+1.75
56	3.05	2.95	4.68	3.12	3.67	18.63	.13	.88	18.30	+2.99	+2.79	+.33
Average	2.51	2.81	4.43	2.96	4.42	15.49	.11	1.96	14.78	+2.85	+2.46	+.71
BEARDEN VERY FINE SANDY LOAM (TYPE NO. 42)												
3	3.32	3.22	4.70	3.25	3.40	11.41	0.12	0.52	10.67	+3.13	+2.88	+0.74
25	3.17	3.51	4.13	3.00	3.47	5.89	.05	.67	4.08	+2.95	+2.80	+1.81
34	2.90	2.61	2.89	2.72	2.62	2.85	.05	.15	49	+2.67	+2.47	+2.36
36	2.77	1.97	7.00	2.80	2.57	10.59	.07	.08	7.92	+2.73	+2.59	+2.67
51	1.79	4.09	6.46	5.09	10.21	10.59	2.21	8.48	9.14	+2.88	+1.73	+1.45
57	3.00	3.12	4.89	2.85	3.50	9.59	.08	1.01	8.32	+2.77	+2.49	+1.27
58	3.09	4.02	3.68	2.75	3.57	3.37	.08	.98	.94	+2.67	+2.59	+2.43
Average	2.86	3.22	4.82	3.21	4.19	7.76	.38	1.70	5.94	+2.83	+2.51	+1.82

TABLE 17.—*Composition of Cass County soils (dry basis)*—Continued

Field No.	Calcium-magnesium ratio (Ca/Mg)			Lime ($CaCO_3$) equivalent of calcium			Lime ($CaCO_3$) equivalent of carbonate carbon			Lime equivalent of calcium minus lime equivalent of carbonate carbon		
	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
BEARDEN FINE SANDY LOAM (TYPE NO. 40)												
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*
8	3.55	2.94	2.86	3.12	2.57	2.52	0.08	0.03	0.05	+3.04	+2.54	+2.47
16	3.25	4.71	4.95	3.05	4.94	7.74	.22	2.47	5.33	+2.83	+2.47	+2.41
35	2.78	2.76	3.75	2.75	2.37	5.37	.07	.02	3.86	+2.68	+2.35	+1.51
55	4.46	10.46	5.46	6.44	18.58	18.53	3.38	11.30	18.90	+3.06	+7.28	−.37
Average	3.51	5.22	4.26	3.84	7.12	8.54	9.4	3.45	7.04	+2.90	+3.66	+1.50
BEARDEN FINE SANDY LOAM, ROLLING PHASE (TYPE NO. 24)												
54	3.51	5.36	4.25	4.80	12.79	16.76	1.63	11.97	16.20	+3.17	+0.82	+0.56
BEARDEN FINE SAND (TYPE NO. 47)												
31	2.97	2.66	3.66	2.85	2.65	6.64	0.11	0.13	5.72	+2.74	+2.52	+0.92
FARGO CLAY (TYPE NO. 14)												
12	1.25	1.88	2.85	3.60	7.07	12.16	0.52	4.96	11.36	+3.08	+2.11	+0.80
33	1.23	2.54	3.23	3.50	9.06	14.38	.81	7.57	14.48	+2.69	+1.49	−.10
60	1.53	3.10	3.49	4.02	11.59	15.28	1.67	10.19	15.87	+2.35	+.40	−.59
65	1.21	1.88	2.54	3.75	7.52	13.24	1.15	7.27	15.66	+2.60	+.25	−2.42
66	1.08	.86	1.88	2.50	2.75	8.37	.15	.99	9.05	+2.35	+1.76	−.68
70	1.20	1.50	2.42	3.05	5.09	10.11	.14	2.62	9.11	+2.91	+2.47	+1.00
Average	1.25	1.96	2.73	3.40	7.18	12.26	.66	5.60	12.59	+2.66	+1.41	−.33
FARGO CLAY, ALKALI PHASE (TYPE NO. 53)												
74	1.12	1.45	2.80	2.60	5.39	14.96	0.12	4.06	17.11	+2.48	+1.33	−2.15
FARGO SILTY CLAY (TYPE NO. 15)												
14	1.05	1.41	2.67	2.37	4.64	13.51	0.07	3.70	14.99	+2.30	+0.94	−1.48
37	1.18	1.47	2.22	2.90	5.72	10.51	.33	5.02	11.72	+2.57	+.70	−1.21
41	1.28	1.84	2.91	3.35	5.84	11.94	.08	3.64	11.48	+3.27	+2.20	+.46
59	1.75	3.05	2.97	3.87	11.89	16.88	.89	12.54	20.47	+2.98	−.65	−3.59
67	.98	2.00	3.58	2.60	6.54	15.53	.09	5.39	16.40	+2.51	+1.17	−.87
73	1.24	.93	2.32	2.72	3.12	10.51	.08	.63	10.85	+2.64	+2.49	−.34
Average	1.25	1.78	2.78	2.97	6.29	13.15	.26	5.15	14.32	+2.71	+1.14	−1.17
FARGO SILTY CLAY LOAM (TYPE NO. 17)												
13	2.07	3.51	2.62	6.47	17.73	16.01	4.22	20.12	20.79	+2.25	−2.39	−4.78
39	1.62	1.48	2.17	2.62	3.92	7.79	.10	2.13	6.86	+2.52	+1.79	+.93
63	1.30	1.80	2.50	2.92	6.09	12.94	.16	5.72	14.58	+2.76	+.37	−1.64
72	1.62	1.15	1.77	2.50	2.05	7.04	.09	.04	7.11	+2.41	+2.01	−.07
Average	1.65	1.98	2.26	3.63	7.45	10.94	1.14	7.00	12.34	+2.48	+.44	−1.39
FARGO CLAY LOAM (TYPE NO. 57)												
61	1.15	2.33	3.38	2.75	6.79	14.11	0.20	4.98	14.90	+2.55	+1.81	−.079

