

SOIL SURVEY OF THE MARSHALL AREA, MINNESOTA.

By HENRY J. WILDER.

LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed lies entirely within Lyon County, which is in southwestern Minnesota, 18 miles east from the Dakota line and 48 miles north from Iowa. The county contains 20 townships, of which the 6 lying nearest the center, Nos. 110, 111, and 112, ranges 41 and 42, comprising an area of 233 square miles or 149,184 acres, were surveyed.

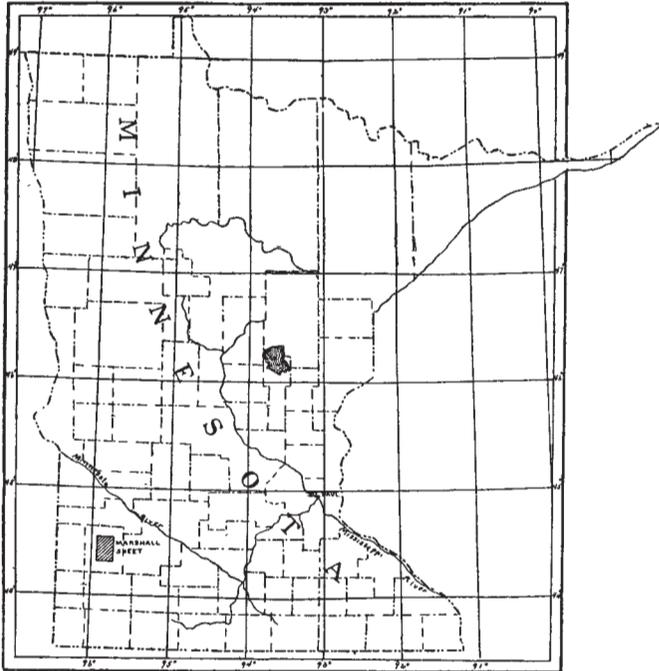


FIG. 40.—Sketch map showing location of the Marshall area, Minnesota.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Prior to the Sioux massacre of 1862 the only white settlers within the present limits of this county were traders who had established stations in the areas now included in the townships of Lynd and Custer.

In June, 1867, the first permanent settlement was made in Lynd. The townships of Custer and Stanley received settlers in 1868, and from that time steady immigration has continued. The first houses were built of logs or sod. A sawmill was started in 1869, continued in operation for three years and then, the supply of timber giving out, was changed to a gristmill. Fishing and hunting were good in the early days of settlement, and in some sections there was considerable trapping.

Lyon County was organized in 1872. The majority of the settlers at that time were chiefly attracted thither by the offer of free Government land. They were mostly speculators who intended to hold their claims only until the growth of population should make their lands valuable. As a result few efforts at farming were made.

The land grant to the Winona and St. Peters Railway included all the odd sections for 10 miles on each side of the road. It was built in a northwesterly direction from one corner of the county to the other, leaving Lynd, the county seat, about 8 miles to the south. In 1872 the railway reached the Redwood River, and in the following year the county seat was removed from Lynd to Marshall, because the latter town was centrally located and on the railway.

By this time, in spite of the northwestern blizzards which visited this section and caused much suffering and often death, settlers from the Eastern States had scattered over a large part of the county. The foreign immigration was large, and included Scandinavians, Belgians, Irish, French, Scotch, and Icelanders. The level and open prairie, with its many streams and lakes and its deep, fertile soil, was very attractive to settlers, and the inflow of immigrants was constant. The prairies afforded excellent pasturage for stock, and were readily prepared for planting. The early settlers cultivated wheat as the principal crop, and to a less extent oats, barley, corn, and flax.

The only timber found at the time the county was settled was located along the stream courses and around a few lakes. This supply was soon exhausted, and many farmers planted small areas to forest trees. At present these trees are only large enough for fuel, but they serve as a most desirable protection from the wind both for dwellings and for crops on the exposed level fields.

CLIMATE.

The climatic conditions of Lyon County are characteristic of the region of the Northwest, being marked by a moderate rainfall and a rather low temperature.

The following table, showing the normal monthly and annual temperature and precipitation, is compiled from the records of the Weather Bureau station at Lynd. These records cover a period of ten

years, and are believed to represent fairly the conditions throughout the area.

Temperatures of 104° have been recorded during the month of August, and the thermometer has registered as low as 38° below zero in February, so that the extreme range of temperature is about 142°. During the last eight years the average date of the last killing frost in spring has been about May 16 and of the first in fall October 4. The latest spring frost during that period occurred June 7 and the earliest in fall September 11. The ground usually freezes to a depth of about 3 feet during the winter, and sometimes has frozen to a depth of 6 feet.

Normal monthly and annual temperature and precipitation.

