

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION, R. W. THATCHER, DIRECTOR; F. J. ALWAY, CHIEF
DIVISION OF SOILS.

SOIL SURVEY OF STEVENS COUNTY,
MINNESOTA.

BY

P. R. McMILLER, OF THE UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION, IN CHARGE, AND REESE F. ROGERS AND WILLIAM G. SMITH, OF THE U. S. DEPARTMENT OF AGRICULTURE.

THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1919.]



WASHINGTON:
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1922,

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., April 26, 1921.

SIR: In the extension of the soil survey in the State of Minnesota during the field season of 1919 a survey was undertaken in Stevens County. This work was done in cooperation with the University of Minnesota Agricultural Experiment Station.

I have the honor to transmit herewith the manuscript report and map covering this work and to request their publication as advance sheets of Field Operations of the Bureau of Soils for 1919, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. H. C. WALLACE,
Secretary of Agriculture.

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MAP.

Soil map, Stevens County sheet, Minnesota.

SOIL SURVEY OF STEVENS COUNTY, MINNESOTA.

By P. R. McMILLER, of the University of Minnesota Agricultural Experiment Station, In Charge, and R. F. ROGERS and WILLIAM G. SMITH, of the U. S. Department of Agriculture.—Area Inspected by THOMAS D. RICE.

DESCRIPTION OF THE AREA.

Stevens County is located in western Minnesota, approximately 150 miles west and 40 miles north of the Twin Cities. It is separated from the South Dakota line by only one tier of counties on the west, and is approximately 150 miles north of the Iowa State line. The county is practically square and has an area of 564 square miles or 360,960 acres.

Stevens County lies wholly within the prairie region of Minnesota and forms a part of the geologic province known as the Glaciated Plains. The topography was greatly altered from time to time by the advance and retreat of ice during the Glacial Period. The last retreat of the ice sheet left a drift-covered plain, varying in topography from flat to undulating and in some places hilly, in which numerous streams have developed a series of young valleys. The topography of the greater part of the county, however, is slightly undulating to gently rolling, the surface being marked by numerous sinks and depressions, shallow lakes and ponds, and level and irregular plains, practically all of these features being due to glacial rather than post-glacial action.



FIG. 1.—Sketch map showing location of the Stevens County area, Minnesota.

The eastern half of the county is covered with glacial drift of varying depths, which has formed a topography more undulating and, in some places, particularly along the streams, quite rolling. The hilly areas in this section are rather moderate as compared with the hilly areas occurring elsewhere, but very little of the county, if any, is hilly enough to prevent the use of farm machinery. On the other hand, the flat, poorly drained areas are large, and in wet seasons some difficulty is experienced in farming the land. Considerable effort is being made to drain these areas with open ditches and tile.

Where this work has been done satisfactorily great improvement has resulted in the quality of the land.

The western half of the county is flat to gently undulating, with almost level areas in Everglade, Eldorado, and Baker Townships, part of Donnelly and Morris Townships, and the western and southern parts of Scott Township. A small area in the northwestern corner lies in the bed of glacial Lake Agassiz.

Along both sides of Pomme de Terre and Chippewa Rivers and Mud Creek terraces from 10 to 18 feet above the level of the streams have been built varying in width from one-fourth mile to $1\frac{1}{2}$ miles. Higher terraces about 40 feet above the stream level occur in four isolated areas and are bordered by the upland till plain. The material comprising the terraces consists principally of gravel and coarse sand. Here the topography is nearly flat, but occasionally broken by shallow basins at lower elevations.

Over the eastern part of the county prominent valleys are of frequent occurrence. Excepting those now occupied by the Pomme de Terre and Chippewa Rivers and Mud Creek, they are not now occupied by streams, but are pitted by swamps and lakes containing rushes and other water-loving vegetation. They represent old stream channels that were partly filled with glacial drift during the advance of the glaciers. One of these valleys occurs in the northern part of Swan Lake Township and others are found in northern Framnas, northwestern Hodges, and central Darnen townships. Their rough, hilly appearance with abrupt slopes forms a topography similar to that adjacent to the present stream valleys.

The highest point in the county is in the extreme northern part of Swan Lake Township, where, according to the United States Geological Survey, the elevation above sea level is 1,250 feet. The lowest point is in the bed of the glacial Lake Agassiz, in the northwestern part of the county, 1,056 feet above sea level. Much of the upland averages 1,150 feet above sea level.

Numerous shallow lakes are situated among the modified morainic hills of the northeastern part of Stevens County. The largest are Pomme de Terre Lakes and Swan Lake in Swan Lake Township; Olson, Long, Cyrus, and Scandia Lakes in Framnas Township; Page Lake in Hodges Township; and Wintermute Lake in Morris Township. Large, shallow lakes are also found in the level west-central areas; among these may be mentioned Lake Hattie and Frog Lake in Scott Township and Fish Lake in Pepperton Township.

A noticeable feature of the topography is the large number of sinks or depressions, in many of which stagnant water stands the year round. They occupy areas ranging in size from a fraction of an acre to a square mile or more. The smaller ones are known locally as "potholes," the larger as marshes and sloughs.

Stevens County includes parts of two large drainage basins, the northwestern part of the county being included in the basin of the Nelson River, the remainder in the basin of the Mississippi River. The divide between the two is not clearly defined, as it traverses relatively flat country and a strip several miles wide may be drained either way. The divide enters Rendsville Township just west of Silver Lake and passes in a southwesterly direction to the southern border of Harstad Slough, thence through the town of Donnelly and southwest to the town of Chokio. From Chokio its course is westward.

The eastern and southern parts of the county are drained by the Pomme de Terre and Chippewa Rivers. Pomme de Terre River, the principal stream in the county, flows in a southerly direction and discharges its waters into the Minnesota River about 30 miles south of the county line. The Chippewa River, which flows in a southerly direction just outside the eastern border of the county, for most of the distance, but passes through the eastern part of Swan Lake Township for a distance of about 4 miles, affords drainage for areas in Swan Lake and Framnas Townships and a relatively large area in Moore Township. Both streams are sluggish, meandering, and very shallow, and during the greater part of the year the waters are muddy, with fine material washed from the adjacent slopes. During the years of early settlement dams were constructed at several places along the Pomme de Terre, which furnished power for the operation of small flour mills.

Mud Creek, the principal tributary of the Pomme de Terre River, drains large areas in Darnen, Morris, Pepperton, Scott, and Baker Townships. In places the channel of this stream has been straightened and deepened and it provides better drainage to a larger area than formerly.

Most of that part of the county included in the basin of the Nelson River is poorly drained by intermittent draws and open ditches. Owing to its level topography seepage is slow, and large areas are flooded during seasons of excessive precipitation.

Stevens County was organized in 1862, but the present boundaries were fixed in 1868. Settlement was retarded for some years after the numerous Indian massacres in 1862. Later, however, numbers of Norwegians settled near the lakes in the northeastern part of the county. The gently rolling topography of the section, together with small forested areas among the numerous lakes, afforded favorable and attractive sites for homes.

During the early sixties a stage line crossed the county, and a point on Wintermute Lake, known as Gager's Station, became a stopping point and trading center. During the late sixties and early seventies the population grew rapidly. The St. Paul & Pacific Railway, now

the Great Northern, was completed to Morris, and trains were running regularly by the late summer of 1871.

According to the Federal census, the population of the county increased from 174 in 1870 to 8,721 in 1900, but dropped to 8,293 in 1910, the decrease being caused by the exodus of people from the villages, especially Morris, to places outside of the county. In 1920 the population was 9,778. Of the total number of inhabitants in 1910, 75 per cent were native born. The foreign population consisted principally of Norwegians, Germans, Swedes, Irish, and Canadians, with a few Danes, Austrians, and Swiss. The census classes all of the population as rural, there being no town with over 2,500 inhabitants.