TABLE 17.—*Composition of Cass County soils (dry basis)*—Continued

Field No.	Calcium-magnesium ratio (Ca/Mg)			Lime ($CaCO_3$) equivalent of calcium			Lime ($CaCO_3$) equivalent of carbonate carbon			Lime equivalent of calcium minus lime equivalent of carbonate carbon		
	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
FARGO SILT LOAM (TYPE NO. 12)												
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
9	1.55	1.52	3.05	2.70	4.87	13.78	0.00	3.08	14.13	+2.70	+1.79	−0.34
19	3.85	6.19	3.17	10.01	14.08	8.64	7.58	13.24	9.43	+2.43	+.84	−.79
40	2.57	2.03	2.09	2.75	2.30	3.97	.00	.00	1.92	+2.75	+2.30	+2.05
Average	2.66	3.25	2.77	5.15	7.08	8.80	2.53	5.44	8.49	+2.63	+1.64	+.31
FARGO LOAM (TYPE NO. 13)												
62	1.84	2.76	3.44	3.25	6.64	14.26	0.61	5.23	14.62	+2.64	+1.41	−0.36
71	2.16	6.03	6.26	3.62	14.88	31.02	.72	9.74	21.12	+2.90	+5.14	+9.90
Average	2.00	4.40	4.85	3.44	10.76	22.64	.67	7.49	17.87	+2.77	+3.27	+4.77
FARGO VERY FINE SANDY LOAM (TYPE NO. 18)												
10	3.10	3.32	1.43	3.05	5.42	12.21	0.08	3.18	13.18	+2.97	+2.24	−0.97
LAMOURE LOAM (TYPE NO. 20)												
42	2.53	3.20	4.04	4.89	9.44	19.16	2.00	8.25	20.46	+2.89	+1.19	−1.30
43	2.37	2.55	2.99	4.70	5.84	7.37	2.15	4.22	6.53	+2.55	+1.62	+.84
Average	2.45	2.88	3.52	4.80	7.64	13.26	2.08	6.24	13.50	+2.72	+1.40	−.23
MAPLE SILTY CLAY (TYPE NO. 30)												
22	3.83	7.40	5.69	10.59	24.15	23.40	4.58	17.73	19.72	+6.01	+6.42	+3.68
MAPLE SILT LOAM (TYPE NO. 27)												
28	4.94	13.62	10.60	29.37	36.66	14.04	26.69	35.02	12.14	+2.68	+1.64	+1.90
MAPLE VERY FINE SANDY LOAM (TYPE NO. 28)												
27	1.64	2.96	3.52	4.70	4.92	7.27	1.62	2.54	5.13	+3.08	+2.38	+2.14
47	3.09	4.45	5.34	3.35	4.87	7.39	.40	2.49	5.79	+2.95	+2.38	+1.60
Average	2.36	3.70	4.43	4.02	4.90	7.33	1.01	2.52	5.46	+3.02	+2.38	+1.87
SIOUX LOAM (TYPE NO. 38)												
4	2.64	2.98	4.60	3.32	5.89	18.48	0.26	4.19	21.08	+3.06	+1.70	−2.60
SIOUX FINE SANDY LOAM (TYPE NO. 11)												
17	2.85	2.40	3.72	2.90	3.10	9.19	0.12	1.23	10.24	+2.78	+1.87	−1.05
SIOUX SANDY LOAM (TYPE NO. 32)												
53	3.12	4.78	5.08	3.65	12.96	16.46	0.42	13.07	18.37	+3.23	−0.11	−1.91
VALENTINE FINE SAND (TYPE NO. 31)												
48	3.34	3.97	7.49	2.50	3.80	5.59	0.22	1.57	3.77	+2.28	+2.23	+1.82

BARNES LOAM

Nine fields of Barnes loam were sampled. The average of the analyses of the surface layer samples was:

	Per cent		Per cent
Nitrogen	0.323	Sulphur	0.0706
Phosphorus	.061	Silicon	34.67
Potassium	1.374	Organic carbon	3.902
Calcium	1.49	Carbonate carbon	.139
Magnesium	.592		

The carbonate carbon is equivalent to 1.16 per cent lime carbonate. Field No. 44 contains much more nitrogen, calcium, and carbonate carbon than the average of the other fields. Field No. 52 has a larger content of carbonate carbon than the combining equivalent of the calcium present, indicating the presence of considerable magnesium carbonate.

The average of the analyses of the subsurface samples was:

	Per cent		Per cent
Nitrogen	0.148	Sulphur	0.1364
Phosphorus	.0464	Silicon	33.60
Calcium	3.03	Organic carbon	1.703
Magnesium	.792	Carbonate carbon	.652

The carbonate carbon is equivalent to 5.43 per cent of lime carbonate.

The average of the analyses of the subsoil samples was:

	Per cent		Per cent
Nitrogen	0.061	Sulphur	0.3294
Phosphorus	.0474	Silicon	30.61
Calcium	5.90	Organic carbon	.673
Magnesium	1.501	Carbonate carbon	1.798

The carbonate carbon is equivalent to 14.99 per cent of lime carbonate. By referring to Table 17 the reader will note that there is a wide variation in the percentage of sulphur in both the subsurface and subsoil samples. Field notes show that gypsum crystals were observed in field No. 5. They were probably present in field No. 23 but escaped notice.

Barnes loam has developed from the weathering of glacial drift under the conditions of a semihumid climate. Its parent material was limestone drift of the late Wisconsin glaciation. The same parent material went into the formation of the dark-colored prairie soil of Iowa, Carrington loam. Carrington loam has developed under conditions of heavier precipitation than that common in Cass County. Both Carrington loam and Barnes loam owe their organic matter to the decomposition of grasses. Analyses have been published by the Iowa Agricultural Experiment Station of the chemical composition of Carrington loam in Boone, Wright, Bremer, Sioux, Webster, and Fayette Counties. In order that these Iowa results may be compared with the Cass County results here reported, the Iowa data has been recalculated back to the percentage basis. As an average of these six Iowa counties, the surface layer of Carrington loam contains:

	Per cent
Nitrogen	0.202
Phosphorus	.054
Organic carbon	2.42

Only a trace of carbonate or inorganic carbon is present. Barnes loam of Cass County contains a distinctly higher percentage of each of these constituents. The subsurface layer of Carrington loam contains:

	Per cent
Nitrogen	0.139
Phosphorus	.044
Organic carbon	1.60

Only a trace of carbonate or inorganic carbon occurs. The subsoil of Carrington loam contains:

	Per cent
Nitrogen	0.059
Phosphorus	.035
Organic carbon	.77

Only a trace of carbonate or inorganic carbon is present.

It is in the subsurface layer and in the subsoil that the greatest difference occurs between Barnes loam of Cass County and Carrington loam of Iowa. Both of these layers of the North Dakota soil contain about the same amount of nitrogen and organic carbon as do the corresponding layers of the Iowa soil, but whereas the Iowa soil is practically devoid of carbonate or inorganic carbon (that is, carbonates such as limestone), the North Dakota Barnes loam contains a large amount of carbonate carbon in the subsoil and considerable in the subsurface soil. In short, there has been less leaching of carbonates from the North Dakota soil.

BARNES FINE SANDY LOAM

This soil resembles Barnes loam in the percentage of nitrogen, phosphorus, and potassium in each soil layer, but its subsurface soil and subsoil are distinctly lower in sulphur, calcium, and magnesium. The entire soil contains only a trace of carbonate carbon.

