

Issued July 15, 1916.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF PENNINGTON COUNTY, MINNESOTA.

BY

WILLIAM G. SMITH, N. M. KIRK, AND FREEMAN WARD.

THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1914.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1916.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,

Washington, D. C., December 8, 1915.

SIR: In the extension of the soil survey in the State of Minnesota work was undertaken in Pennington County and completed during the field season of 1914.

The accompanying report and map cover this survey and are submitted for publication as advance sheets of Field Operations of the Bureau of Soils for 1914, as authorized by law.

Very respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

CONTENTS.

| | Page. |
|--|-------|
| SOIL SURVEY OF PENNINGTON COUNTY, MINNESOTA. By WILLIAM G. SMITH, N. M. KIRK, and FREEMAN WARD..... | 5 |
| Description of the area..... | 5 |
| Climate..... | 6 |
| Agriculture..... | 8 |
| Soils..... | 12 |
| Fargo series..... | 13 |
| Fargo fine sandy loam..... | 14 |
| Fargo loam..... | 15 |
| Fargo clay loam..... | 16 |
| Benoit series..... | 17 |
| Benoit fine sand..... | 18 |
| Benoit fine sandy loam..... | 18 |
| Benoit loam..... | 20 |
| Benoit silt loam..... | 22 |
| Sioux series..... | 23 |
| Sioux sandy loam, beach-ridge phase..... | 23 |
| Miscellaneous material..... | 25 |
| Peat..... | 25 |
| Summary..... | 27 |

ILLUSTRATIONS.

FIGURE.

- FIG. 1. Sketch map showing location of the Pennington County area, Minnesota..... 5

MAP.

Soil map, Pennington County sheet, Minnesota.

SOIL SURVEY OF PENNINGTON COUNTY, MINNESOTA.

By WILLIAM G. SMITH, N. M. KIRK, and FREEMAN WARD.

DESCRIPTION OF THE AREA.

Pennington County is in the northwestern part of Minnesota. It lies within the bed of the ancient Glacial Lake Agassiz. The county is bounded on the north by Marshall County, on the east by Beltrami and Clearwater Counties, on the south by Polk and Red Lake Counties, and on the west by Polk County. The county is nearly rectangular, with a length from east to west of about 42 miles and a width from north to south of about $14\frac{1}{2}$ miles. It contains 607 square miles, or 388,480 acres.

The county is essentially a plain, with a slight southwest slope. The highest elevation, 1,186 feet above sea level, is near the northeastern corner, while in the southwestern corner the elevation is less than 1,000 feet. Except for the beach lines, or "sand ridges," the surface is flat, with slight depressions and low swells, which are barely perceptible. The streams of the county are immature. Thief, Red Lake, and Clear Water Rivers are the only ones having a continuous flow, and they have practically no tributaries. The rivers flow in crooked courses. They are only about one-sixteenth mile wide, and the channels range from 5 to 20 feet in depth. Except along the lower reaches of the streams, or where the channels are deeper, no bottom land is developed. The bottom-land areas are relatively small and are very irregularly distributed.



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

The beach lines, or "sand ridges," in the two western tiers of townships, by reason of the level character of the surrounding lands, form conspicuous topographic features quite out of proportion to their extent. They occur as long, north-south ridges one-eighth to 1 mile wide and about 4 to 17 feet above the surrounding country.

Owing to the dominantly level surface, the natural drainage of the county is for the most part poor and must be assisted by artificial means. The principal streams of the county, Thief River and Red

Lake River, unite at the city of Thief River Falls and flow southward out of the county, ultimately finding outlet into the Red River of the North.

Pennington County was organized in 1910 from a part of Red Lake County. The section west of Thief River Falls was opened to settlement over 30 years ago, while the eastern part, comprising about two-thirds of the county, was opened to settlement in 1904, having been a part of the Red Lake Indian Reservation. In each case the land was homesteaded soon after it was opened.

In addition to persons of native birth, the population of the county includes many Scandinavians, Germans, French, English, and others of foreign birth. In the 1910 census the population of the county is reported as 9,376, 60.4 per cent of which, or 9.3 per square mile, is classed as rural. Thief River Falls, the county seat, is the only town of any considerable size; its population is given as 3,714.