The least thickly settled parts of the county are the townships of Eldorado and Everglade, where the population in 1920 was 282 and 277, respectively. The most thickly settled township is Framnas, with 470, followed by Morris, with 406.

Morris, the county seat, located in the east-central part of the county, had a population of 2,320 in 1920; Hancock, in the southeastern part, 763; Donnelly, in the northern part, 354; Chokio and Alberta, with 420 and 109, respectively, are small trading centers in the west-central part, on the Browns Valley Branch of the Great Northern Railway. All the towns are equipped with facilities for shipping stock and grain. Cooperative farmers' creameries are located at Hancock, Donnelly, and Chokio. Morris is a thriving, progressive city with three banks, good hotels, many modern stores, grain elevators, churches, graded and high schools, a creamery, and a flour mill. An experimental substation and agricultural school of the University of Minnesota also is located at Morris.

The main line of the Great Northern Railway traverses the county diagonally in a southeast-northwest direction, giving excellent transportation facilities to the markets of the Twin Cities. A branch of the same railroad extends west from Morris, terminating at Browns Valley, on the border line of the State. A branch line of the Northern Pacific, extending west from Little Falls and terminating at Morris, affords transportation facilities to points north and east of Morris.

The main highways between the towns are usually kept in good condition. Very little attention is given to most of the roads outside of the main State roads, although some effort is made to drag them after rains, which greatly improves their condition.

Rural mail deliveries and telephone lines are in common use over all parts of Stevens County, and schools and churches are numerous. A large consolidated school is located at Alberta.

CLIMATE.

The climate of Stevens County is marked by wide variations in temperature. The mean annual temperature is 38.3° F. January

and February are the coldest and July and August are the warmest months.

The mean annual precipitation is 24.19 inches. The total precipitation in the driest year on record (1910) was 15.45 inches, and for the wettest year (1906), 33.03 inches. About two-thirds of the annual precipitation falls during the growing season, and the rainfall is usually well distributed over the months of April, May, June, and July. June and July are the wettest months of the year. The average yearly snowfall is 29.2 inches, most of it occurring in the months of January, February, and March.

The average date of the last killing frost in the spring is May 18 and that of the first in the fall is September 28. This gives an average growing season of 133 days. The latest recorded killing frost in the spring occurred on June 17, 1915, and the earliest in the fall on August 27, 1915.

The prevailing wind is from the south, but during the months of January and February the wind is from the northwest, and during November from the north.

The following table, compiled from the records of the Weather Bureau station at Morris, shows the monthly, seasonal, and annual temperature and precipitation for Stevens County:

Normal monthly, seasonal, and annual temperature and precipitation at Morris.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1906).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	15.3	52	-34	0.67	0.55	0.80	4.4
January.....	6.6	52	-40	0.46	0.72	.73	5.2
February.....	10.5	60	-40	0.55	.30	.47	5.4
Winter.....	10.8	60	-40	1.68	1.57	2.00	15.0
March.....	26.7	83	-28	.96	.48	.72	7.8
April.....	44.2	89	4	2.44	2.33	2.04	2.1
May.....	55.5	95	18	3.41	1.16	6.00	.5
Spring.....	41.5	95	-28	6.81	3.97	8.76	10.4
June.....	65.0	98	30	4.14	2.98	6.82	0.0
July.....	70.3	103	38	3.84	1.22	4.03	.0
August.....	67.5	99	32	3.22	3.44	5.40	.0
Summer.....	67.6	103	30	11.24	7.64	16.25	.0
September.....	58.2	97	20	2.14	1.16	3.24	0.0
October.....	45.8	87	1	1.69	.92	1.96	.6
November.....	29.8	74	-27	.63	.20	.82	3.2
Fall.....	33.4	97	-27	4.46	2.28	6.02	3.8
Year.....	38.3	103	-40	24.19	15.45	33.03	29.2

AGRICULTURE.

The agricultural development of Stevens County dates back to 1866. Prior to that year the presence of hostile Indians discouraged the taking up of the public lands, and it was not until the late sixties that permanent settlement was really under way.

The crops grown during the years of early settlement, 1870 to 1890, were wheat, oats, barley, and flax. Wheat and oats were the leading crops, although a considerable acreage was devoted to flax. Potatoes and other vegetables were grown in quantities sufficient to supply home demands. Wheat has been the main cash crop since the early nineties, although flaxseed was a considerable source of income up to 1905.

The period of greatest growth was between 1890 and 1900, during which time large areas of virgin prairie were broken and with very little other preparation seeded to flax. The production of wheat reached a maximum during this period. Later barley, corn, and oats increased in importance.

The agriculture of Stevens County at the present time consists of the production of general farm crops for sale and for farm use in various lines of animal husbandry. Rapid progress is being made in hog raising, the production of beef cattle, and in dairying. The major crops of the area are wheat, oats, barley, corn, and hay; the secondary crops are flax, potatoes, rye, and emmer.

Corn is grown more extensively each year, the acreage having increased from 338 in 1879 to 21,767 in 1919. The yield varies from year to year, depending upon weather conditions. In 1919 the average yield was 28.8 bushels per acre, but this is less than the average for the county over a number of years. In a four-year rotation consisting of corn, wheat, oats, and clover, carried on at the Minnesota agricultural substation at Morris, the average yield of corn was 36 bushels per acre; where the land was treated with 8 tons of manure applied once in four years the average yield was 41.9 bushels; where the soil was treated with acid phosphate alone the yield was 40.5 bushels. Corn varieties recommended for this section of the State by the experiment station are Minnesota No. 23 and Northwestern Dent. Both mature at about the same time, but the latter gives much higher yields. Practically all the corn produced in the county is used for feeding work stock and fattening hogs and cattle. Frequently corn is shipped in to supply the local demands.

Wheat has been grown since the earliest settlement. The area devoted to it increased from 31,517 in 1879 to 123,782 acres in 1899, but in 1909 the crop occupied only 62,332 acres and 64,400 acres in 1919. In 1909 the average yield was more than 16 bushels per

acre; in 1919 it was only 9.5 bushels. In recent experiments¹ at Morris the average yield of wheat was 24.7 bushels per acre; where manure was applied the yield was 27.6 bushels; and where acid phosphate alone was added the average yield was increased to 30 bushels.

The varieties of wheat most commonly grown are Marquis, Blue-stem, and durum. According to the variety tests carried on at the experiment station, Marquis is the highest yielding red wheat at the present time, notwithstanding the fact that it is severely damaged by rust and scab. Preston wheat, commonly known as Velvet Chaff, has made about as good yields as Marquis. Of the durum varieties Mindum and Kubanka have given the best yields. No winter wheat is grown, the plants usually being unable to withstand the severe winters. A large percentage of the wheat produced is sold to local elevators and shipped to Minneapolis and Duluth, while some is used by the flour mill in Morris.

The acreage in oats has steadily increased since the early seventies. The crop was grown on 7,682 acres in 1879 and on 50,894 acres in 1919, the production in the latter year being 1,271,032 bushels, or an average of 25 bushels per acre. A large proportion of the oats produced is fed to work stock and the remainder is sold to the local elevators and shipped to outside markets.

Considerable barley also is grown, each census period showing an appreciable increase in acreage. The greatest increase was between 1899 and 1909, the crop occupying 3,638 acres in the former and 25,122 acres in the latter year. The 1920 census reports 23,641 acres in this cereal. The average yield is about 25 bushels per acre. Manchuria (Minnesota No. 105) is the variety recommended for general use. Much of the crop is used for feed, the rest being sold and shipped to points outside the county.

Hay, cultivated and wild, is an important crop. In 1919 hay was cut on 45,369 acres, yielding 50,104 tons. Of the total area, 15,599 acres were in cultivated grasses which yielded about 1.1 tons per acre, and 29,770 acres were in prairie grasses, which gave an average yield of 1.1 tons per acre. Practically all of the wild hay is cut from the low-lying areas. Most of the hay is used on the farm for feeding stock, and practically none is shipped out of the county.