BEARDEN SILTY CLAY LOAM

Seven fields of Bearden silty clay loam were sampled. The average of the analyses of the surface layer samples was:

	Per cent		Per cent
Nitrogen	0.273	Sulphur	0.0828
Phosphorus	.0643	Silicon	33.63
Potassium	1.507	Organic carbon	3.353
Calcium	1.70	Carbonate carbon	.169
Magnesium	.757		

The carbonate carbon is equivalent to 1.41 per cent of lime carbonate.

The average of the analyses of the subsurface layer samples was:

	Per cent		Per cent
Nitrogen	0.120	Sulphur	0.0636
Phosphorus	.056	Silicon	31.99
Calcium	3.98	Organic carbon	1.440
Magnesium	1.117	Carbonate carbon	1.082

The carbonate carbon is equivalent to 9.02 per cent of lime carbonate.

The average of the analyses of the subsoil layer was:

	Per cent		Per cent
Nitrogen	0.052	Sulphur	0.0646
Phosphorus	.0641	Silicon	28.29
Calcium	6.70	Organic carbon	.586
Magnesium	1.990	Carbonate carbon	2.403

The carbonate carbon is equivalent to 20.03 per cent of lime carbonate. Bearden silty clay loam is characterized by a uniformly high percentage of lime carbonate in the subsoil layer, although the surface layer frequently contains only a trace of carbonates.

BEARDEN SILTY CLAY AND BEARDEN SILT LOAM

The chemical composition of these two soil types resembles closely that of Bearden silty clay loam. In Bearden loam, of which five fields were sampled, the average of the analyses of the surface layer was:

	Per cent		Per cent
Nitrogen	0. 230	Sulphur	0. 0708
Phosphorus	. 0462	Silicon	36. 18
Potassium	1. 338	Organic carbon	2. 815
Calcium	1. 19	Inorganic carbon	0. 013
Magnesium	. 481		

The lime carbonate equivalent of the carbonate carbon is 0.11 per cent.

The average of the analyses of the subsurface layer was:

	Per cent		Per cent
Nitrogen	0. 100	Sulphur	0. 0854
Phosphorus	. 0385	Silicon	36. 68
Calcium	1. 77	Organic carbon	1. 133
Magnesium	. 623	Carbonate carbon	. 236

The carbonate carbon is equivalent to 1.96 per cent lime carbonate.

The average of the analyses of the subsoil layer was:

	Per cent		Per cent
Nitrogen	0. 046	Sulphur	0. 554
Phosphorus	. 0436	Silicon	31. 00
Calcium	6. 20	Organic carbon	. 503
Potassium	1. 329	Carbonate carbon	1. 774

The carbonate carbon is equivalent to 14.78 per cent of lime carbonate.

Bearden loam, being a coarser member of the Bearden series than those previously discussed, contains, as would be expected, a higher percentage of silicon in the surface and subsurface layers. This soil type is also characterized by a relatively low nitrogen content in the subsurface and subsoil layers. Its phosphorus content is relatively low throughout the soil. With one exception, the subsoil was found to contain relatively larger amounts of sulphur. This soil is also characterized by containing scarcely a trace of lime carbonate in the surface soil and frequently but little in the subsurface layer, but with one exception the subsoil was found to be well supplied with lime carbonate.

BEARDEN VERY FINE SANDY LOAM

Seven fields of Bearden very fine sandy loam were sampled. The average of the analyses of the surface layer was:

	Per cent		Per cent
Nitrogen	0. 186	Sulphur	0. 0517
Phosphorus	. 0464	Silicon	36. 88
Potassium	1. 321	Organic carbon	2. 189
Calcium	1. 28	Carbonate carbon	. 045
Magnesium	. 489		

The carbonate carbon is equivalent to 0.38 per cent lime carbonate.

The average of the analyses of the subsurface layer was:

	Per cent		Per cent
Nitrogen	0.095	Sulphur	0.0458
Phosphorus	.0396	Silicon	37.22
Calcium	1.68	Organic carbon	1.108
Magnesium	.507	Carbonate carbon	.204

The carbonate carbon is equivalent to 1.70 per cent lime carbonate.

The average of the analyses of the subsoil was:

	Per cent		Per cent
Nitrogen	0.037	Sulphur	0.1193
Phosphorus	.0411	Silicon	35.82
Calcium	3.11	Organic carbon	.418
Magnesium	.622	Carbonate carbon	.713

The carbonate carbon is equivalent to 5.94 per cent lime carbonate. This soil type is characterized by a very small content of lime carbonate in the surface layer. Field No. 51 is an exception, as in this the surface layer contains the equivalent of 2.21 per cent. Bearden very fine sandy loam is also characterized by a relatively low percentage of sulphur throughout the entire soil. The nitrogen content of the entire soil is considerably lower than in the heavier members of the Bearden series. The phosphorus percentages are relatively low as compared to other soils in the county.

BEARDEN FINE SANDY LOAM, BEARDEN FINE SANDY LOAM, ROLLING PHASE, AND BEARDEN FINE SAND

The chemical composition of Bearden fine sandy loam, Bearden fine sandy loam, rolling phase, and Bearden fine sand resembles rather closely the chemical composition of Bearden very fine sandy loam and is, therefore, not discussed separately.

FARGO CLAY

Fargo clay is one of the most important types of soil in the county. Its chemical composition is therefore of special interest. Six fields of it were sampled. The average of the analyses of the surface layer was:

	Per cent		Per cent
Nitrogen	0.324	Sulphur	0.0643
Phosphorus	.0657	Silicon	29.56
Potassium	1.715	Organic carbon	4.060
Calcium	1.36	Carbonate carbon	.079
Magnesium	1.089		

The carbonate carbon is equivalent to 0.66 per cent of lime carbonate.

The average of the analyses of the subsurface layer was:

	Per cent		Per cent
Nitrogen	0.159	Sulphur	0.043
Phosphorus	.0576	Silicon	28.26
Calcium	2.88	Organic carbon	1.896
Magnesium	1.446	Carbonate carbon	.672

The carbonate carbon is equivalent to 5.60 per cent of lime carbonate.

The average of the analyses of the subsoil layer was:

	Per cent		Per cent
Nitrogen	0.095	Sulphur	0.0648
Phosphorus	.0560	Silicon	26.30
Calcium	4.91	Organic carbon	1.066
Magnesium	1.799	Carbonate carbon	1.510

The carbonate carbon is equivalent to 12.59 per cent of lime carbonate.

Fargo clay is characterized, as would be expected, by a relatively low percentage of silicon in the entire soil. Fargo clay, alkali phase, and Fargo silty clay contain a relatively higher percentage of potassium in the surface soil than any of the other soil types in the county. Fargo clay resembles Barnes loam very closely in the percentage of nitrogen in the surface and subsurface soils. It, like Barnes loam, is relatively high in its content of phosphorus. The surface soil is characterized by the presence of only traces of lime carbonate, but the subsoil is well supplied with it. The surface layer of Fargo clay contains about the average amount of sulphur, but the subsurface layer is relatively poor in sulphur.