Month.	Lynd.		Month.	Lynd.	
	Temper- ature.	Precipi- tation.		Temper- ature.	Precipi- tation.
	° F.	Inches.		° F.	Inches.
January	13.2	0.55	August.....	68.8	2.78
February.....	13.3	.36	September.....	61.0	2.29
March.....	26.1	1.49	October.....	48.5	1.62
April.....	45.9	4.98	November.....	29.2	.90
May.....	57.3	3.20	December.....	19.9	.51
June.....	67.1	3.63	Year.....	48.5	25.15
July.....	71.6	2.84			

During the winter months the prevailing winds are from the northwest and north, but throughout the growing season they are from the southwest and south. Crops are most liable to suffer from drought during the month of July, when hot south winds often occur. The grain crops often suffer in May and June, but corn is usually revived by the rains of August and September, and a fair yield secured. Once in perhaps five or six years a hot south wind will blow continuously for several days, and if this occurs just as grain is in the milk stage its effect is most disastrous, as it causes the kernels of grain to shrivel. The yield is then small and the quality is greatly impaired. A remnant of the hot simoon winds which occur in Kansas and Dakota sometimes reaches this area and causes all crops to wilt seriously.

PHYSIOGRAPHY AND GEOLOGY.

The surface of the Marshall area consists of a vast prairie of gently undulating or, in some portions, moderately rolling till or glacial drift, which almost imperceptibly increases in elevation from northeast to southwest until it ascends to the highland known as the "Coteau des Prairies." The rise in elevation from Lucas, the northeastern township of the county, where the mean elevation is 1,125 feet above sea level, to the beginning of the Coteau des Prairies in Lyons Township

is only 350 feet in a distance of 25 miles, and in the first half of this distance the increase in elevation is only 75 feet.

The elevated tract of land extending from southeast to northwest through the southwestern part of the county was called by the earliest French explorers the "Coteau des Prairies," meaning the Highland of the Prairies. On the northeast border of this highland is the second terminal moraine of the last ice sheet. The most hilly part of this moraine is a belt from a half mile to $1\frac{1}{2}$ miles wide along the border of the prairie. At that line it has usually many irregular knolls, hills, and short ridges, which are from 25 to 50 feet above the intervening depressions.

In this highland the streams of the area have their source. Of these water courses the Redwood River is the most important. It crosses Lyon County from southwest to northeast, and its drainage basin, with that of its most important tributary, Three-mile Creek, includes an area of 325 square miles in this county. An area of about 240 square miles in the southern and southeastern parts of the county is drained by the Cottonwood River and its many branches. These streams have cut valleys from 20 to 75 feet below the general level. Both the Redwood and Cottonwood rivers are tributary to the Minnesota River.

Formerly there were many lakes in the county, but most of these are now dry and in many cases their beds are tilled. The only lake of importance in the area surveyed is Lake Marshall, in the southeast corner of Lake Marshall Township.

The greater part of the soil of this area is derived from the boulder clay of the unmodified glacial drift. This deposit consists of materials gathered during the Ice Age from a district to the north and spread over this region in an unstratified mass. This sheet is chiefly of clay, but also includes considerable proportions of sand and gravel and occasional boulders. The majority of these boulders are granite and gneiss, while the clay is thought to be derived from the beds of clay and shale of Cretaceous age, which are believed to underlie the glacial drift throughout the greater part of this area. A few outcrops of sandstone have been found in the northwestern part of the county, and clay and shale, bearing characteristic Cretaceous fossils, have been encountered in digging wells in Eidsvold and Grandview townships.^a

Fragments of magnesian limestone are of frequent occurrence throughout the area, and in the pulverized form this is an important ingredient of the soils. It has the disadvantage, however, of making the water of the region very hard, thus rendering it less suitable for boiler purposes.

^a Vol. I, Geology of Minnesota.

SOILS.

Eight types of soil were recognized in the area surveyed. The following table shows the acreage of each type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall loam.....	108,352	72.7	Marshall gravel	1,216	0.8
Miami black clay loam.....	29,760	19.9	Marshall gravelly loam.....	960	.6
Miami loam.....	3,968	2.7	Meadow	448	.3
Fairview sandy loam	3,008	2.0	Total.....	149,184
Marshall sandy loam.....	1,472	1.0			

MARSHALL LOAM.

The surface soil of the Marshall loam consists of a medium or heavy dark-brown or grayish-brown loam, with a depth of from 6 to 14 inches. In the greater part of the area the soil has an average depth of 12 inches, and is sufficiently stiff to be classed as a hard soil to plow. On the crests of hills, where the soil is more shallow, the color usually is a brownish yellow, due to the incorporation of some of the yellow subsoil during the processes of cultivation. The subsoil is a heavy, stiff, yet sticky yellow clay loam or clay to a depth of 3 feet. This is underlain by stiff yellow or mottled bowlder clay, which becomes very stiff and hard when thoroughly dried. This material is often exposed in railway cuts to a depth ranging from 30 to 40 feet. Occasionally this clay gives way to a slightly stiffer blue clay at a depth of from 10 to 30 feet. This change is frequently found in boring wells and sometimes may be seen in railway cuts and along the bluffs of the Redwood River.