The county is supplied with good railway transportation. Through lines of the Great Northern and Soo lines cross the county north and south through Thief River Falls, and this town is the principal point for the shipment of farm products to markets in the United States and Canada. St. Hilaire also is a shipping point of some importance. A gas-electric railway has recently been constructed from Thief River Falls to a point about 20 miles to the east and affords transportation to the eastern part of the county.

The underground water supply of the county on the whole is ample for household and stock use. Bored wells less than 50 to 200 feet in depth reach water-bearing strata supplying good drinking water; in some cases the water is "soft," or comparatively free from minerals.

CLIMATE.

The records of the Weather Bureau station at Crookston, Polk County, about 20 miles to the southwest, are representative of the climatic conditions in Pennington County.

The winters are rather long and cold. The summers are characterized by warm days, but the nights are usually cool. The mean annual temperature is reported as 38.3° F. The highest temperature recorded, in June, is 104°, and the lowest, in February, -45° F. For the winter months of December, January, and February the temperature averages 6.6°. For the summer months, June, July, and August, it averages 65.8°, and for the spring and fall months 38.6° and 41.8°, respectively.

The alternate severe freezing and thawing that occurs during the late fall, winter, and early spring has a highly beneficial effect on

the physical condition of the soils, especially the clay types. This benefit is greatest on soils that have been plowed early in the fall. For this reason, and in order to begin spring work earlier, much fall plowing is done. On the other hand, exposed vegetation is subject to injury by the alternate freezing and thawing, especially when there is no snow cover. Crops subject to injury in this way are not extensively grown, and such as are grown are protected by a straw blanket or a thin soil cover, which is removed in the spring. The grasses, except on unusually exposed places, are not injured as a rule.

The springs are characterized by northwest winds and wet, cold weather. These factors delay the seeding of crops, but the moisture stored in the soil at this time is valuable for crop use later in the season. The relatively short but hot summer season, with 14 to 16 hours of sunshine daily, favors the quick growth and maturity of crops. Warm south and southwest winds, with showers about every third or fourth day, are other favorable factors. The falls are marked by less rainfall, by cold, frosty nights, and by some rather warm "Indian-summer" days, conducive to the growth of fall-seeded crops and favorable for outdoor farm work.

The mean annual precipitation is reported as 23.01 inches. The total for the driest year on record is about 16 inches and for the wettest year about 30 inches. The rainfall is greatest in the summer months. Three-fourths of the precipitation occurs within the period usually considered as the open growing season, April to September, inclusive. The mean annual snowfall is about 36 inches. If the snow cover is heavy and melts rapidly wet conditions in the spring may follow before the drainage ditches can carry off the excess water, thus delaying spring seeding. On the whole the distribution of the precipitation is such that injurious droughts are of rare occurrence.

The average date of the last killing frost in the spring is May 15, and of the first in the fall September 22. This gives a normal growing season of 130 days. The date of the latest recorded killing frost in the spring is June 7, and that of the earliest in the fall, September 9.

The rather short period between dates of killing frost is likely to affect the maturing of corn. However, if conditions are not unfavorable, early maturing varieties can be ripened, and corn for ensilage is easily grown.

The following table, compiled from the records of the Weather Bureau station at Crookston, gives climatological data applicable to Pennington County.

Normal monthly, seasonal, and annual temperature and precipitation at Crookston, Polk County, Minn.