A COMPARISON OF FARGO CLAY (CASS COUNTY, N. DAK.) WITH CLYDE SILTY CLAY (WELLS COUNTY, IND.)

Fargo clay has developed under an annual rainfall ranging from 20 to 24 inches. It will be of interest, therefore, to compare its chemical composition with the chemical composition of a lacustrine clay developed under different climatic conditions. Through the courtesy of A. G. McCall, Chief of Soil Investigations, Bureau of Chemistry and Soils, United States Department of Agriculture, there is included the analysis of a sample of Clyde silty clay from Indiana. This soil developed under an annual rainfall ranging from 30 to 46 inches and averaging 36.94.

The percentage of nitrogen in the respective layers of the two soils is very similar. The Clyde soil contains about twice as much phosphorus as does Fargo clay. The sulphur percentages are noticeably higher in the Clyde soil, as is also the percentage of potassium in the surface layer. Fargo clay, however, contains much more calcium and magnesium throughout.

The chemical composition of different layers of Clyde silty clay in Wells County, Ind., is given in Table 18.

TABLE 18.—*Chemical composition of Clyde silty clay in Wells County, Ind.*

Element	0 to 6 inches	6 to 16 inches	16 to 36 inches	Element	0 to 6 inches	6 to 16 inches	16 to 36 inches
	Per cent	*Per cent*	*Per cent*		*Per cent*	*Per cent*	*Per cent*
Silicon	26.36	30.78	31.40	Magnesium	0.77	0.92	1.02
Titanium	.41	.43	.43	Potassium	2.32	2.22	2.30
Iron	3.35	3.78	3.73	Sodium	.37	.53	.40
Aluminum	7.47	7.63	7.68	Phosphorus	.18	.14	.11
Manganese	.03	.04	.05	Sulphur	.11	.08	.08
Calcium	.91	1.14	.99	Nitrogen	.31	.15	.09

As Fargo clay closely resembles Fargo silty clay in chemical composition, the chemical composition of Clyde silty clay will be compared with the chemical composition of Fargo clay.

A COMPARISON OF FARGO CLAY (CASS COUNTY, N. DAK) WITH TWO RESIDUAL CLAYS: HOUSTON BLACK CLAY (DALLAS COUNTY, TEX.) AND DAVIDSON CLAY (ROCK HILL, S. C.)

Davidson clay occurs in a region having an annual rainfall ranging from 35 to 68 inches, with an average of 49 inches, and Houston black clay in a region having a rainfall range from 18 to 60 inches, with an average of 38 inches. Both soils occur in regions where there is practically no soil freezing. Davidson clay is residual from igneous rocks.

It contains very much less nitrogen, phosphorus, calcium, magnesium, and potassium than Fargo clay and is much lower in the total silicon. Fargo clay, on the other hand, is distinctly lower in total phosphorus than Davidson clay.

Houston black clay, residual from limestone, is a much more calcareous soil than Fargo clay, for it still contains much carbonate carbon in its surface layers. Houston black clay contains only about half as much nitrogen in its surface 6-inch layer as does Fargo clay, but the rest of the soil is not very greatly different. The potassium content of the surface soil of Houston black clay is significantly lower than that of Fargo clay. The two soils are rather similar in their sulphur content, the Fargo soil being somewhat higher. The Fargo soil contains more phosphorus in its surface 6-inch layer and approximately the same in the rest of the mass.

The chemical composition of various layers of a sample of Davidson clay taken 1½ miles north of Rock Hill, S. C., is shown in Table 19.[8]

TABLE 19.—*Chemical composition of Davidson clay from near Rock Hill, S. C.*

Element	0 to 5 inches	5 to 36 inches	Element	0 to 5 inches	5 to 36 inches
	Per cent	*Per cent*		*Per cent*	*Per cent*
Silicon	16.89	16.56	Potassium	0.31	0.26
Titanium	3.20	1.37	Sodium	.05	.04
Iron	15.63	14.58	Phosphorus	.15	.12
Aluminum	12.13	14.82	Sulphur	.02	.01
Manganese	.17	.044	Nitrogen	.09	.02
Calcium	.17	.16	Loss on ignition	11.28	12.24
Magnesium	.21	.22			

The chemical composition of various layers of a sample of Houston black clay taken 1 mile southwest of Reinhardt, Dallas County, Tex., is shown in Table 20.[8]

TABLE 20.—*Chemical composition of Houston black clay from near Reinhardt, Tex.*

Element	0 to 6 inches	6 to 14 inches	14 to 26 inches	26 to 40 inches	Element	0 to 6 inches	6 to 14 inches	14 to 26 inches	26 to 40 inches
	Per cent	*Per cent*	*Per cent*	*Per cent*		*Per cent*	*Per cent*	*Per cent*	*Per cent*
Silicon	27.28	24.22	14.68	6.79	Sodium	0.15	0.16	0.10	0.23
Titanium	.41	.33	.27	.14	Phosphorus	.07	.08	.08	.04
Iron	2.88	3.01	2.31	.152	Sulphur	.04	.06	.06	.04
Aluminum	5.85	6.04	4.30	.258	Nitrogen	.18	.19	.10	.05
Manganese	.16	.13	.08	.03	Loss on ignition	15.99	19.04	27.99	36.03
Calcium	8.55	11.08	21.82	30.92	Carbonate carbon	1.99	2.92	6.02	8.74
Magnesium	.92	.96	.75	5.1					
Potassium	1.26	1.21	0.81	0.46					

FARGO CLAY, ALKALI PHASE

Only one field of Fargo clay, alkali phase, was sampled. This sample contains considerably more sulphur in the entire soil than does Fargo clay, but in other respects it resembles it in chemical composition.

FARGO SILTY CLAY

Six fields of Fargo silty clay were sampled. The chemical composition of Fargo silty clay closely resembles that of Fargo clay in all respects.

[8] Courtesy of A. G. McCall.

FARGO SILTY CLAY LOAM

Four fields of Fargo silty clay loam were sampled. The chemical composition of this soil closely resembles that of the heavier members of the Fargo series, except that the potassium content of its surface layer is distinctly lower and the silicon content of the entire soil is slightly higher. This soil, with one exception, is characterized by a low percentage of lime carbonate in the surface layer, but there is an abundance in the subsoil.

FARGO CLAY LOAM

The chemical composition of Fargo clay loam resembles closely that of the heavier members of the Fargo series. Only one field was sampled, and on this one field the percentage of sulphur was relatively low, especially in the subsoil. In this respect the soil is quite different from most of the soils in the county.