Timothy alone and mixed timothy and clover supply the bulk of the tame-hay crop. In 1919, 11,869 acres were in timothy and 1,818 acres were in clover and timothy mixed. The average yield per acre of the former is approximately 1 ton per acre, and of the latter 1.1 tons. In the same year 198 acres were in red clover and 969 acres in other tame grasses.

¹ Minn. Agr. Expt. Sta. Report of West Central Expt. at Morris, 1918.

Alfalfa is grown to only a limited extent and with varying degrees of success, the best results being obtained on the better drained soils. At the Morris substation the Grimm and Baltic have regularly out-yielded all other varieties. The other sorts suffer from winter killing, except Turkestan, which is hardy but gives low yields at the second and third cuttings. The 1920 census reports 745 acres in alfalfa, yielding 2,195 tons.

Potatoes in 1919 occupied 959 acres and yielded 37,636 bushels, or an average of 39.2 bushels per acre. The crop is grown on practically every farm for home use; but only in favorable years is there a surplus for sale, and frequently potatoes are shipped in to supply the local demand.

Apples and plums are the only fruits of any importance, and they are not grown on a commercial scale. The 1920 census reports 2,917 apple trees and 2,035 plum trees in the county. Strawberries and raspberries are grown in small quantities.

The most important live-stock industries are hog and sheep raising and the production and fattening of beef cattle. The 1920 census reports 16,332 hogs in the county. The pure breeds consist mainly of Duroc-Jersey, Poland-China, and Chester White. Many of the hogs are of mixed breed, only the more progressive farmers keeping purebreds. The hogs are shipped to South St. Paul.

Sheep have showed a marked increase at each census period up to 1910; in 1899 there were 4,344, as compared with 10,483 ten years later, but the 1920 census reports only 5,693 sheep in the county. This section of the State has proved to be well adapted to the sheep-raising industry and the decrease is due to other than natural causes.

In 1919 there were 9,781 horses in the county, an average of about 8 per farm. Many of the horses are bred to a high standard, being principally Percheron and Belgian grades.

Considerable attention is being given to the raising and fattening of beef cattle. Purebred stock is gaining favor, the most common breeds being Shorthorn, Angus, and Hereford. Several carloads of cattle are shipped in annually and fattened on pasture, roughage, and some concentrates. The census of 1920 reports 10,503 head of beef cattle. Nearly all are sold to local dealers who market them outside the county.

Dairying is becoming an important industry in Stevens County. Cooperative creameries are located in the principal towns. In 1919 there were 12,749 dairy cattle, an increase of nearly 100 per cent in the last decade. During that year the value of dairy products excluding home use of milk and cream amounted to \$369,609. The number of purebred cattle, mainly Holstein, is increasing, herds of this breed being found in different parts of the county. In the last five years many silos have been constructed, until in 1918 there were 102. Nearly half of these were in the eastern tier of townships.

Along the course of the Pomme de Terre River, where the land is rolling to hilly, permanent pastures are utilized for cattle and sheep feeding. Also in the less thickly settled areas, notably Everglade and Eldorado Townships, large areas are devoted to the same purpose.

Very little attention is paid to the adaptation of crops to particular soils, although more corn is grown in the southern and eastern parts of the county, where the soil is relatively light in texture and the topography undulating to rolling. Here corn matures earlier and is not subject to flooding. Patches of alfalfa occur more frequently on the Clarion loam than on the heavier Clarion silt loam. The areas occupied by the Fargo clay loam are devoted mostly to the production of wild hay. When these areas are first drained small grains have a tendency to lodge, therefore cultivated grasses are usually grown for several years following reclamation.

Preparation of the land for seeding usually consists of late summer or early fall plowing, although large areas are left unplowed until spring. Land plowed in the fall is disked and harrowed the following spring, grain then seeded with a disk drill, and the land harrowed again. About one-half the corn grown is check-rowed and the remainder is drilled, much of the drilled corn being used as fodder or ensilage. Corn is usually cultivated three or four times, seldom more.

Crop rotation is practiced by the more progressive farmers. Continuous cropping is still followed by many, but most farmers realize the need of rotation. The usual rotation consists of wheat, barley, oats, and clover and timothy mixed. Corn in small patches occupies some of the fields each year, but the corn area never equals the grain area.

Modern farm machinery is used extensively in Stevens County. Most of the plowing is done with gang plows, using five or six horses on the heavier soil types and usually four on the lighter loams and fine sandy loams. Small tractors pulling three or four plows are common, and some large outfits are used where extensive areas are under cultivation. Most of the grain is harvested with 7 and 8 foot binders. Thrashing is done by large outfits, owned and operated by farmers, which travel from place to place. Most of the grain is thrashed from the shock, although a considerable quantity is stacked and thrashed late in the fall.

Little commercial fertilizer is used in Stevens County, and this is confined chiefly to acid phosphate on the small grains. A very small amount of mixed fertilizer is used on corn.

In a fertilizer experiment on the Morris farm, commenced in 1914, a four-year rotation of corn, wheat, oats, and clover is employed.²

² Univ. of Minn. Agr. Expt. Sta. Rept. of West Central Expt. Sta. at Morris, 1918.

Univ. of Minn. Agr. Extension Division, Special Bulletin No. 23, Experiments with Phosphate Fertilizers in Minnesota.

The fertilizers used include manure, acid phosphate, and rock phosphate alone, as well as combinations of each phosphate with manure. In 1918 cooperative experiments also were carried on with 20 farmers in different parts of the county, in which acid phosphate was used on small grains, on fields most of which had never received any manure.³

In the Morris experiment both acid phosphate and manure, when used alone, gave profitable returns on all the crops. In the first few years rock phosphate did not give increases as promising as either acid phosphate or manure, but during the last two years its effects have been more pronounced. The combination of each of the two phosphates with manure gave slightly higher yields on the average than the manure alone, but not sufficient to pay for the fertilizer. Inasmuch as the yields obtained by applying acid phosphate alone are approximately the same as those obtained from its combination with manure, it is considered inadvisable to use the combination.

From this experiment it appears that acid phosphate can not profitably be used where there is sufficient manure to apply as much as 8 tons per acre once every 4 years; neither does it appear profitable to supplement manure with either of the phosphates. However, not enough live stock is kept on the farms in this county to furnish this amount of manure for all of the improved land, only enough being produced to supply approximately 40 per cent of the improved area. In view of the above experiments, therefore, it would appear that a large quantity of acid phosphate might be profitably used.

In the cooperative experiments of 1918 referred to above, three of the small grains—wheat, barley, and oats—were used, the majority of the fields being in wheat. On all except 4 of the 20 fields increased yields, ranging from 2.1 to 10.5 bushels per acre, were obtained.

The advocacy of the use of phosphate on the soils of Stevens County does not mean that it is impossible to obtain good yields without an application of this fertilizer, but that on many of the fields much better results are obtained when it is used, as shown by the experiments mentioned above.

Most of the labor performed on the farms is done by the farmer and members of his family. Labor is scarce during grain harvest and thrashing time.

In 1919 there were 1,163 farms in the county, of an average size of 271.7 acres, of which 88.4 per cent was classed as improved. In 1900, 16 per cent of the farms were operated by tenants; in 1910 the percentage had increased to 34.6, and in 1920 to 46.7. Under the usual system of leasing the owner and tenant share the grain crops

³ Univ. of Minn. Agr. Extension Division, Special Bulletin No. 34, Phosphate Demonstration in Stevens County in 1918.

equally, the tenant furnishing man and horse labor, machinery and twine, and half the cost of thrashing, and the owner furnishing the seed. A small proportion of the land is rented on a cash basis.