The Marshall loam is the most extensive soil type in the area surveyed. It extends in a broad, unbroken belt from northwest to southeast across the southern half of the area, while it is the predominant type in the northeastern half, where it is more or less interrupted by areas of Miami black clay loam. It also occupies large connected areas in the townships adjoining the area on the west and south.

The boundaries of the main body of this type are distinctly marked. Beginning at the valley which extends directly northwest from Lake Marshall to the northwestern corner of Grandview Township, a low, steep bluff or a series of low foothills indicates for much of the distance a sharp change of soil type. In other places the slope from the valley to the uplands is so gradual that it is hardly noticeable in driving several miles, though the change of soil type can be readily determined. Once the level of the upland is reached the major part of the surface of this main area is level or gently rolling, though in local areas it is

prominently rolling and even hilly. This region is commonly spoken of as the clay uplands.

The streams have cut deep, narrow valleys, the steep slopes of which are mostly uncultivated. West of Lynd the Redwood River has carved for some distance through this type a valley 100 feet or more in depth. The slopes are much too steep to be cultivated, and, besides, they are very gravelly in some places. The soil is thin and frequently the yellow boulder clay is very near the surface. These slopes are generally covered by a growth of scrubby trees, which grow better there than on the open prairie, because of the protection from the sweeping winds which is afforded by the banks.

Several variations of this type were noted. In some places low ridges and small knolls of sandy or gravelly texture occur, but do not cover a sufficient area to be classed as a separate type. Narrow bands of lighter, sandier soils also occur in a number of places in the Marshall loam. In section 2 of Lynd Township the Marshall loam grades so imperceptibly into the Miami black clay loam that the boundary between the two types had to be drawn arbitrarily, the soil partaking of the nature of both types. In Fairview Township, on the east side of section 24, the subsoil grades into medium sand at a depth of 30 inches. In the northeast corner of section 7 of the same township small areas of gravel occur. This gravel is all fine to medium in size, and is found most frequently on the small rounded knolls. It is sometimes found on the surface, but more often is mixed evenly with both the soil and subsoil.

Along the east side of sections 13 and 24 of Lake Marshall Township the subsoil is underlain at a depth of from 27 to 36 inches by a loose, sandy loam, which contains a small amount of silt. This material is extremely incoherent, and resembles road dust, even when the soil above is in a moist condition.

The mean elevation of the areas lying in the northeastern half of the county is less than that of the upland. The surface of these areas is rolling, and the drainage is good. The drainage in the upland area also is well established, and sufficient for a section with so little rainfall as this, though artificial drainage would be beneficial in a few small, low-lying areas.

The soil is derived from the unstratified mass of materials spread over this region in glacial times. The stones and boulders which were scattered over small areas of this type have been removed from the more level portions. Occasionally pebbles occur on the surface of the soil, and sometimes they occur in the subsoil, but not in sufficient quantity to interfere with cultivation or to affect the crop value.

The Marshall loam is the safest soil in the area, as it is the surest to produce at least an average crop. This is because the heavy clay loam subsoil is very retentive of moisture, and in the seasons of most severe

drought this always prevents total failure and generally insures a good yield. On the other hand, the rolling topography of this formation insures good drainage, and in a season of excessive rainfall a much better crop is harvested than on the lower lying types of soil.

The estimated average yields on this soil are 33 bushels of corn, 13 bushels of wheat, 40 bushels of oats, 35 bushels of barley, and 10 bushels of flax per acre. The Marshall loam, taken as a whole, excels all other soil types of the area in the production of wheat, on account of the superior quality of grain produced. Further mention of this characteristic soil feature is made in describing the principal agricultural products in the final chapter of this report.

The Marshall loam is also well adapted to dairying and stock raising, and as returns from wheat farming are decreasing rapidly, it should be devoted to these industries.