FARGO SILT LOAM

Three fields of Fargo silt loam were sampled. Field No. 19 was very different from fields Nos. 9 and 40 in chemical composition, in that it contained more nitrogen and organic carbon in the surface layer than did the other two fields. Field No. 19 was also high in sulphur in the surface layer and high in lime carbonate throughout. In other respects Fargo silt loam resembled in chemical composition the other soils of the Fargo series.

FARGO LOAM

Only two fields of Fargo loam were sampled. Except for the high nitrogen content in the surface layer and the unusually high percentage of sulphur throughout in field No. 71, Fargo loam closely resembles the other members of the Fargo series. The explanation of the high sulphur content of field No. 71 is possibly its location or association. This field of Fargo loam is a low area within an area of Bearden soils. The other field (No. 62) is a comparatively high area surrounded by other lower-lying types of the Fargo series.

FARGO VERY FINE SANDY LOAM

Only one field of Fargo very fine sandy loam was sampled. This soil contained a relatively low percentage of nitrogen throughout, contained the smallest percentage of potassium in the surface layer of any member of the Fargo series, was distinctly low in sulphur throughout, and had a higher content of silicon in the surface layer. Its percentage of organic carbon is relatively low, and it contains only a trace of carbonate carbon in the surface soil. In other respects it resembles the other members of the Fargo series in chemical composition.

LAMOURE LOAM

Two fields of Lamoure loam were sampled. This soil contains a relatively high percentage of nitrogen and phosphorus in the surface layer. The potassium content, however, is relatively low. The soil is also high in organic carbon throughout and especially in the surface layer. Though the sulphur content is high in the surface soil, there is no increase in it in the subsurface and subsoil layers.

MAPLE SILTY CLAY, MAPLE SILT LOAM, AND MAPLE VERY FINE SANDY LOAM

Four fields of the Maple soils were sampled. Maple silty clay and silt loam have nearly twice as high a percentage of nitrogen in the surface layer as the other soils of the county, but Maple very fine sandy loam contains only an average percentage of nitrogen.

Maple silt loam is an unusual soil in all respects, being very high in total calcium in the surface and subsurface layers but relatively lower in the subsoil. It also contains a relatively high percentage of magnesium in the surface layer with a relatively low percentage in the lower layers.

Maple silty clay contains a high percentage of sulphur throughout. The surface layer of Maple silt loam and Maple very fine sandy loam is also high in sulphur, but the subsurface and subsoil layers do not contain unusual amounts. Maple silt loam contains a high percentage of organic carbon in the surface and subsurface layers. For this reason the percentages of silicon are correspondingly lower in these layers.

SIOUX LOAM, SIOUX FINE SANDY LOAM, AND SIOUX SANDY LOAM

One field each of Sioux loam, Sioux fine sandy loam, and Sioux sandy loam was sampled. The series is represented by only the coarser members. These soils have a relatively low percentage of phosphorus and a high percentage of silicon throughout, especially in the surface and subsurface layers. The amount of organic carbon in the surface layer is relatively low, although not so low as might have been expected. Special attention is called to the fact that a relatively high percentage of the soil of each type fails to pass through the 20-mesh sieve.

VALENTINE FINE SAND

One field of this soil was sampled. The soil is, as would be expected, very low in nitrogen and contains a low percentage of all of the elements on which analyses were made, except silicon. The soil is relatively unimportant in the county.

A GENERAL DISCUSSION OF THE CHEMICAL COMPOSITION OF THE SOILS OF CASS COUNTY

Eight series of soils are represented in Cass County. The average chemical composition of all fields of each type is given in Table 21 and of all the fields of each series in Table 22. The Barnes, Bearden, and Fargo are the three most important series in the county. Special attention is called to the following facts with respect to the chemical composition of the soils in Cass County.

Of the important soils in the county, the Bearden soils contain distinctly less nitrogen throughout than either the Barnes or the Fargo soils. The Maple soils have a very high nitrogen content in the surface layer and the Valentine a very low nitrogen content throughout.

The phosphorus content of the Fargo soils is generally above the average. Of the major soil types, Bearden silty clay loam is characterized by having a phosphorus content above the average throughout. Other members of the Bearden series are generally below the average. The phosphorus content of the Barnes soils approximates the average.

The Lamoure soils contain high percentages of phosphorus throughout. The Maple soils contain high percentages of phosphorus in the surface layer but only about an average amount in the subsurface and subsoil layers. The Sioux and Valentine soils contain low percentages of phosphorus throughout.

The Fargo soils contain a higher percentage of potassium in the surface soil than members of any other soil series in the county.

There are rather remarkably uniform percentages of calcium in the soils of the main soil series in the county.

The Fargo soils contain relatively high percentages of magnesium throughout, especially in the subsurface and subsoil layers. The calcium-magnesium ratio of the Fargo soils is remarkably lower throughout than that in any of the other series. In three instances the Fargo soils contained more magnesium than they did calcium; namely, in the subsurface layer of Fargo clay, field No. 66; in the surface layer of Fargo silty clay, field No. 67; and in the subsurface layer of Fargo silty clay, field No. 73

The Maple soils contain a high percentage of magnesium in the surface layer but do not contain an unusual amount in the other layers. The Valentine soils contain low amounts of calcium and magnesium throughout.

Cass County soils contain, on the average, relatively higher percentages of sulphur than of phosphorus throughout the soil. It is suggestive that the lower-lying and poorly drained soils have accumulated a relatively higher content of sulphur.

The Bearden soils contain relatively less organic carbon throughout than do either the Barnes or the Fargo. The Lamoure and Maple soils are relatively high in organic carbon in the surface layer. The Lamoure soil has a high and the Valentine soil a low percentage of organic carbon throughout.

The distribution of the carbonate carbon in each of the soil layers is of special interest. With the exception of Maple silt loam, the deeper the layer the higher the carbonate carbon content. Sixty-three fields of the Barnes, Bearden, and Fargo soils were sampled. Of these 63 fields, 49 contained less than 0.1 per cent of carbonate carbon in the surface soil. The average lime equivalent of the carbonate carbon in these three main series was:

	Per cent
Surface layer	0.86
Subsurface layer	4.77
Subsoil	13.23

As zero results in duplicate were frequently obtained in the use of the apparatus and method used for the determination of carbonate carbon, it is doubtful whether only a very slight amount or any of the carbonate carbon represented is due to a slight decomposition of organic matter in the soil by the dilute hydrochloric acid used during the process of analysis. The subsurface soil and subsoil are generally well supplied with lime. The high frequency of low percentages of carbonate carbon in the surface soil indicates that many of the surface soils may be acid or may become acid in chemical reaction.