Land values vary according to the soil, topography, location, improvements, and distance from markets. Prices range from \$65 to \$175 or more an acre. The lowest priced land is to be found in the northwestern part of the county. There are, however, well-improved places in this section that are high priced. The average selling price for improved farm land in the county is around \$150 an acre. The 1920 census reports the average assessed value of farm land as \$91.64 an acre.

SOILS.

The greater part of the surface of the county is covered by soils that have been derived from the slow weathering of thick deposits of glacial drift, probably ranging from 100 to 400 feet in depth, overlying rocks of Archean and Cretaceous age. This drift material was deposited by a great glacier which had its origin north of Winnipeg and which slowly advanced southward, terminating in the central part of Iowa. The soil material has a relatively high lime content, and owing to the fine texture of the greater proportion of it, the leaching of this carbonate in the course of soil development has not extended below an average depth of about 2 feet. In many cases the surface foot still contains a large quantity of lime, but in a few places on the relatively high areas in the northeastern part of the county the surface material of the coarser textured soils shows a slightly acid reaction, but only very rarely is the acidity strong enough to warrant a trial application of lime, even for alfalfa, the crop most sensitive to any deficiency of lime.

The soil material of a small area in the northwestern part of the county, in the townships of Eldorado, Everglade, and Donnelly, has been modified to some extent by water action. In Eldorado Township section 6 and parts of sections 4, 5, 7, 8, 18, and 19 comprise a part of the bed of the glacial Lake Agassiz.⁴ This old lake was formed during the recession of the ice sheet by the temporary damming of the water over a vast shallow basin. During its existence the waters were lowered and remained at certain levels for long periods of time. This resulted in the removal of more or less of the fine particles, leaving near the outer edges a large area of sandy material varying from a few inches to several feet in depth. This sandy material is found in the sections of Eldorado Township above noted. At the outer edge of this great lake the waves reworked and washed up the soil material, with the result that beaches were built

⁴ Geologic Atlas of the U. S., Herman-Morris Folio No. 210. By Frederick W. Sardeson, U. S. Geological Survey, 1919.

up consisting largely of stratified layers of sand and gravel. These rise a few feet above the general level of the plain and are noticeable over the entire area of the Red River Valley. One of these old beaches, known as the "sand ridge," runs diagonally across the northwest corner of Eldorado Township and is the outer limit of the old lake.

In the northwest corner of the county, comprising all of Eldorado Township outside the beach lines, the northwestern part of Donnelly Township, and most of Everglade Township, soils of a peculiar formation are found.

They owe their origin to the position of the ice border during the retreat of the last glacier and to the high elevation of land separating the two large drainage basins.

The great ice sheet as it left what is now Stevens County melted away most rapidly on the southeast, leaving the margin of the ice extending in a northeast-southwest direction. This relative position of the ice front was slightly altered from time to time, but was generally maintained during its retreat, which appears to have been quite rapid. When the ice front had reached a point north and west of the boundaries of the county it appears to have remained stationary for some time, the forward movement being just rapid enough to countervail the melting or retreat of the ice. Between the ice at this point and the high land forming the divide southeast of it a large body of water accumulated, forming a shallow lake. It appears probable that it existed for a shorter period of time than did glacial Lake Agassiz, since no pronounced beach lines were formed as in the case of the latter, or the water may have been so shallow that wave action was insufficient for the building of a beach. As the ice front retreated farther to the north, that part of Stevens County covered by these ponded waters was drained into the Mustinka River by Twelvemile Creek and its tributaries. After the water had receded to a point at present occupied by the Herman beach it was held again, drainage to the north being prevented by the slowly retreating ice. The ponding of this water for a long time was responsible for the formation of the Herman beach. Breaks in the beach in the southeastern corner of section 18 and the west-central part of section 19, Eldorado Township, are evidence that the drainage from this basin was effected through these breaks after or during the formation of the beach.

The presence of a large body of water over so large a territory in the northwest corner of Stevens County was instrumental in modifying the character of the soils. Before the ponding commenced the area was a till plain, not unlike that occurring in other parts of the area, with an undulating to flat surface pitted with shallow basins and potholes. At present this area in Eldorado Township and the northern half of Everglade Township is almost entirely devoid of

these depressions. In the southern part of Everglade Township, however, they occur more frequently, but here they are to be regarded more as low-lying flats than as potholes, sloughs, or sunken basins. Their absence may be attributed to the deposition of silt and sand particles from the heavily charged waters issuing from the melting ice. As the waters spread out over a large area the silt was deposited in large quantities, but unevenly. Wave action aided in distributing it, filling the basins and potholes and forming a plain on a level with the till, which in some places is devoid of any such covering. Consequently the thickness of the deposit varies, being in some places several feet deep, in others very shallow or altogether lacking.

The surface soil over most of this area is black and varies from 8 to 24 inches in depth. Where the water-laid material is deep a clean, fine, yellow silty sand, remarkably uniform in texture and structure, is encountered at depths ranging from 18 to 60 inches. The soil is free from stone and pebbles and the subsoil is open and porous. Where the deposit is shallow or absent the typical till is encountered, with its characteristic pebbly, stony, and more compact subsoil.

The terrace soils occupy two levels and are found on both sides of the Pomme de Terre River, and in smaller areas adjacent to the Chippewa River and to Mud Creek, the main tributary of the Pomme de Terre. Most of the terrace soils occupy the second bottoms and occur on nearly level, benchlike areas 10 to 18 feet above the streams. Owing to the open structure of their subsoil, these soils are usually well drained and free from overflow. Terrace soils, developed by the Chippewa River, are found in the extreme southeastern part of the county. They occupy about 12 square miles and lie so low that in wet seasons farming operations are carried on with great difficulty. A large open ditch has been constructed through this area, and when the proposed tile lines are laid the land will be greatly benefited.

A characteristic feature of the entire area is the large number of depressed areas, most of which are without natural outlets. Some are occupied by ponds and swamps ranging in size from less than an acre to large-sized sloughs covering in some cases over 640 acres. They consist mostly of black clay loams overlying compact grayish subsoils; in a few places, however, a layer of peat, from 3 to 10 inches thick, covers the black soil. The soil is abundantly supplied with organic matter and contains considerable limestone, which in many places occurs as small concretions. During wet seasons many of these areas are covered with standing water, and the vegetation consists of a dense growth of water-loving plants.

Stevens County lies wholly within the prairie region of Minnesota, and climatic conditions favorable for maximum plant growth caused the accumulation of organic matter in the soils. Much of this still remains, especially in the level and flat areas, but on the more rolling areas where oxidation is more rapid the supply of humus has in many instances become deficient and methods of maintaining it are frequently employed.

Along most of the creeks and natural drainage ways willow and box elder are fairly common. Among the lakes in Swan Lake, Framnas, and Rendsville Townships narrow fringes of tree growth are found consisting chiefly of box elder, black ash, basswood, elm, poplar, and cottonwood, while in some localities, such as Olson Lake, medium-sized oak growth occurs. The native tree growth, however, occupies a relatively small area, practically all of the upland being prairie land.

The soils of the county have been grouped into soil series on the basis of similarity in color, structure, drainage, topography, and origin. The series are divided into types on the basis of texture.

The Clarion series is characterized by black surface soils ranging from a few inches to 2 feet in depth. The dark-colored surface soil grades into a yellowish-brown subsoil at a depth of several inches, then passes into the characteristic yellow or lemon-colored substratum typical of the series. A noticeable feature of the soils of the Clarion series in the county is the uneven thickness of the surface layer. It is not uncommon to encounter areas where the surface soil is not over 3 inches deep and within a radius of several feet other areas where it extends to 12 to 18 inches. On the gently undulating and level areas of the series the soils are even more variable in color, texture, and structure. In most cases the surface soil and subsoil are neutral in reaction, the substratum usually effervescing freely with hydrochloric acid. Three types of this series are mapped—the fine sandy loam, loam, and silt loam.