The results of mechanical analyses of the soil and subsoil of the Marshall loam are given in the following table:

Mechanical analyses of Marshall loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
8406	Sec. 21, Fairview.	Black loam, 0 to 10 inches.	P. ct. 4.65	P. ct. 2.34	P. ct. 5.56	P. ct. 6.40	P. ct. 24.80	P. ct. 15.50	P. ct. 36.00	P. ct. 7.98
8386	Sec. 17, Lake Marshall.	Loam, 0 to 10 inches..	4.05	1.84	8.96	6.74	19.06	14.06	40.10	12.12
8388	Sec. 10, Sodus.....	Loam, 0 to 8 inches...	3.72	2.42	7.18	7.52	19.84	13.98	36.44	12.58
8410	Sec. 30, Fairview.	Medium loam, 0 to 12 inches.	5.29	1.06	3.68	5.00	17.52	12.50	47.38	12.82
8407	Subsoil of 8406....	Heavy clay loam, 10 to 36 inches.	2.19	1.68	5.12	6.26	22.56	12.88	34.90	16.56
8411	Subsoil of 8410....	Clay loam, 12 to 36 inches.	6.64	1.12	4.84	5.30	16.46	10.40	40.18	21.70
8389	Subsoil of 8388....	Brown clay loam, 8 to 36 inches.	1.00	2.04	5.88	5.62	13.10	9.30	37.86	26.20
8387	Subsoil of 8386....	Drab clay loam, 10 to 36 inches.	1.05	2.22	4.80	4.62	11.66	8.98	38.66	29.00

The following samples contained more than one-half per cent of calcium carbonate (CaCO₃): No. 8388, 1.44 per cent; No. 8407, 6.87 per cent; No. 8411, 1.08 per cent; No. 8389, 12.98 per cent; No. 8387, 12.18 per cent.

MIAMI BLACK CLAY LOAM.

The surface soil of the Miami black clay loam is a rich, mellow, very black clay loam from 8 to 24 inches deep, with an average depth of 14 inches. In dry seasons the characteristic deep-black color is said to turn somewhat ashy. The soil is easy to till when dry and in proper condition for working, but becomes very sticky when wet.

The subsoil consists of clay loam, steel or drab in color, slightly heavier than the surface soil and very tenacious. Near the line of contact with the Marshall loam this material grades into the stiff subsoils of that type at depths ranging from 3 to 6 feet, and it is probable that this character of subsoil underlies the entire formation.

The most important occurrence of this type is in the low-lying area at the foot of the Marshall loam uplands. Beginning near Lake Marshall, at the extreme southeast corner of the township of that name, a band or valley of this soil from 1 mile to 2 miles wide extends directly northwest for a distance of 18 miles, broken only at the Redwood River, where it is replaced by the Miami loam for a distance of 3 miles. This band also extends far beyond the limits of the present survey.

In Grandview Township many smaller areas of this soil are connected with the above-mentioned band on the east. So continuous are these areas that this type occupies, in the aggregate, more than half of Grandview Township. There are also extensive areas along the valleys of Redwood River, and of Three-mile Creek in the township of Fairview. Many small areas of this type are found throughout the area surveyed, due to the imperfect drainage conditions which obtain in the depressions which they occupy.

There is one notable occurrence of the Miami black clay loam which illustrates admirably its formation at the present time. Formerly many glacial lakes existed in the area surveyed, but of these Lake Marshall is the only one that has never been dry. All of these lakes were shallow, and depended upon drainage from the surrounding slopes for their supply of water. When the land was broken for farming purposes, the soil absorbed so much more moisture than it had before that the lakes, deprived of their usual supply of water, began to decrease in volume, and in a few years the smaller ones were dry. Black Rush Lake, which had an area of 420 acres, has been dry for several years and good crops have been grown in its bed. Unusual rains, however, have flooded this lake bed in part at the time of the present survey (May, 1903), but the owner has resorted to artificial drainage and thus has insured against damage from like conditions in the future.

The accumulation of organic matter which naturally takes place in these depressions, supplemented by the slight wash from the surrounding slopes, explains the formation of this soil.

In sections 6, 11, and the northeastern part of 14 of Fairview Township small areas of this type are underlain at a depth of from 24 to 30 inches by fine to medium gravel, in quantity almost sufficient to form a bed. In a few places it is difficult to penetrate this with the auger, but usually it is a mass made sticky with the subsoil of the true type.

The same crops are grown on this soil as on the Marshall loam, but

the acreage of wheat is relatively small, and the yield of corn is noticeably larger than is obtained on that type of soil. The crop returns in general are comparatively high. The average yield of corn is nearly 40 bushels, that of wheat 16 bushels, and of oats 40 bushels to the acre.

As a corn soil the Miami black clay loam is markedly superior to the Marshall loam, even under the prevailing methods of cultivation, and it is probable that a more intensive system of farming would make the difference in yield still more striking. Occasional yields, far in excess of the average given above, indicate, in some measure, the excellent returns that may be obtained when the land shall be thoroughly subdued and carefully cultivated.

Wheat grown on the Miami black clay loam, however, puts on a too heavy growth of straw and is liable to lodge. This tendency, together with the inferior grade of wheat produced, makes it impossible for farmers on this soil to compete, in the production of that grain, with those located on the large adjoining areas of the Marshall loam.

White alkali is found in local areas of this type, but it does not occur in sufficient quantity to change the crop conditions of the soil.