The frequent occurrence of insufficient calcium to combine with all of the carbonate carbon in the subsoil assures that much of the carbonate carbon exists in combination with magnesium in the form of magnesium carbonate. This condition is positively known to exist in the surface soil of one field of Barnes loam and may exist in the entire soil mass in many instances.

Table 21.—*Average composition of Cass County soils by type*

Soil series	Soil type	Number of fields	Total nitrogen			Total phosphorus			Total potassium (surface)	Total calcium			Total magnesium		
			Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil		Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Barnes	Loam	9	0.323	0.148	0.061	0.0616	0.0464	0.0474	1.374	1.49	3.03	5.90	0.592	0.792	1.501
Do	Fine sandy loam	1	.349	.118	.048	.0757	.0462	.0376	1.296	1.18	.95	.99	.413	.386	.420
Bearden	Silty clay	2	.298	.138	.067	.0657	.0580	.0622	1.527	1.42	4.03	5.63	.828	1.045	1.780
Do	Silty clay loam	7	.273	.120	.052	.0643	.0560	.0641	1.507	1.70	3.98	6.70	.757	1.117	1.990
Do	Silt loam	2	.256	.126	.054	.0598	.0551	.0621	1.446	1.33	2.56	6.83	.586	.864	1.974
Do	Loam	5	.230	.100	.046	.0462	.0385	.0436	1.338	1.19	1.77	6.20	.481	.623	1.329
Do	Very fine sandy loam	7	.186	.095	.037	.0464	.0396	.0411	1.321	1.28	1.68	3.11	.489	.507	.622
Do	Fine sandy loam	4	.189	.085	.030	.0480	.0326	.0358	1.276	1.54	2.85	3.42	.426	.456	.728
Do	Fine sandy loam, rolling phase	1	.366	.203	.061	.0605	.0570	.0591	1.352	1.92	5.12	6.71	.547	.956	1.578
Do	Fine sand	1	.199	.113	.050	.0472	.0379	.0398	1.386	1.14	1.06	2.66	.384	.399	.727
Fargo	Clay	6	.324	.159	.095	.0657	.0576	.0560	1.715	1.36	2.88	4.91	1.089	1.446	1.799
Do	Clay, alkali phase	1	.389	.172	.075	.0655	.0450	.0522	1.680	1.04	2.16	5.99	.928	1.489	2.137
Do	Silty clay	6	.340	.162	.094	.0639	.0543	.0547	1.795	1.19	2.52	5.26	.961	1.394	1.900
Do	Silty clay loam	4	.311	.143	.076	.0644	.0484	.0530	1.548	1.45	2.98	4.38	.853	1.289	1.887
Do	Clay loam	1	.331	.185	.080	.0656	.0540	.0597	1.481	1.10	2.72	5.65	.959	1.166	1.671
Do	Silt loam	3	.364	.119	.051	.0652	.0515	.0465	1.379	2.06	2.84	3.52	.722	.883	1.220
Do	Loam	2	.281	.134	.061	.0589	.0492	.0492	1.410	1.38	4.31	9.07	.690	.976	1.827
Do	Very fine sandy loam	1	.168	.061	.042	.0502	.0534	.0533	1.330	1.22	2.17	4.89	.393	1.460	1.533
Lamoure	Loam	2	.352	.196	.114	.0744	.0638	.0568	1.268	1.92	3.05	5.31	.784	1.051	1.442
Maple	Silty clay	1	.629	.150	.040	.0803	.0510	.0572	1.232	4.24	9.67	9.37	1.108	1.307	1.646
Do	Silt loam	1	.930	.343	.068	.1112	.0674	.0394	.577	11.76	14.68	5.62	2.382	1.078	.530
Do	Very fine sandy loam	2	.324	.062	.023	.0602	.0407	.0442	1.331	1.61	1.96	2.94	.789	.552	.690
Sioux	Loam	1	.336	.197	.030	.0650	.0664	.0391	1.046	1.33	2.36	7.40	.503	.792	1.609
Do	Fine sandy loam	1	.218	.109	.031	.0554	.0418	.0394	1.316	1.16	1.24	3.68	.407	.517	.989
Do	Sandy loam	1	.265	.181	.019	.0584	.0584	.0272	1.305	1.46	5.19	6.59	.468	1.086	1.297
Valentine	Fine sand	1	.096	.076	.053	.0338	.0371	.0375	1.216	1.00	1.52	2.24	.299	.383	.299

TABLE 21.—*Average composition of Cass County soils by type*—Continued

Soil series	Soil type	Number of fields	Total sulphur			Total silicon			Organic carbon			Carbonate carbon		
			Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
			Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Barnes	Loam	9	0.0706	0.1364	0.3294	34.67	33.60	30.61	3.902	1.703	0.673	0.139	0.652	1.798
Do	Fine sandy loam	1	.0833	.0328	.0420	35.14	37.46	38.10	4.256	1.269	.473	.007	.003	.006
Bearden	Silty clay	2	.1032	.2002	.1131	32.21	31.58	28.51	3.826	1.692	.691	.090	.486	1.868
Do	Silty clay loam	7	.0828	.0636	.0646	33.63	31.99	28.29	3.353	1.440	.586	.169	1.082	2.403
Do	Silt loam	2	.0474	.0412	.0698	35.00	34.17	28.88	3.222	1.479	.660	.026	.540	2.326
Do	Loam	5	.0708	.0854	.5554	36.18	36.68	31.00	2.815	1.133	.503	.013	.238	1.774
Do	Very fine sandy loam	7	.0517	.0458	.1193	36.88	37.22	35.82	2.189	1.108	.418	.045	.204	.713
Do	Fine sandy loam	4	.0762	.5413	.1894	37.10	36.92	35.95	2.215	.958	.352	.112	.414	.844
Do	Fine sandy loam, rolling phase	1	.0610	.1648	.7215	33.69	31.01	29.57	4.285	2.221	.743	.196	1.437	1.944
Do	Fine sand	1	.0674	.0560	.0430	37.30	37.94	35.95	2.330	1.260	.506	.013	.016	.698
Fargo	Clay	6	.0643	.0430	.0648	29.56	28.26	26.30	4.060	1.896	1.066	.079	.672	1.510
Do	Clay, alkali phase	1	.0853	.1049	.2087	30.93	29.70	25.84	5.088	2.167	.772	.015	.487	2.053
Do	Silty clay	6	.0712	.0475	.0760	30.56	29.28	26.54	4.252	1.869	.989	.031	.618	1.718
Do	Silty clay loam	4	.0798	.0482	.0771	32.22	30.63	27.64	3.900	1.695	.800	.137	.840	1.480
Do	Clay loam	1	.0538	.0319	.0244	30.13	29.18	25.65	4.309	2.283	.834	.024	.597	1.788
Do	Silt loam	3	.0827	.0589	.1572	32.96	32.84	31.44	4.190	1.294	.510	.303	.653	1.019
Do	Loam	2	.0686	.7324	2.1236	33.75	31.20	36.93	3.450	1.468	.628	.080	.898	2.144
Do	Very fine sandy loam	1	.0297	.0255	.0708	36.41	36.21	30.72	2.009	.673	.425	.009	.381	1.582
Lamoure	Loam	2	.0866	.0812	.0843	33.18	32.88	31.20	4.350	2.272	1.372	.249	.742	1.620
Maple	Silty clay	1	.5032	2.0528	1.7545	27.76	24.85	26.48	7.234	1.706	.530	.549	2.128	2.366
Do	Silt loam	1	.1499	.1002	.0389	19.10	21.64	34.08	10.168	4.113	.762	3.203	4.203	1.457
Do	Very fine sandy loam	2	.1086	.0500	.0557	35.79	37.65	47.72	3.442	1.230	.260	.122	.302	.656
Sioux	Loam	1	.0703	.0735	.0447	35.17	35.14	29.60	3.982	2.011	.319	.031	.503	2.530
Do	Fine sandy loam	1	.0609	.0338	.0319	36.83	37.40	35.13	2.699	1.201	.289	.015	.148	1.229
Do	Sandy loam	1	.0893	.0570	.0426	36.05	32.30	32.13	3.141	1.741	.167	.050	1.569	2.204
Valentine	Fine sand	1	.0440	.0526	.0593	39.41	38.73	37.69	1.100	.821	.641	.026	.188	.452