The terrace soils developed principally along the Pomme de Terre and Chippewa Rivers and Mud Creek belong to the Sioux series. These soils range from dark brown to black in the surface and light brown to brown in the upper subsoils. The lower subsoil is composed of stratified beds of sand and gravel containing large quantities of calcareous material. The terraces are above overflow and well drained—in fact, are inclined to be droughty because of the open nature of the lower subsoil. Two types are mapped—the fine sandy loam and loam.

The Bearden series includes soils that have been modified by water action. The types are characterized by dark-colored surface soils and a gray and yellow or light-brown subsoil, normally coarser in texture than the surface soil and friable and open in structure. The

subsoil is strongly calcareous. The Bearden fine sandy loam, loam, and silt loam are mapped.

The soils occurring in the depressions, swampy areas, and sloughs are included in the Fargo series. They have dark-gray to black surface soils and a yellow mottled silty clay subsoil. They have been formed from reworked glacial material weathered under conditions of poor drainage. One type, the Fargo clay loam, is mapped in Stevens County.

The Lamoure series includes soils having black surface soils overlying a gray mottled subsoil. It differs from the Fargo mainly in being located along the stream channels and in being subject to overflow in times of high water. The Lamoure clay loam is the only type mapped.

The Benoit series is characterized by dark-brown to black surface soils with gray or yellow subsoils that grade into beds of stratified sand and gravel. Stones are almost entirely absent in the Benoit series. The soils and subsoils are calcareous and effervesce freely with hydrochloric acid. One type is mapped, the Benoit loam.

Eleven types and one phase are mapped in Stevens County. In the following pages of this report the various soils of Stevens County are described in detail and their relation to agriculture discussed. The distribution of the soils is shown on the accompanying map, and the table below gives the name and actual and relative extent of each :

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clarion silt loam.....	188,288	52.2	Benoit loam.....	3,840	1.1
Clarion loam.....	59,392	16.5	Lamoure clay loam.....	3,712	1.0
Fargo clay loam.....	43,840	12.1	Sioux fine sandy loam.....	2,048	.7
Bearden silt loam.....	25,152	6.9	Beach-ridge phase.....	512	
Sioux loam.....	15,808	4.4	Clarion fine sandy loam.....	192	.1
Bearden loam.....	11,968	3.3	Total.....	360,960	
Bearden fine sandy loam.....	6,208	1.7			

CLARION FINE SANDY LOAM.

The surface soil of the Clarion fine sandy loam is a dark-brown to black fine sandy loam 6 to 8 inches deep. It is underlain by a light-brown loamy fine sand, which grades into a light-brown to yellow silt loam at depths varying from 12 to 18 inches. The surface soil is usually well supplied with organic matter, but in places on the more hilly areas the supply has become somewhat depleted.

The type is inextensive. It occurs in isolated hilly areas in the northern part of Donnelly Township, in the vicinity of Moose Island. It is farmed in much the same manner as the adjacent Clarion loam

and Clarion silt loam. All the type is under cultivation, most of it being devoted to the raising of corn and small grains. Land of this type is usually sold with the adjacent types.

CLARION LOAM.

The surface soil of the Clarion loam is a dark-brown to black loam 4 to 16 inches deep, normally containing a relatively large proportion of fine sand and very fine sand. The soil is underlain by a yellow to yellowish-brown friable silt loam subsoil, and this passes into a substratum of yellow silty clay loam. In places thin layers of coarse sand and gravel are found within the 3-foot section, and these are more abundant in the substratum. As a rule, the subsoil is uniform in structure and somewhat compact, but not to such an extent as to form a hardpan.

The subsoil and substratum are highly calcareous, and in many places the surface material is well supplied with lime. In some places, however, the surface soil shows an acid reaction, this condition occurring on areas where the soil is somewhat coarser in texture than typical and more permeable, with the consequent removal of the lime by leaching.

A few scattered boulders are found here and there on the surface. For the most part the rocks are of granitic origin, though not infrequently rocks of limestone formation are encountered. The Clarion loam is one of the most extensive soil types in the county. It covers a large part of the territory lying east of the Pomme de Terre River. Smaller areas are found adjacent to Mud Creek in Darnen Township, and other relatively small areas are mapped in the southern parts of Synnes and Stevens Townships and in the eastern part of Rendsville Township. The greater part of the type is gently undulating or slightly rolling, but in some places, notably in parts of Rendsville, Swan Lake, Hodges, and Framnas Townships, the surface has a hilly appearance, and a few small areas are subject to slight erosion but not sufficient to interfere in any degree with the production of any of the farm crops.

The natural drainage of the type is good, but on the relatively few level and low-lying parts it appears to be somewhat deficient. In many places local depressions, known as potholes, occur. Most of these are undrained and are used as pasture or hay lands. The soil is rich in plant food and when properly drained it soon becomes mellow and friable and produces well. In general the need for artificial drainage on the Clarion loam is not nearly so great as on the large areas of the Clarion silt loam.

The larger part of the Clarion loam originally supported a growth of prairie grass, except adjacent to the lakes, where there were belts of forest trees. Some of the forested areas have been cleared, but a

large proportion still retains the original tree growth, consisting of oak, poplar, willow, cottonwood, and elm. The forested areas, however, are relatively small. They afford suitable locations for farmsteads and permanent pastures.

Practically all the type is under cultivation, only the tree-covered and extremely hilly areas, usually adjacent to the streams and lakes, being used for pasture. Small grains, such as wheat, barley, and oats, are grown to a considerable extent. Some rye is also grown. Pastures of timothy and clover are common, and alfalfa is grown to a small extent. The type is especially suited to alfalfa, but some difficulty has been experienced in maintaining a stand for any number of years. One reason for this difficulty is the fact that the varieties used are not of sufficient hardiness to withstand the severe winters. Among the cultivated crops corn ranks first, although potatoes do well and are grown to some extent. Dairy and beef cattle and some sheep are found on most farms. Many hogs are raised, and hog raising is increasing in importance.

Yields of wheat range from 8 to 35 bushels per acre, oats 20 to 75 bushels, barley 10 to 55 bushels, rye 10 to 20 bushels, and flaxseed 6 to 18 bushels per acre. Hay yields from three-fourths to 1½ tons, corn 20 to 50 bushels per acre. Some corn is put into silos.

The type, owing to its friable and loamy structure, forms a seed bed favorable to the production of a wide range of crops. The compactness and uniform nature of the subsoil enable it to store sufficient moisture to supply growing crops during short periods of drought, but in seasons of subnormal precipitation crop yields are frequently reduced by lack of moisture. Some system of crop rotation is generally practiced, but in many places the practice of continuous cropping to small grains still prevails. Three to five year rotations are commonly practiced; one rotation consists of corn, oats, barley, clover, and timothy. Barnyard manure is applied to the land once in six or seven years, but owing to the size of the farms many of the outlying fields do not receive any manure.

Land of this type ranges in price from \$75 to \$175 an acre, depending upon the improvements.

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

Mechanical analyses of Clarion loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
321016.....	Soil.....	0.5	2.4	3.4	16.6	22.4	46.8	7.9
321017.....	Subsurface..	.0	1.1	2.3	15.4	23.4	45.2	12.9
321018.....	Subsoil.....	1.0	3.3	2.5	13.9	12.8	44.5	22.3

CLARION SILT LOAM.

The surface soil of the Clarion silt loam is a dark-brown to black silt loam, 6 to 24 inches deep. The shallow soil is found usually in gently rolling areas; on the large undulating and flat areas the surface soil is darker and extends in many places to a depth of 24 inches. Underlying the surface soil of the gently rolling areas is a compact, somewhat friable silty clay loam, ranging in color from yellowish brown to grayish yellow and extending to a considerable depth into the substratum. The subsoil of the undulating and flat areas is of a finer texture, approaching in some places a clay loam, and differs from that of the gently rolling areas in color, which is grayish brown to bluish gray. In the case of both, the surface material is composed of varying amounts of silt and clay, which give to the type variations from light silt loams to almost silty clay loams. As a rule the lighter soils are found on the areas having a topography that is slightly undulating to gently rolling and the heavier ones occupy the areas that are comparatively level. Instances of light soil development occur in the relatively large tracts in Darnen, Hodges, Horton, Synnes, Scott, and Pepperton Townships and of the heavier soils in the townships of Rendsville, Donnelly, Baker, Morris, Stevens, and the southern and western part of Scott Township.