The texture of both soil and subsoil is shown in the following table of mechanical analyses:

Mechanical analyses of Miami black clay loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
8394	Sec. 22, Lyons T...	Black clay loam, 0 to 10 inches.	8.85	0.60	7.24	8.00	18.98	13.22	37.08	14.84
8392	SE. cor. sec. 22, Lake Marshall T.	Black loam, 0 to 12 inches.	5.73	.14	1.76	3.48	21.70	16.46	39.72	16.72
8396	Sec. 28, Grandview T.	Black clay loam, 0 to 14 inches.	7.65	1.88	4.36	5.34	14.76	12.00	42.90	18.76
8397	Subsoil of 8396....	Heavy black clay loam, 14 to 36 inches.	3.46	1.54	4.94	5.68	16.06	12.58	42.12	16.96
8395	Subsoil of 8394....	Black clay loam, 10 to 36 inches.	6.07	1.06	6.40	6.10	15.18	11.10	39.14	20.28
8393	Subsoil of 8392....	Black clay loam, 12 to 36 inches	2.72	.26	1.52	2.96	19.80	13.38	39.04	23.04

The following samples contained more than one-half per cent of calcium carbonate (CaCO₃): No. 8392, 2.76 per cent; No. 8393, 3.62 per cent.

MARSHALL GRAVEL.

The Marshall gravel is one of the less extensive soil types of the Marshall area. Bordering Lake Marshall on the east for a distance of about 2 miles there is a series of steep knolls of glacial origin which extend back from the lake for a distance not exceeding one-third of a

mile. The soil is a sandy loam containing a very high percentage of fine gravel. At a depth of from 15 to 18 inches this gravel becomes a band so dense that it is impossible to penetrate it with a soil auger. A railway cut discloses pockets of medium sand underlying this band of gravel.

The other chief occurrences of this type are on the hills along the Redwood River in Lyons Township. The soil here is somewhat more loamy than that just described, but the band of gravel lies much nearer the surface.

This soil is seldom cultivated, but furnishes good pasturage early in the season. Some of the knolls contain an excellent quality of gravel for roadbed material, and a considerable tract near Russell has been bought by the railway company for use in roadbed construction.

The following table gives mechanical analyses of the fine earth of this soil:

Mechanical analyses of Marshall gravel.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
8404	½ mile E. of Russell T.	Brown sandy loam, 0 to 12 inches.	5.85	9.68	20.78	11.90	15.28	6.00	27.48	8.88
8402	Sec. 5, Lyons T. . . .	Brown sandy loam, 0 to 15 inches.	5.00	7.20	18.04	16.60	18.22	5.40	23.98	10.56
8405	Subsoil of 8404. . . .	Gravel and sand, 12 to 36 inches.	1.81	12.96	33.26	19.80	9.66	3.10	12.56	8.66
8403	Subsoil of 8402. . . .	Gravel and sand, 15 to 36 inches.	2.92	13.24	22.02	13.70	15.70	5.38	17.28	11.90

The following samples contained more than one-half per cent of calcium carbonate (CaCO₃): No. 8403, 1.68 per cent; No. 8405, 7.80 per cent.

FAIRVIEW SANDY LOAM.

The surface soil of the Fairview sandy loam is a heavy brown sandy loam, fine to medium in texture, with a depth of about 18 inches. This is underlain by medium sand to a depth of 36 inches. Like the Marshall sandy loam, this type is irregular in occurrence, but usually occupies low ridges between the Miami black clay loam and the Marshall loam.

A light phase of this type occurs on the ridge just west of Lake Marshall, and here a few stones are found scattered over the surface.

The Fairview sandy loam is a well-drained soil of glacial origin, but is too light for good results with the staple crops. Corn yields from 15 to 25 bushels, oats from 25 to 30 bushels, barley from 20 to 25 bushels, and flax from 8 to 9 bushels per acre.

In the following table the mechanical analyses of samples of this soil are given:

Mechanical analyses of Fairview sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
8414	Sec. 9, Fairview T.	Medium sandy loam, 0 to 18 inches.	2.82	1.52	14.00	22.96	24.82	6.04	23.64	7.02
8416	Sec. 15, Fairview T.	Brown sandy loam, 0 to 12 inches.	3.56	2.32	10.86	11.26	34.14	7.56	23.18	10.10
8415	Subsoil of 8414....	Medium sand, 18 to 36 inches.	.79	1.74	14.10	30.20	29.60	3.70	10.12	10.12
8417	Subsoil of 8416....	Medium sand, 12 to 36 inches.	.64	1.54	10.66	33.20	22.38	8.98	12.02	10.90

MIAMI LOAM.

The surface soil of the Miami loam consists of rich, mellow black loam, with a depth of from 20 to 24 inches, grading into a yellow loam subsoil. Both soil and subsoil often contain a small amount of medium sand. A low percentage of surface gravel occurs in small patches. When not in a moist condition the surface soil cracks open.