| Month. | Temperature. | | | Precipitation. | | | |
|----------------|--------------|-------------------|-------------------|----------------|-----------------------------------|------------------------------------|----------------------|
| | Mean. | Absolute maximum. | Absolute minimum. | Mean. | Total amount for the driest year. | Total amount for the wettest year. | Snow, average depth. |
| | ° F. | ° F. | ° F. | Inches. | Inches. | Inches. | Inches. |
| December..... | 12.0 | 49 | -33 | 0.51 | 0.05 | 0.20 | 5.7 |
| January..... | 2.2 | 57 | -44 | .62 | .60 | 1.58 | 6.3 |
| February..... | 5.7 | 51 | -45 | .79 | .70 | .97 | 6.7 |
| Winter..... | 6.6 | 57 | -45 | 1.92 | 1.35 | 2.75 | 18.7 |
| March..... | 20.3 | 60 | -35 | 1.12 | .11 | 2.45 | 8.8 |
| April..... | 42.1 | 88 | -13 | 1.91 | .24 | 5.23 | 3.2 |
| May..... | 53.5 | 94 | 14 | 2.99 | 1.23 | 8.13 | .2 |
| Spring..... | 38.6 | 94 | -35 | 6.02 | 1.58 | 15.81 | 12.2 |
| June..... | 63.5 | 104 | 31 | 3.64 | 3.50 | 2.95 | 0.0 |
| July..... | 68.2 | 101 | 38 | 3.47 | 2.34 | 1.05 | 0.0 |
| August..... | 65.8 | 98 | 32 | 3.45 | 1.81 | 3.13 | 0.0 |
| Summer..... | 65.8 | 104 | 31 | 10.56 | 7.65 | 7.13 | 0.0 |
| September..... | 56.5 | 97 | 11 | 2.03 | 2.20 | 2.29 | Trace. |
| October..... | 43.7 | 87 | 9 | 1.80 | 2.92 | 1.02 | .4 |
| November..... | 25.2 | 63 | -30 | .68 | .17 | 1.30 | 4.5 |
| Fall..... | 41.8 | 97 | -30 | 4.51 | 5.29 | 4.61 | 4.9 |
| Year..... | 38.3 | 104 | -45 | 23.01 | 15.87 | 30.30 | 35.8 |

AGRICULTURE.

When the land in Pennington County was first homesteaded it was acquired mainly for speculation, rather than for agricultural development. Prior to the establishment of the large drainage ditches, which have been constructed mainly within the last five years, the greater part of the county was wet and unsuited to agriculture. Considerable wild hay was produced and small grains were grown in the better drained areas. Since the installation of the extensive drainage systems considerable progress in agriculture has been made. The present tendency is toward the development of the live-stock industries in conjunction with small-grain farming.

The only census data available for the county are those published in the 1910 census. Since that year considerable progress has been made in agriculture. The cultivated acreage, as well as that devoted to hay and forage crops, has been extended, land values have increased, and the live-stock industry has become more important. The data published in the census of 1910, however, are indicative of the present type of agriculture. The following table shows the acreage, yield, and value of farm products for that year:

Farm products, census of 1910, Pennington County, Minn.

| Product. | Acres. | Per cent of crop acreage. | Production. | Yield per acre. | Unit value. ¹ | Total value. |
|--|----------------|---------------------------|-------------------------|--------------------|--------------------------|-------------------------|
| Cereal, grain, and seed: | | | | | | |
| Wheat..... | 214,803 | 19.4 | <i>Bushels.</i> 331,193 | <i>Bush.</i> 15.2 | <i>Dolls.</i> 0.78 | <i>Dollars.</i> 258,331 |
| Oats..... | 16,033 | 14.3 | 421,078 | 26.2 | .31 | 130,534 |
| Flaxseed..... | 8,505 | 7.6 | 57,885 | 6.8 | 1.00 | 57,885 |
| Barley..... | 6,396 | 5.7 | 115,024 | 18.0 | .44 | 50,611 |
| Rye..... | 820 | .7 | 11,492 | 14.0 | .55 | 6,321 |
| Corn..... | 168 | .1 | 5,815 | 34.6 | .42 | 2,442 |
| Emmer and spelt..... | 227 | .2 | 4,957 | 21.8 | .42 | 2,082 |
| Buckwheat..... | 44 | .1 | 811 | 18.4 | .80 | 649 |
| Dry edible beans..... | 16 | | 80 | 5.0 | 2.00 | 160 |
| Total..... | 54,012 | 48.1 | | | | 509,015 |
| Hay and forage: | | | | | | |
| Wild hay..... | 47,269 | 42.1 | <i>Tons.</i> 45,099 | <i>Tons.</i> 0.95 | 5.00 | 225,495 |
| Timothy..... | 5,089 | 4.5 | 4,652 | .91 | 6.23 | 28,982 |
| Timothy and clover mixed..... | 3,839 | 3.4 | 4,612 | 1.2 | 6.23 | 28,733 |
| Other tame grasses..... | 604 | .5 | 626 | 1.0 | 6.23 | 3,900 |
| Coarse forage..... | 350 | .3 | 1,765 | 5.0 | 5.00 | 8,825 |
| Grains cut green..... | 145 | .1 | 183 | 1.3 | 6.23 | 1,140 |
| Clover..... | 122 | .1 | 169 | 1.4 | 6.23 | 1,053 |
| Millet..... | 57 | .1 | 103 | 1.8 | 5.00 | 515 |
| Alfalfa..... | 11 | | 23 | 2.1 | 6.23 | 143 |
| Total..... | 57,486 | 51.1 | | | | 298,786 |
| Special crops: | | | | | | |
| Potatoes..... | 627 | .6 | <i>Bushels.</i> 74,933 | <i>Bush.</i> 119.5 | .40 | 29,973 |
| Other vegetables..... | 280 | .2 | | | | 11,818 |
| Raspberries..... | 2 | | <i>Quarts.</i> 1,915 | <i>Quarts.</i> 947 | | 817 |
| Strawberries..... | 2 | | 1,800 | 900 | | |
| Total..... | 911 | .8 | | | | 42,608 |
| Grand total..... | 112,409 | | | | | 850,409 |
| Live-stock products: | | | | | | |
| Dairy products, excluding home use..... | | | | | | 227,900 |
| Animals sold and slaughtered..... | | | | | | 202,649 |
| Poultry and eggs..... | | | | | | 51,789 |
| Wool..... | | | | | | 3,882 |
| Total..... | | | | | | 486,220 |
| Total value of all field and live-stock products..... | | | | | | 1,336,629 |