The topography of this soil varies from relatively flat to undulating or gently rolling, the former being found in Baker Township and the western half of Scott Township, where the natural drainage is somewhat poorly established, and the latter in Darnen and Framnas Townships. While the texture of the soil in the level areas appears to be somewhat finer, the soils over both areas are remarkably alike in their content of fine material.

The Clarion silt loam as mapped includes several variations. The four most prominent variations are: First, a soil containing a relatively large quantity of very fine sand which gives it a somewhat loamy texture, the subsoil being typical. This variation occurs on high areas in Synnes and Rendsville Townships. Second, a soil with a deep black surface soil, much finer than typical in texture of the subsurface and subsoil, underlain by a dark-brown compact clay loam, which extends to a considerable depth into the substratum. This variation is developed in the southern part of Baker Township and in parts of Stevens Township. Third, a soil with a black surface soil having a depth of 8 to 12 inches and containing sufficient quantities of fine material to make it a silty clay loam, the subsoil being similar to the typical. Fourth, a soil with a grayish-black to black surface soil underlain by a grayish-yellow silty clay loam subsoil. This variation is found in the southern and western parts of Stevens Township.

The soil of the Clarion silt loam is abundantly supplied with organic matter and the subsoil and substratum are heavily charged with calcareous material. The surface soil, especially in the lighter areas, is variable as to reaction, but usually in those that show acid reaction the degree of acidity is not sufficiently great to affect seriously the growth of legumes. In the more level areas an abundance of lime is present in the surface layer.

The Clarion silt loam has undergone very little modification since it was deposited by the glaciers, except in the addition of organic matter, which has accumulated in large quantities over most of the area. Boulders occur here and there on the surface, but in no place are they numerous.

The Clarion silt loam is the most extensive soil type in the county. Undulating areas lie adjacent to the stream valleys, and more level areas are located some distance from the streams and natural drainage ways. Commonly on the former the natural drainage is sufficient, although potholes and sloughs, which are abundant on all the types in the area, require some form of artificial drainage. It is on the extensive level areas of the type that the natural drainage is most deficient, but considerable progress has been made in the construction of large open ditches and the laying of tile drains to remove the excess water. In years of unusually heavy precipitation the tillage operations and the planting of the crops are delayed by the water-logged condition of the soil.

The Clarion silt loam when well drained is one of the most desirable soils in the county for general farming. Excepting the numerous sloughs and poorly drained areas, it is practically all under cultivation. Most of the type is devoted to the production of barley, oats, wheat, and timothy and clover. A considerable acreage is given to corn and to potatoes. As a rule corn matures a few days later than on the other upland soils, owing to the necessity of planting later in the spring and to the slower development of the plants. Tame grass is being grown more extensively each year, and a considerable quantity of the hay is sold. The poorly drained areas and sloughs furnish wild hay, a large quantity of which is cut and stacked in the field. Alfalfa is grown, but not so extensively as on the Clarion loam. The live-stock industry consists of the raising of hogs and beef cattle. Dairying is increasing annually.

During years of normal precipitation and favorable temperatures the crop yields are high. The average yield of wheat is 20 bushels per acre, although in very favorable years and on well-prepared land over 30 bushels is not uncommon. Oats yield from 30 to 70 bushels, and barley from 16 to 35 bushels per acre. Corn yields 20 to 40 bushels per acre, and clover and timothy about $1\frac{1}{4}$ tons of hay per acre. Potatoes average 125 bushels per acre.

The Clarion silt loam is quite friable under ordinary methods of cultivation, but extreme care must be taken to handle it when in the proper moisture condition. If plowed when too wet the soil has a tendency to puddle, while if plowed when too dry it clods.

Crop rotation is not generally practiced; only the most progressive farmers use a definite system of rotating the crops. A large part of the type is devoted to alternate and continuous cropping of small grains, a practice which has allowed the yields to decrease and the fields to become badly infested with weeds. All the barnyard manure produced on the farms is returned to the land, but owing to the size of the farms not enough manure is produced to be applied to all the land within a reasonable period of years. In fact many of the outlying fields have never received any manure at all.

The farms on this soil are well improved. Some are thoroughly tile drained, but on many a large amount of tiling still remains to be done in order to give satisfactory drainage. Good water is found on most farms, the wells ranging in depth from 18 to 125 feet.

Improved farms on undulating and rolling areas of this type usually sell for \$75 to \$175 an acre. Poorly drained farms bring less than \$100 an acre.

For the improvement of the soil the greatest needs are: (1) thorough drainage; (2) a systematic rotation in which cultivated crops are grown to keep weeds under control; and (3) the raising of more live stock to utilize roughage, such as straw, thus producing more manure, so that the land may receive an application once in every three or four years.

SIoux FINE SANDY LOAM.

The surface soil of the Sioux fine sandy loam is a dark-brown to black fine sandy loam 6 to 12 inches deep. This grades gradually into a light-brown or yellow fine sand containing amounts of silt sufficient to give a somewhat loamy texture. At 3 feet, clear stratified sand and small gravel are found. The subsoil and substratum of the type differ somewhat from that of the Sioux loam in that the stratified layers of coarse sand and gravel are found much deeper, with the result that the fine sand is less droughty. At depths of 6 to 15 feet gravel is more abundant. As in case of the loam, the material is highly calcareous and in places limestone pebbles are present throughout the soil profile.

The type occurs as terraces along the Pomme de Terre River, in the vicinity of the Pomme de Terre Lakes. The largest area lies southwest of the Pomme de Terre Lakes, and other areas of smaller extent along the Pomme de Terre River in Framnas and Swan Lake Townships. The areas are flat and from 5 to 10 feet higher than the

Sioux loam. The drainage is good. Most of the rainfall sinks into the soil.

Practically all the type is under cultivation, a considerable part of it being devoted to the production of tame hay. Small grains and cultivated crops, such as corn and potatoes, are grown to some extent. In the years of abundant rainfall these do well, but during prolonged dry periods they suffer from lack of moisture.

Land of this type sells for about the same price as the Sioux loam. Most of it is included in farms with adjacent types, principally the Sioux loam.

Sioux fine sandy loam, beach-ridge phase.—The Sioux fine sandy loam, beach-ridge phase, consists of about 6 to 8 inches of dark-brown to nearly black fine sandy loam, underlain by a bed of brownish calcareous sand and gravel—mainly coarse sand, rounded pebbles, and small stones—which shows horizontal stratification. The layer of coarse material extends to a considerable depth into the substratum.

The Sioux fine sandy loam, beach-ridge phase, is of small extent. It occupies an elongated area in northwestern Eldorado Township locally known as a "sand ridge." This is the old beach of glacial Lake Agassiz, a narrow strip running in a northeast-southwest direction, about 4 miles in length and varying in width from one-fourth to one-half mile. The beach rises to a height of 4 to 8 feet above the surrounding plain and is a noticeable topographic feature of this part of the county.

The natural drainage of the phase is excellent, and at no times are crops injured by excessive precipitation. In periods of drought, however, some injury is caused to the crops by the excessive drying out of the soil.

The main crops of the area are grown on the phase, no special attention being paid to the adaptability of the type to certain crops, owing to its limited area.

SIoux LOAM.