The Miami loam occupies the broad and level terrace along the Redwood River, where that stream, after emerging from the uplands, crosses the long belt of Miami black clay loam which extends diagonally across the area. There are also a few narrow bands of this soil farther down the river. Although nearly level, this type is, for the greater part, well drained because of its mellow nature. The soil was formed by river deposit.

This is perhaps the most productive soil of the area, and is tilled much easier than the upland soils. Wheat yields from 16 to 20 bushels, corn from 35 to 45 bushels, oats from 40 to 75 bushels, barley from 20 to 60 bushels, and flax from 13 to 15 bushels per acre.

The Miami loam, although of small extent, is an important soil. It is adapted particularly to the production of corn, and it gives excellent yields of the small grains, though the quality of the wheat is inferior to that grown on the uplands.

In sections 4, 5, 7, and 8 of Lake Marshall Township narrow bands of a sandy loam occur between the Redwood River and the Miami loam. The area of this soil probably does not exceed 35 acres, and it was mapped as a phase of the Miami loam. It is subject to overflow in times of high water, and on this account is used mostly for pasturage, though crops may be grown successfully in seasons free from floods.

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

Mechanical analyses of Miami loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
8382	Sec. 12, Lynd T....	Black loam, 0 to 15 inches.	4.03	1.74	6.40	7.28	16.82	13.96	42.46	11.24
8380	Sec. 7, Lake Marshall T.	Medium loam, 0 to 12 inches.	4.30	5.54	16.66	10.82	15.80	10.50	29.24	11.44
8383	Subsoil of 8382....	Light loam, 15 to 36 inches.	5.29	.50	2.32	4.04	16.38	17.80	48.58	10.36
8381	Subsoil of 8380....	Medium loam, 12 to 36 inches.	3.80	5.52	17.44	12.66	15.98	9.02	25.68	13.60

The following samples contained more than one-half per cent of calcium carbonate (CaCO_3): No. 8380, 1.60 per cent; No. 8381, 5.44 per cent; No. 8382, 5.12 per cent; No. 8383, 4.03 per cent.

MARSHALL GRAVELLY LOAM.

The surface soil of the Marshall gravelly loam is a heavy loam from 10 to 15 inches deep, usually containing from 5 to 25 per cent of fine gravel, underlain by a dense band of fine gravel.

The type occurs only in the township of Lyons, where it occupies the slopes at the foot of the Marshall gravel hills as they grade down to the surrounding Marshall loam. The soil is a composite of these two types, and is derived from reworked glacial material.

The Marshall gravelly loam produces fairly good crops in favorable seasons, but is liable to suffer from drought. It is used also to some extent for pasturage.

The following table gives the results of mechanical analyses of the fine earth of this type:

Mechanical analyses of Marshall gravelly loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
8420	$\frac{1}{2}$ mile S. of Russell.	Medium loam, 0 to 10 inches.	6.46	7.50	12.64	7.04	14.50	14.08	30.16	13.28
8418	SE. cor. sec. 21, Lyons T.	Medium loam, 0 to 12 inches.	7.76	7.32	20.14	10.78	8.74	5.86	28.84	17.90
8421	Subsoil of 8420....	Gravel and sand, 10 to 36 inches.	2.28	7.98	18.00	14.34	18.92	11.24	18.02	11.50
8419	Subsoil of 8418....	Gravel and sand, 12 to 36 inches.	2.87	9.24	28.08	16.34	9.42	5.50	16.98	14.32

The following samples contained more than one-half per cent of calcium carbonate (CaCO_3): No. 8419, 4.47 per cent; No. 8421, 7.28 per cent.

MARSHALL SANDY LOAM.

The surface soil of the Marshall sandy loam consists of a dark-brown sandy loam from 8 to 14 inches deep. The subsoil is a sandy loam somewhat heavier than the soil, contains small amounts of fine gravel, and is underlain by gravel.

This type is found chiefly in Lyons Township and is irregular in occurrence. It occupies gently rolling country or the slopes between the Marshall gravel and the Marshall loam or the Miami black clay loam, a position similar to that of the Marshall gravelly loam. In some cases it is reworked material between the Fairview sandy loam and the Marshall loam. It also occurs bordering the depressions of the Miami black clay loam.

The Marshall sandy loam thus is seen to be both glacial and alluvial in origin. It produces average crops of the cereals in seasons when moisture conditions are favorable, but it is so unretentive of moisture that crop yields are very uncertain under the semiarid conditions which prevail in the area.