¹ Minn. Bureau of Immigration, report of Nov. 1, 1911, p. 40.² Based on local estimates.

The 1910 census reports a total of 1,244 farms of an average size of 207 acres. Two-thirds of the total area of the county is reported in farms, and of the farm land 53.1 per cent, or about 110 acres per

farm, is reported improved. The average value of farm land is given as \$16.40 an acre. According to local estimates, the present value of farm land ranges from \$5 to \$80 or more an acre, according to the character of the land, improvements, and location. About 88 per cent of the farms in 1910 were operated by the owners, the remainder by tenants.

Hay and forage occupied more than half the total area in crops. Wild grasses were reported on 47,269 acres, and tame or cultivated grasses, mainly timothy or timothy and clover mixed, on 9,722 acres. The principal grain crops were wheat, which was grown on 21,803 acres, with a production of 331,193 bushels, and oats, which occupied 16,033 acres, with a total production of 421,078 bushels. Flax is reported on 8,505 acres, and barley on 6,936 acres. Other crops are not of economic importance in the agriculture of the county. Rye was grown on 820 acres in 1909, potatoes on 627 acres, and all other vegetables on 280 acres.

Market-garden and truck crops and fruit are grown mainly for home use. Owing to improved drainage conditions, corn is now grown to a greater extent than in 1909. Considerable interest is taken in the development of varieties best suited to local conditions. Both the bluestem and bearded varieties of wheat are grown. Some farmers are experimenting with Russian strains of winter wheat, and report favorable yields.

Totals of 2,377 calves and 8,082 other cattle are reported sold or slaughtered in 1909. In addition, 2,757 hogs and 1,669 sheep and goats were sold or slaughtered, and 225 horses and mules were sold. The total value of animals sold or slaughtered is given as \$202,649. The value of dairy products, excluding home use, is given at \$227,900. Those products, mainly cream, are sold to creameries and cheese factories within the county. The poultry and eggs sold in 1909 were valued at \$51,789.

The 1910 census reports a total expenditure of \$98,794 for labor in Pennington County. If hired for long periods farm laborers are paid \$35 to \$40 per month with board. During the harvest season they receive about \$2.50 to \$3 or more per day with board.

The farm improvements are typical of those of a region but recently opened to agricultural development. On some farms the houses, barns, farm machinery, etc., appear to be adequate, with a sufficient number of good horses as work stock. Other farms are less well supplied, but there is a gradual improvement in the equipment and stock.

The practice of fall plowing the land is quite common. The beneficial effect of the severe freezing and thawing on plowed land, especially the clayey soils, is generally recognized. Fall plowing has the added advantage of lessening the press of spring work. Heavy

double and single riding plows, drawn by either horses or oxen, are used, though the single walking plow is also used. Such crops as corn and potatoes are tilled mainly with horse-drawn riding cultivators.