Soil series	Soil type	Number of fields	Calcium magnesium ratio Ca/Mg			Lime ($CaCO_3$) equivalent of calcium			Lime ($CaCO_3$) equivalent of carbonate carbon			Lime equivalent of calcium minus lime equivalent of carbonate carbon		
			Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
			Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Barnes	Loam	9	2.48	3.43	3.92	3.73	7.57	14.74	1.16	5.43	14.99	+2.57	+2.14	−0.25
Do	Fine sandy loam	1	2.86	2.46	2.36	2.95	2.37	2.47	.06	.02	.05	+2.89	+2.35	+2.42
Bearden	Silty clay	2	1.70	3.85	3.16	3.54	10.06	14.06	.75	4.05	15.56	+2.79	+6.01	−1.50
Do	Silty clay loam	7	2.26	3.59	4.09	4.25	9.94	16.88	1.41	9.02	20.03	+2.84	+.92	−3.26
Do	Silt loam	2	2.28	2.94	3.68	3.32	6.39	17.06	.22	4.50	19.38	+3.10	+1.89	−2.32
Do	Loam	5	2.51	2.81	4.43	2.96	4.42	15.49	.11	1.96	14.78	+2.85	+2.46	+.71
Do	Very fine sandy loam	7	2.86	3.22	4.82	3.21	4.19	7.76	.38	1.70	5.94	+2.83	+2.51	+1.82
Do	Fine sandy loam	4	3.51	5.22	4.26	3.84	7.12	8.54	.94	3.45	7.04	+2.90	+3.66	+1.50
Do	Fine sandy loam, rolling phase	1	3.51	5.36	4.25	4.80	12.79	16.76	1.63	11.97	16.20	+3.17	+.82	+.56
Do	Fine sand	1	2.97	2.66	3.66	2.85	2.65	6.64	.11	.13	5.72	+2.74	+2.52	+.92
Fargo	Clay	6	1.25	1.96	2.73	3.40	7.18	12.26	.66	5.60	12.59	+2.66	+1.41	−.33
Do	Clay, alkali phase	1	1.12	1.45	2.80	2.60	5.39	14.96	.12	4.06	17.11	+2.48	+1.33	−2.15
Do	Silty clay	6	1.25	1.78	2.78	2.97	6.29	13.15	.26	5.15	14.32	+2.71	+1.14	−1.17
Do	Silty clay loam	4	1.65	1.98	2.26	3.63	7.45	10.94	1.14	7.00	12.34	+2.48	+.44	−1.39
Do	Clay loam	1	1.15	2.33	3.38	2.75	6.79	14.11	.20	4.98	14.90	+2.55	+1.81	−.79
Do	Silt loam	3	2.66	3.25	2.77	5.15	7.08	8.80	2.53	5.44	8.49	+2.63	+1.64	+.31
Do	Loam	2	2.00	4.40	4.85	3.44	10.76	22.64	.67	7.49	17.87	+2.77	+3.27	+4.77
Do	Very fine sandy loam	1	3.10	3.32	1.43	3.05	5.42	12.21	.08	3.18	13.18	+2.97	+2.24	−.97
Lamoure	Loam	2	2.45	2.88	3.52	4.80	7.64	13.26	2.08	6.24	13.50	+2.72	+1.40	−.23
Maple	Silty clay	1	3.83	7.40	5.69	10.59	24.15	23.40	4.58	17.73	19.72	+6.01	+6.42	+3.68
Do	Silt loam	1	4.94	13.62	10.60	29.37	36.66	14.04	26.69	35.02	12.14	+2.68	+1.64	+1.90
Do	Very fine sandy loam	2	2.36	3.70	4.43	4.02	4.90	7.33	1.01	2.52	5.46	+3.02	+2.38	+1.87
Sioux	Loam	1	2.64	2.98	4.60	3.32	5.89	18.48	.26	4.19	21.08	+3.06	+1.70	−2.60
Do	Fine sandy loam	1	2.85	2.40	3.72	2.90	3.10	9.19	.12	1.23	10.24	+2.78	+1.87	−1.05
Do	Sandy loam	1	3.12	4.78	5.08	3.65	12.96	16.46	.42	13.07	18.37	+3.23	−.11	−1.91
Valentine	Fine sand	1	3.34	3.97	7.49	2.50	3.80	5.59	.22	1.57	3.77	+2.28	+2.23	+1.82