The following table contains mechanical analyses of the Marshall sandy loam:

Mechanical analyses of Marshall sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
8398	2½ miles NE. of Russell.	Brown sandy loam, 0 to 10 inches.	3.53	4.62	13.96	12.72	22.50	10.08	24.00	12.06
8400	NE. cor. sec. 22, Lyons T.	Sandy loam, 0 to 14 inches.	6.03	5.88	18.54	16.20	16.42	5.00	24.88	13.04
8401	Subsoil of 8400....	Sandy loam, 14 to 36 inches.	2.46	2.82	16.06	19.48	23.58	6.52	21.50	10.02
8399	Subsoil of 8398....	Sandy loam, 10 to 36 inches.	.29	5.74	15.10	14.72	26.90	8.04	16.26	13.12

The following samples contained more than one-half per cent of calcium carbonate (CaCO₃): No. 8401, 1.13 per cent; No. 8399, 1.03 per cent.

MEADOW.

The occurrence of Meadow in this area is so limited that it requires only a brief description. In nearly every case the low-lying areas adjoining stream courses have been classified with the soil types already described, because they are very rarely overflowed. Limited areas along the Redwood River and Three-mile Creek, however, can be classed only as Meadow.

The soils classed under this type name are very indefinite in character, but in this area they usually consist of a large proportion of sand

with streaks of gravel, marking a former stream course through the type. These areas are for the most part uncultivated and are used for pasturage.

AGRICULTURAL METHODS.

The prevailing methods of cultivation throughout the area are still crude. The general principle seems to be to give the land as little preparation as possible and hope that a favorable season and the natural productiveness of the soil will overcome this lack of cultivation and insure a good crop.

Only a small proportion of the land is properly fitted for planting. The land is plowed to a depth of 3 or 4 inches with a double gang plow drawn by 3 or 4 horses. In many cases the furrows are left at a slant of 45 degrees. After going over this once with a "drag" or spike-toothed harrow it is planted.

Every possible precaution should be taken in this climate for the conservation of soil moisture. For this reason, if for no other, shallow plowing should be abandoned and the soil stirred as deeply and as thoroughly as practicable. The more successful farmers have come to realize this, and methods of cultivation are improving rapidly.

It is claimed by some of the best farmers that new land will produce now twice the amount of wheat that it would twenty years ago, because of the improved implements used in preparing the soil. Then the "drag" was the only implement used, and unfortunately its sole use is still adhered to by many.

Nearly every farm is well equipped with modern harvesting machinery, but many wasteful practices are still common, as is indicated by the reapers that are left unsheltered all winter.

When the country was first settled the same methods of cropping were employed as have always obtained on virgin soils of the western States. Wheat has been the almost universal crop until profitable yields are no longer produced. Indeed, so strong is the force of habit that wheat is sown even after the unprofitable stage is reached.

It is said that continuous cropping to wheat does not exhaust the soil provided it is properly worked and fertilized, but these requirements have been supplied by very few, and for the last two or three years the acreage of wheat has decreased rapidly.

For many years little stock was kept and no manure was applied to the soils. At the present time the manure that is made on the farm is hauled to the fields, generally as fast as it is made, but in quantity this is sufficient only for about one acre in twenty under cultivation. No commercial fertilizer is used. The greater part of the manure is used for corn.

The unprofitableness of wheat for the past few years has caused more attention to be given to other crops. Corn yields well on land which has been exhausted by successive cropping with wheat, and

consequently it is destined to be, if indeed it is not already, the leading crop of this region.

Flax, like wheat, has been raised ever since the country was settled. Usually it has been sown on new ground just after breaking, and has been followed by wheat. Flax should be sown just as soon as the land can be plowed. It will then get ahead of the weeds, which it will choke out, and leave the land clean. To get a good stand is the chief difficulty. If the ground is moist when the seed is sown a good stand is assured, but if dry only the seed which is in the moist soil underneath the dust blanket will germinate. This gives the weeds a chance to get started and they smother the late-germinating flax plants.

Flax can be grown on a field only once in five years, because of a fungous growth which develops on the decaying flax stubble. This fungus attacks the crop of the following season when it is about 2 inches high, causing it to wilt, and bringing total failure of the crop. At the end of five years no trace of the old straw will remain, and another crop can be grown successfully.

Flax is an exhaustive crop on the soil, but is little affected by drought because of its long taproot, which penetrates the heavy clay subsoil.

Oats and barley are also important crops, and the acreage devoted to their growth is increasing slightly.

A regular rotation of crops is practiced by the most careful farmers, but too frequently no system is followed and crops are planted in any sequence that seems convenient. One of the more common rotations at the present time is wheat, followed by corn, oats, barley, and flax. Those who still raise a large proportion of wheat break the continuity by an occasional shift with corn and oats. More careful attention to the method of crop rotation and to the system of cultivation is earnestly recommended.

AGRICULTURAL CONDITIONS.