The contract price for plowing stubble or old ground is usually about \$2 an acre, and for new breaking of prairie land about \$4, or more where there is a growth of brush. For new breaking of peaty lands the price varies from about \$5 to \$7 an acre, according to the depth of plowing. Heavy traction engines are considered desirable in plowing peaty lands, as the compression of the material by the weight of the engine is beneficial. Peat land on which stock has been pastured for a long time is improved by the trampling of the animals. Traction engines are also used to a greater or less extent in breaking native sod and old ground on the other soils.

Flax usually is the first crop seeded on new land, though small grains are sometimes sowed. Flax is said to impair the producing power of the soil if grown too often on old land, but is considered a good initial crop for new land. All the small grains except rye are almost invariably sowed in the spring. Rye is fall seeded, usually in September, and, like flax, is grown for a special purpose. It is sowed to a considerable extent on lands with leachy subsoils or on lands on which crops are subject to drought. It makes a part of its growth in the fall and reaches maturity early the following summer, thus utilizing the fall and spring rains. Barley matures quickly, and can be sowed on land which remains wet until too late in the season for other grains.

Modern farm machinery with horse motive power is used to a great extent in seeding and harvesting the cereal crops. The hay crops also are handled under improved methods.

Considerable small grain is thrashed from the shock, but stacking is regarded as the better practice, as it obviates the danger of the grain sprouting in the shocks in case of rain. Stacked grain also goes through a "sweat" which hardens it and insures it against future injury from overheating or molding in grain bins or elevators. In order to counteract the tendency toward heating when the grain is stored in bulk from shock thrashing, some farmers utilize movable galvanized metal bins designed properly to protect the grain against rain, to ventilate it, and to cure it for marketing at some later time when it can be conveniently hauled. Some straw stacks are disposed of by burning, but where needed the straw is kept for use as food and bedding for live stock.

Crop rotation is not practiced in the county, at least not for the purpose of conserving or improving the producing power of the soils. Under the present practice weeds which are difficult to eradicate, such as the sow thistle, Canada thistle, and quack grass, have gained

a strong foothold. Some plan of crop rotation, coupled with summer fallowing, and the use of good seed, is suggested in Bulletins 129 and 139 of the University of Minnesota Agricultural Experiment Station as an effective means of eradicating even the more serious weeds. A rotation to include small grains, tame grasses, including clovers, and corn or other intertilled crops, has proved elsewhere its value in maintaining the productiveness of soils as well as in controlling to a considerable degree weed growth and crop diseases. Such a system is most effective where accompanied by the use of barnyard manure and proper cultivation. Practically no commercial fertilizers are used in the county.

SOILS.

The materials that make up the soils of Pennington County originally were deposited as glacial drift. Subsequently during a period of submergence by the waters of Glacial Lake Agassiz, a considerable modification of the surface by lacustrine deposits took place. After the deep waters receded surface weathering under poor drainage conditions became active and organic matter was added to give the soils their present composition.

During the glacial period the advances and recessions of the ice sheet over a wide region, of which Pennington County is a part, left a great mass of glacial débris, consisting mainly of clay, with an admixture of bowlders, pebbles, and sand. This mass of material has a depth of 400 to 500 feet in this county, and rests on a granite floor. The top layer, known as gray drift or bowlder clay, is of immediate interest in that it gives character to all the soils of the county to a greater or less degree. The Fargo soils are derived from the material slightly modified by lacustrine agencies.

Following the deposition of the glacial material the entire area for a long period of geologic time was covered to a considerable depth by a great body of water, known to geologists as Glacial Lake Agassiz. This lake existed during the recession of the ice sheet and was, in fact, due to the temporary damming of the water over a vast shallow, northward-tilting basin by the receding ice. At the time of its greatest extension it covered in the United States the present Red River Valley and extended into Canada as far north as the Nelson and Saskatchewan Rivers.

As the level of this great glacial lake was lowered, successive shoreline areas were exposed to varying degrees of wave action. This resulted in the removal of more or less of the clay in places, and in the formation of large areas of gravelly, sandy material of varying depth, which in most cases are now covered by a mantle of heavier textured material about 1 foot in thickness. Such areas have been classed in soil mapping on the basis of depth to the gravelly, sandy

subsoils and substrata, as well as according to certain well-defined surface features, with two soil series, the Benoit and the Sioux soils. The Sioux series includes what is geologically termed beaches, locally known as "sand ridges." The areas of Sioux soils or beaches were built up through longer exposure to wave action than the more level outlying areas included with the Benoit soils.