The surface soil of the Sioux loam is a dark-brown to black mellow loam, which at 4 to 12 inches grades into stratified layers of light-colored sand and gravel. The sand predominates and is usually of a rusty yellow brown color. Small pockets of very fine sand occur throughout the substratum. There are several variations of the type, ranging in texture from rather heavy loams to sandy and fine sandy loams, which owing to their small development did not warrant separation. In some areas along the Pomme de Terre River in Darnen and Horton Townships the sandy and gravelly material does not appear within 24 inches of the surface; in others, particularly in the northern part of the county, it is within a few inches.

The soils of the Sioux series are not as high in organic matter as are those of the heavier Clarion series, owing to their open structure

and leachy nature. Both the surface soil and subsoil are normally calcareous, a considerable number of the pebbles being of limestone origin.

The Sioux loam represents the remnants of old glacial river terraces built up at times when the streams flowed at a much higher level than now. The stratification of the sand and gravel in the subsoil is due to its deposition by flowing water. The type is mainly developed as terraces along the Pomme de Terre and Chippewa Rivers, but smaller areas occur near the small creeks and adjacent to some of the old lakes.

The type is level to gently undulating and usually lies 8 to 14 feet above the overflow bottom land. It is easily recognized by its flat, benchlike appearance. Two areas of the type, one on each side of the Pomme de Terre River, $1\frac{1}{2}$ miles southeast of Morris, lie on an older terrace somewhat higher than the typical terrace level. Here the leachy subsoil does not appear within 30 inches of the surface.

The type is naturally well to excessively drained. Most of the rain water escapes by percolation.

The Sioux loam is relatively small in extent, but is rather important owing to the fact that it is practically all under cultivation. It is easy to work, falling into a mellow tilth when plowed and harrowed. It warms up quickly in the spring and is thus favorable for early planted crops.

All the staple crops of the area are grown. Corn is the principal crop. Small grains and mixtures of timothy and clover also are grown extensively. Small patches of alfalfa are established in many places. On the areas of thin soil crops often suffer from lack of moisture, but during years of normal rainfall, well distributed over the growing period, the Sioux loam generally has a sufficient moisture-holding capacity to meet the demands of the crop.

Yields of the different crops vary considerably with the season and with the water-holding capacity of the soil from place to place. Commonly the yields of small grain are lower than on the Clarion loam and silt loam, but corn seems to yield about as well.

Farms on this type are usually well improved and range in price from \$70 to \$150 an acre.

BEARDEN FINE SANDY LOAM.

The surface soil of the Bearden fine sandy loam is a dark-brown to black fine sandy loam. The subsoil, beginning at about 10 inches, consists of a grayish-brown or yellowish-brown rather compact fine sandy loam to loam, which grades at about 15 inches into a light-brown or yellowish-brown fine sand with some admixture of silt. The surface soil is uniform, but some variation occurs in the subsoil from place to place. In a few places the lower levels consist of a

material somewhat heavier than fine sandy loam. Such areas, however, are not extensive.

The Bearden fine sandy loam is of glacial origin and, like other soils of the Bearden series, has been modified by water and possibly to some extent by wind action. The type occurs as elongated ridges with gradually sloping sides and from one-half mile to $1\frac{1}{2}$ miles wide.

The type is confined to parts of Eldorado, Everglade, and Donnelly Townships. Four areas are mapped, all of which occur on low ridges in regions of gently rolling topography. The drainage of the type is good, and may be excessive at times. The subsoil material is fairly retentive and furnishes crops sufficient moisture during short periods of dry weather.

Practically all of this soil is under cultivation. It is commonly included in farms with other soils and little effort is made to select crops that are more adapted to its lighter texture. It is a common practice to use it for corn and potatoes where these crops are grown. Very little tame hay is produced on this type, most of it being devoted to the ordinary crops of the county. The yields of grain vary greatly from season to season, depending upon the weather conditions, but in general do not differ greatly from those on the adjoining Bearden loam and Bearden silt loam.

On account of its light texture and good drainage, this is an early and easily managed soil. It can be tilled under a wide range of moisture conditions.

The land sells for \$75 to \$125 an acre, most of it being sold with the adjacent type with which it is usually farmed.

BEARDEN LOAM.

The surface soil of the Bearden loam consists of a very dark brown to black loam, 8 to 16 inches deep, underlain by a grayish loam containing considerable quantities of fine sand. The subsoil is a friable, yellow silt loam resting on a bed of clean, yellow very fine sand. Variations occur in which the surface soil in places contains sufficient fine sand to be termed a fine sandy loam. In other places the proportion of fine sand is less and of silt greater, the soil approaching a silt loam. Variations in the subsoil similar to those encountered in the Bearden silt loam also occur. Crystals of gypsum likewise are abundant and distributed over all the type.

The Bearden loam is developed in the better drained areas of Eldorado, Everglade, and Donnelly Townships. The surface is gently undulating, and the natural drainage is better than on the silt loam of the series.

Like the Bearden silt loam, the native vegetation consisted of prairie grasses. Practically all the soil is now under cultivation. It is considered a good agricultural soil. The same crops are grown as on the Bearden silt loam, namely, wheat, barley, oats, corn, and

hay. The live-stock industries are the same, but less attention is given to the raising and fattening of beef cattle.

The yields of small grains are about the same as on the Bearden silt loam, but corn yields are somewhat higher, ranging from 20 to 50 bushels per acre. Land of the Bearden loam sells for \$75 to \$125 an acre.

BEARDEN SILT LOAM.

The surface soil of the Bearden silt loam consists of a grayish-black to black silt loam, varying in depth from 8 to 14 inches. Beneath this, and averaging about 8 inches deep, is a layer of fine silt loam distinctly gray in color, and this is underlain by a yellowish-brown silt loam gradually merging into a bed of fine yellow sand, extending to depths greater than 3 feet and resting on a heavy, compact clay loam. In places the stratum of yellow sand is not encountered within the 3-foot section. The structure of the subsoil of the Bearden soils is distinctly different from that of the Clarion soils. In the Bearden the material is more open and porous and crumbles easily when pressed between the fingers. Variations of the type occur, however, in which the subsoil closely resembles the Clarion silt loam.

The soils of the Bearden series in Stevens County have been modified by water action after the deposition of the glacial drift. The water-modified deposit occurs unevenly and in places is entirely absent. It is in these latter cases that the variations of the type occur, and while the surface soil is similar in color to that of the Bearden, the subsoil is typical of the Clarion, being a yellowish-brown heavy silt to silty clay loam, with a structure more compact and impervious.

A noticeable feature of the soils of the Bearden series is the occurrence of gypsum, usually as small elongated crystals, in small pockets distributed unevenly throughout the soil section. Its formation is attributed to the crystallization of calcium sulfate from concentrated solution left after the receding of the water. During dry periods a white incrustation of this salt is noticeable over large areas and is especially observed on the plowed fields before they are covered with vegetation. No deleterious effects on crop yields have been noticed as the result of the presence of these large quantities of gypsum, the yields of grain being equal to those on the soils of Clarion series, unless weather conditions are such as to influence them.

The type in general is slightly undulating, but some large areas are quite flat. Potholes and depressions are much less numerous than in the Clarion soils, and the surface is almost entirely free of small stones and boulders.

The surface drainage of the type is poor, most of the water escaping through the subsurface layers. Very little tiling has been done,

but a large drainage ditch has recently been constructed northwest of Chokio.

The Bearden silt loam is an important soil type. Like the other soils of the county, it originally supported a heavy growth of prairie grass. About 75 per cent of the type is under cultivation, the remainder being used for pasture and for the cutting of wild hay.

Wheat, barley, and oats are the principal crops. Corn is also grown quite extensively, but the areas are small compared with those devoted to the small grains. Some tame hay is produced. Raising hogs and raising and fattening beef cattle are the important livestock industries.

The yields of grain are about as follows: Wheat 8 to 20 bushels, oats 20 to 40 bushels, barley 15 to 30 bushels, and corn 15 to 40 bushels per acre.

Farms on the Bearden silt loam are usually well improved. The land sells for \$60 to \$125 an acre, depending mainly upon the improvements.