The farmers of the Marshall area are just now enjoying a period of general prosperity. The rapid improvement in farm equipment, the increase of more desirable farm buildings, the safe extension of credit, and the encouraging growth of the business centers which depend almost entirely on the financial condition of the surrounding farmers all attest this fact. This condition, however, has not been constant. Partial crop failures have not been uncommon, and there are but few farmers who have not experienced periods of depression during which it was difficult to meet their obligations. A succession of unfavorable seasons has often brought business failures to those who had insufficient capital to tide them over these years of poor crops. Those who have been able to pass through these depressing periods and still have a working capital have almost invariably been able to recuperate and are now prosperous.

It is estimated that from 80 to 90 per cent of the farms of the area are tilled by the owners, but probably 75 per cent of this number are subject to mortgage to secure loans on the real estate, and a large proportion of the remaining 25 per cent are mortgaged to the amount of one-fourth their value to procure improved farm equipment. The farmers of more limited means usually hold a deed to at least one half of their land, which is subject to mortgage, and have a contract for a deed to the other half of their holdings.

The usual method of renting land is by the share system, by which the landowner gets one-third of all the crops delivered free, but pays the cost of thrashing his share. Rarely the owner furnishes the seed and receives one-half the crop. The payment of a stated cash rental is less common, but seems to be growing in favor. In such cases the rent paid ranges from \$1.25 to \$3 an acre.

The farms vary in size from a quarter-section (160 acres) to one or more sections. Probably one-half of the farms of the county comprise a half-section, or 320 acres. Farms of 160 acres are considered small, and are about equal in number to those of 480 acres, or three-quarters of a section. An entire section is a large farm, and few hold a larger tract unless for speculation.

Labor presents a serious problem. It is difficult to hire efficient help that can be depended upon to remain throughout the season. Trouble of this kind may be avoided by those farmers who are so situated that they can give their men employment by the year, paying wages slightly above the rates generally established. The exceptional wages offered by the owners of thrashing machines during the period of harvest are sufficient temptation to cause many of the laborers to break their agreement to work for the season. It is said that two-thirds of the farm help is foreign born, and that the children of such parents constitute the greater part of the remaining third.

The character of the principal products is changing rapidly, as the area is just in the stage of transition from grain farming to stock raising and dairying. The inability to withstand the competition of the cheaper land farther west and north, which as yet has not become too exhausted by successive cropping for the profitable production of wheat, is the cause of this change. Because of these conditions the acreage of corn is being increased at a phenomenal rate, and the introduction of stock follows closely to make a market for the corn. Inasmuch as the season is a little shorter than in the corn-growing States farther south, it is necessary to plant a variety of corn which matures early, even though it does not yield as much as the varieties which mature later.

Oats are a secondary crop, though good yields of excellent quality are produced when sown early.

White barley of the best quality does not grow in this country, and consequently barley is one of the less important crops. The barley grown here is not suitable for malting purposes because of its dark color, and as a result most of it is shipped to Chicago to be ground for stock feed.

Spelt has been introduced to a limited extent and gives enormous yields of grain which may be utilized as food for fattening hogs.

Flax is considered a sure money crop and the straw furnishes a poor quality of roughage feed for stock.

Hay is not a successful crop because of its liability to suffer from drought and because proper methods of cultivation are not in use. Timothy and clover are raised in small quantities, but are not considered safe crops. The tame grasses do not grow well until all of the wild sod has been killed. Bluegrass and redtop have been tried successfully for pasture and satisfactory experiments have been made with Hungarian brome grass (*Bromus inermis*), which is less susceptible to damage by frost and drought than the other varieties of grasses, though it can not be used as pasture until the second year of growth. Many farmers depend upon millet and oats as substitutes for hay. Experiments are being made to test the possibility of using sorghum for hay, the seed being sown very thickly with drills.

Vegetables and fruit are not produced in sufficient quantity to supply the local demand.

Little attention has been given in this area to the adaptation of soils to crops. Wheat has been the principal crop grown on every type of soil. Differences in the quality of the wheat, however, can be traced directly to the type of soil upon which the grain is produced. In wet seasons the uplands of the Marshall loam produce practically all of the No. 1 wheat sold from the area. In dry seasons the areas lying northeast of the diagonal of the county also produce some wheat of first quality. In general, the wheat from the Miami black clay loam averages about one grade lower than that from the upland Marshall loam areas, while that from the lower lying areas is about midway between them. On the other hand, the Miami black clay loam easily excels in the production of corn, oats, barley, and grass.

The transportation facilities of the area are good. The Chicago and Northwestern and the Great Northern railway systems traverse the area diagonally and cross near the center of the county. The former is the direct route to Chicago, and the latter to Minneapolis, St. Paul, and Sioux City. Excellent markets are made easy of access by these convenient railway systems. Grain is shipped chiefly to Minneapolis and St. Paul, live stock to Sioux City and Chicago, and cream, except that hauled by teams to the Marshall creamery, to Sioux Falls and Minneapolis.

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