TABLE 22.—*Average composition of fields of Cass County soils, by series*

Series	Number of fields	Number of types	Total nitrogen			Total phosphorus			Total potassium (surface)	Total calcium			Total magnesium			Total sulphur			Total silicon		
			Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil		Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Barnes	10	2	0.326	0.145	0.060	0.0630	0.0463	0.0464	1.365	1.46	2.82	5.41	0.574	0.752	1.393	0.0719	0.1260	0.3007	34.72	33.98	31.36
Bearden	29	8	.234	.110	.046	.0537	.0453	.0498	1.389	1.43	2.73	5.09	.572	.741	1.298	.0700	.1401	.2054	35.46	35.03	32.00
Fargo	24	8	.324	.147	.079	.0637	.0529	.0533	1.612	1.39	2.85	5.16	.897	1.288	1.766	.0703	.1058	.2573	31.39	30.16	28.25
Lamoure	2	1	.352	.196	.114	.0744	.0638	.0568	1.268	1.92	3.05	5.31	.784	1.051	1.442	.0866	.0812	.0843	33.18	32.88	31.20
Maple	5	4	.588	.149	.036	.0773	.0471	.0466	1.139	4.17	6.09	4.93	1.121	.817	.884	.2113	.4616	.3901	30.11	31.56	33.88
Sioux	3	3	.273	.162	.027	.0596	.0555	.0352	1.222	1.32	2.93	5.89	.459	.798	1.298	.0735	.0548	.0397	36.02	34.95	32.29
Valentine	1	1	.096	.076	.053	.0338	.0371	.0375	1.216	1.00	1.52	2.24	.299	.383	.299	.0440	.0526	.0593	39.41	38.73	37.69
Average	74	27	.302	.133	.059	.0603	.0488	.0497	1.429	1.61	3.01	5.14	.712	.931	1.425	.0805	.1424	.2356	33.69	33.06	30.89

Series	Number of fields	Number of types	Organic carbon			Carbonate carbon			Calcium magnesium ratio (CaMg)			Lime ($CaCO_3$) equivalent of calcium			Lime ($CaCO_3$) equivalent of carbonate carbon			Lime equivalent of calcium minus lime equivalent of carbonate carbon		
			Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil	Surface	Subsurface	Subsoil
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Barnes	10	2	3.937	1.659	0.653	0.126	0.587	1.619	2.54	3.75	3.88	3.65	7.04	13.51	1.05	4.80	13.50	+2.60	+2.15	+0.01
Bearden	29	8	2.843	1.281	.514	.085	.529	1.554	2.50	3.68	3.92	3.67	6.82	12.71	.71	4.41	12.96	+2.86	+2.41	−.25
Fargo	24	9	4.014	1.721	.848	.097	.680	1.586	1.55	2.21	2.92	3.47	7.12	12.39	.81	5.67	13.22	+2.66	+1.45	−.83
Lamoure	2	1	4.350	2.272	1.372	.249	.742	1.620	2.45	2.90	3.68	4.80	7.62	13.26	2.08	6.19	13.51	+2.72	+1.43	−.25
Maple	5	3	6.415	1.932	.420	.813	1.460	1.243	3.72	7.45	5.58	10.41	15.21	12.31	6.78	12.17	10.36	+3.63	+3.04	+1.95
Sioux	3	3	3.274	1.651	.258	.032	.740	1.988	2.88	3.67	4.54	3.30	7.32	14.71	.27	6.17	16.58	+3.03	+1.15	−1.87
Valentine	1	1	1.100	.821	.641	.026	.188	.452	3.34	3.97	7.49	2.50	3.80	5.59	.22	1.57	3.77	+2.28	+2.23	+1.82
Average	74	27	3.647	1.554	.649	.145	.658	1.557	2.31	3.45	3.77	4.02	7.52	12.69	1.21	5.49	12.98	+2.81	+2.03	−.29

[PUBLIC RESOLUTION—No. 9]

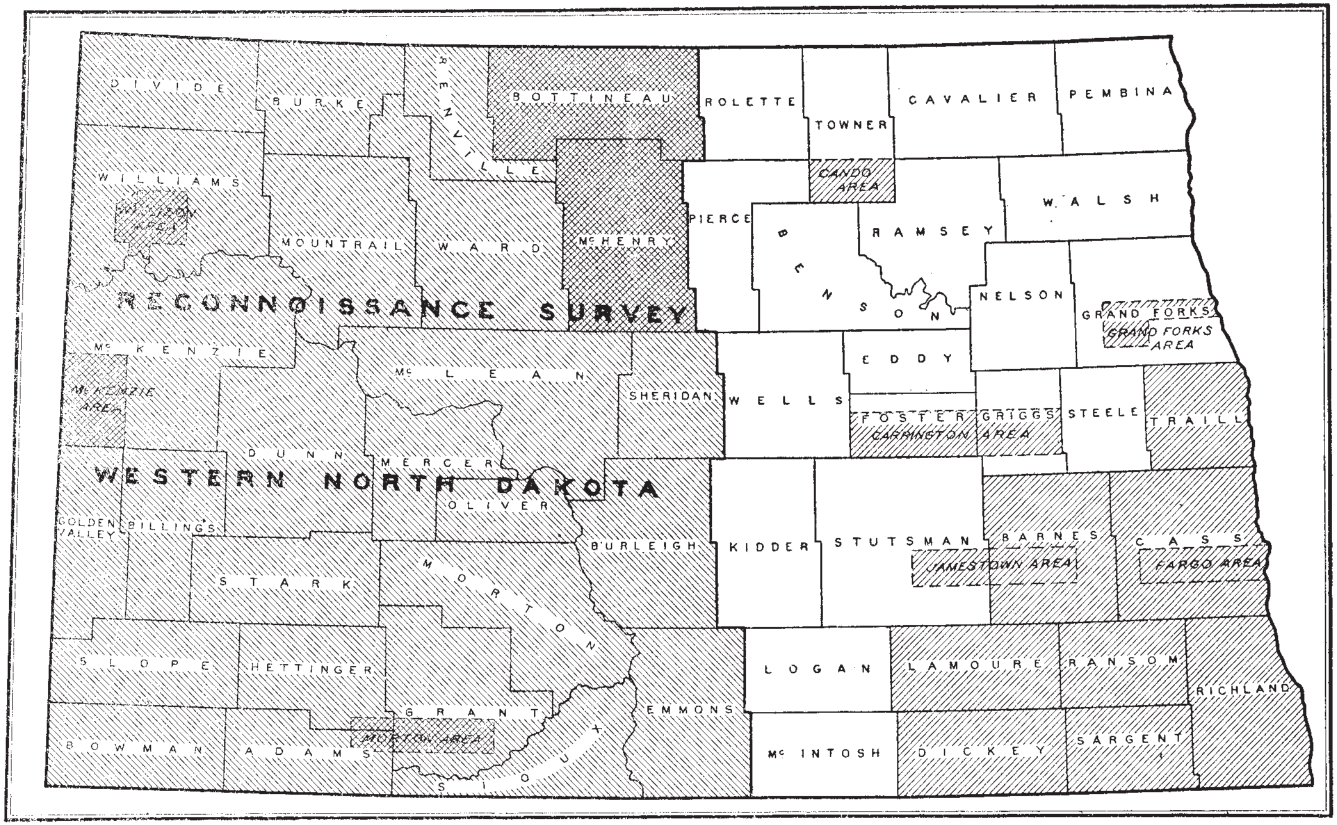
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in North Dakota, shown by shading

U.S. GOVERNMENT PRINTING OFFICE: 1929

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