The soil is usually well supplied with organic matter, and the plowing under of green manure crops is not recommended. More effort should be given to the removal of excess water by the construction of open ditches and the laying of tile drains.

FARGO CLAY LOAM.

The surface soil of the Fargo clay loam is a dark-brown to black clay loam containing much organic matter. In many areas the surface foot consists largely of a black mucky clay loam with here and there a thin upper layer of brown peat. Underlying the surface layer at about 20 inches is a subsoil of dark-gray silty clay loam, which grades into a grayish-blue silty clay, containing sand and gravel of calcareous origin. In areas formerly occupied by lakes but now drained, some admixture of fine sand and very fine sand are present, giving the soil and subsoil the approximate texture of a sandy loam. Both the surface soil and subsoil are highly calcareous, and in many places pebbles of limestone origin are abundant throughout the soil section.

The Fargo clay loam consists largely of fine sediment washed down from the drift-covered slopes and reworked by water in the low depressions. The type occurs as pothole depressions within areas of the Clarion and Bearden series and occupies areas ranging in size from less than 1 acre to more than 1 square mile. Frequently it occurs in narrow strips. Effort was made in mapping to show all of this type, and in many cases where the areas were small it was necessary to exaggerate their size so that they might be shown on the map. Small isolated potholes, however, are indicated on the map by swamp symbols. These depressions and flats have been filled with water at various times to depths of several feet. Under natural conditions

the water is removed slowly by drainage through the subsoil and by evaporation. As a result there has developed a soil that has the characteristics of a lacustrine deposit. Growth and decay of swamp vegetation have left their impress on the character and composition of the soil, and in many of the areas where water stands continuously a shallow layer of peat has formed.

In many places the type contains considerable quantities of alkali salts, and the surface material shows a whitish incrustation after the water has been removed by seepage or evaporation. This incrustation is often noticed after the areas have been drained, and sometimes the soluble alkali salts do not entirely disappear until several years have elapsed after the laying of tile.

Utilization of the type for growing farm crops is dependent upon adequate artificial drainage. The value of tile drainage in reclaiming this type has been thoroughly demonstrated and such drains are being extended from year to year.

In the aggregate the type occupies an extensive area. While the drainage of some areas lying but little above the normal flow of streams may not be practicable, a very large proportion of the type situated in the upland can be more or less completely drained. Probably more than 85 per cent of the total area of the type is still undrained. In its natural condition the type supports a luxuriant growth of water grasses and swamp vegetation, which furnishes pasture and hay. The drained areas support a good growth of tame grass and give good yields of all the general farm crops. In some of the reclaimed areas grain lodges badly. The usual practice after tiling the land is to break it in the summer or fall, allow it to remain untouched over winter, prepare a seed bed in the spring by double disking and harrowing, and sow flax. This crop is usually repeated the second year, after which the land is in shape for seeding to grass or small grain.

Owing to the small size of the individual areas of the type it is commonly included in fields with other soils. It usually is held at about the same price as the associated soil.

In the improvement of the type the first need is drainage. The soil, owing to its high content of lime and organic matter, is very productive, and should not require any fertilization for some time.

LAMOURE CLAY LOAM.

The Lamoure clay loam is similar to the Fargo clay loam, except that it lies along the major streams and is subject to overflow. It is not very extensive and is unimportant in the agriculture. It forms the first-bottom land immediately adjacent to the Pomme de Terre and Chippewa Rivers and Mud Creek. None of the type has been brought under cultivation. It is used for pasture and the cutting of wild hay.

BENOIT LOAM.

The surface soil of the Benoit loam consists of about 8 to 12 inches of dark-brown to black loam, underlain by gray to brownish sandy material. Coarse sand and some gravel are encountered at depths of 3 to 6 feet or more.

The type occurs in two isolated areas in the county, one containing about 4 square miles in the southeastern part of Moore Township, and the other of about the same extent, in the northwestern part of Eldorado Township. There are some local variations in texture, the soil ranging from a rather light loam to a heavy loam. In places in the Moore Township area the 3-foot soil section is similar to that of the Sioux fine sandy loam, consisting of 8 to 14 inches of dark-brown to black loam overlying yellowish-gray, friable silt loam, which in turn rests upon a grayish sandy material of considerable depth. The most nearly typical part of the Benoit loam adjoins the beach ridge in Eldorado Township. The surface is level. The water table lies near the surface and keeps the land somewhat waterlogged for considerable periods, making farming operations difficult.

The Benoit loam is used mainly as pasture and for the cutting of wild hay. Some of it, however, is planted in corn, small grains, and tame grasses. In Moore Township a large drainage ditch is in course of construction. The completion of this ditch will make more extensive use of the type possible.

Land of the Benoit loam type is usually sold in farms with other soils. It has a lower value than the associated types.

SUMMARY.

Stevens County is located in the western part of Minnesota. It has an area of 564 square miles, or 360,960 acres. The topography is that of an undulating to rolling glacial drift plain, the eastern, southern, and portions of the northern parts of the county being rolling. The Pomme de Terre River drains large areas in the central and eastern parts of the county; the western part is poorly drained by intermittent draws and open ditches.

The climate is marked by a wide range in temperature, the maximum being 103° F., the minimum -40° F., and the mean annual temperature 38.3° F. The mean annual precipitation is 24.19 inches. The average length of the growing season is 133 days.

The population in 1920 was 9,778. Morris, the largest town, is the county seat. Other towns are Hancock, Chokio, Donnelly, and Alberta.

The county has excellent railroad facilities, being on the main line of the Great Northern.

The most important crops are wheat, oats, barley, and corn. Hay, both tame and wild, is produced in considerable quantities. Hog and sheep raising and some beef production, along with dairying, are the

main live-stock industries and are increasing in importance annually. Cooperative creameries are located in three of the towns. Land values range from \$65 to \$200 an acre.

The soils of Stevens County are largely derived from unstratified material of glacial origin, although there are soils which occur in depressions in relatively small areas, known locally as potholes, which have to some extent been modified by water action. In the aggregate they constitute a large area and are distributed over the entire county. A large level area in Everglade and Eldorado Townships also has been affected by water action.

The Clarion fine sandy loam is an inextensive soil type found in the northern part of the county near Moose Island. It is farmed with adjacent soil types.

The Clarion loam is the second most extensive type and occurs principally in the eastern and southern parts of the county. The topography is more rolling than that of the Clarion silt loam. The type is well suited to general farming.

The Clarion silt loam is the most extensive soil type in the county. Its surface is undulating to rolling. It is highly productive, and all crops common to the area are successfully grown on it, but it is particularly well adapted to grain farming.

The Sioux fine sandy loam is similar to the Sioux loam. A large area is located southwest of Pomme de Terre Lakes.

The Sioux fine sandy loam, beach-ridge phase, occurs as a sand ridge in Eldorado Township and covers approximately four square miles.

The Sioux loam occurs as terraces along the stream valleys and is rather extensive. It is inclined to be more droughty than the other important soils of the area.

The Bearden fine sandy loam occurs as elongated and flattened ridges with gentle slopes, naturally well drained, and is inclined to be somewhat droughty.

The Bearden loam occurs as undulating areas with better surface and underdrainage than the Bearden silt loam.

The Bearden silt loam is a somewhat poorly drained soil, modified by water action, which is productive when drained.

The Fargo clay loam is found in depressions and potholes. It is an extensive soil type. About 85 per cent still remains uncultivated. When satisfactorily drained it produces well.

The Lamoure clay loam is similar to the Fargo clay loam, differing from the latter in that it is confined to areas adjacent to the streams, is subject to overflow, and can not be drained by ordinary means.

The Benoit loam occurs as poorly drained areas in the southeastern and northwestern parts of the county.

[PUBLIC RESOLUTION—No. 9.]

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

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

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

Approved, March 14, 1904.

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

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