The depressions that contained more or less water until a comparatively recent time have been filled through the growth and decay of swamp vegetation with peaty material, varying from a few inches to about 5 feet in thickness. These areas are differentiated according to the depth of the peat, the deeper material being mapped as Peat, and the shallower as Peat, shallow phase. The Peat lands comprise about one-sixth the area of Pennington County.

Surficially the Fargo and Benoit soils apparently are similar. A study of the subsoils, however, discloses certain physical characteristics that indicate important differences in agricultural value. The areas of Peat and the Sioux soil (sand ridges) are easily distinguished by their topographic features. The types with clay subsoils are considered as having the greater general agricultural value. Including Peat, nine different soil types are mapped in the county. One type is represented only by a phase, and phases of three other types are shown. Three soil series are represented.

The following table gives the name and the actual and relative extent of each soil type mapped in Pennington County:

Areas of different soils.

| Soil. | Acres. | Per cent. | Soil. | Acres. | Per cent. |
|-----------------------------|---------|-----------|--|---------|-----------|
| Fargo clay loam..... | 141,632 | 36.4 | Sioux sandy loam, beach- ridge phase..... | 13,184 | 3.4 |
| Fargo loam..... | 67,328 | 17.3 | Fargo fine sandy loam..... | 13,056 | 3.4 |
| Peat..... | 8,384 | 17.1 | Benoit silt loam..... | 8,384 | 3.0 |
| Shallow phase..... | 57,792 | | Benoit heavy-substratum phase..... | 3,072 | |
| Benoit loam..... | 24,192 | 14.5 | Benoit fine sand..... | 3,264 | .8 |
| Heavy-substratum phase..... | 32,320 | | | | |
| Benoit fine sandy loam..... | 12,672 | 4.1 | Total..... | 388,480 | |
| Heavy-substratum phase..... | 3,200 | | | | |

FARGO SERIES.

The soils of the Fargo series are dark brown to black, underlain by gray, yellowish or greenish-yellow, calcareous subsoils as heavy as or heavier than the soil. They are developed in areas of imperfect drainage, either lake beds or other depressed areas within the glaciated region of the United States. They may be derived from glacial till with little or no lake-deposited material or they may be derived wholly from lake-laid material. Cobblestones, bowlders, and gravel may occur on the surface and throughout the 3-foot section

and beneath, but as a rule not in sufficient quantities on the surface to interfere with the use of the land for agriculture. The substratum consists of gray, calcareous clay of considerable depth, with a varying admixture of cobblestones, bowlders, and gravels. In Pennington County the Fargo series is represented by three types, the fine sandy loam, the loam, and the clay loam, which cover approximately three-fifths of the total area of the county.

FARGO FINE SANDY LOAM.

The Fargo fine sandy loam consists of about 12 to 18 inches of dark-brown, fine sandy loam, underlain by a gray, calcareous bowlder clay which extends to a depth of 3 feet or more.

Some scattered bowlders, cobblestones, and gravel, mainly of limestone origin, occur on the surface and within the 3-foot section. These, however, are not present in sufficient quantities to interfere with cultivation. In some cases the larger stones are removed from time to time after plowing. The upper 4 to 6 inches of the soil contains varying quantities of organic matter; the lower part contains less organic matter, and, in many instances, is somewhat coarser textured than the upper layers. The line of demarcation between the surface soil and the clay subsoil is rather sharply defined in most cases. Newly plowed fields show alternate black and light-brown spots, but these colors blend, giving the soil a brown to dark-brown color in older fields. The surface soil shows less tendency to bake or become compact than the surface soils of the other types of this series. It is easily kept in a loose, mellow condition. The subsoil is identical in character with that of the loam type, consisting of a gray, calcareous bowlder clay. The type conserves moisture for crop use fairly well without surface cultivation, but better where cultivated. The substratum consists of gray, calcareous bowlder clay, and is similar in all respects to the subsoil except that it apparently is less weathered.

The Fargo fine sandy loam is inextensive and is confined largely to the east-central part of the county, where it is associated with the loam and clay loam types of the series.

The type has a little more relief than the other two types of this series. Low ridges occur in places, but on the whole the topography is that of a plain modified by broad swells.

The Fargo fine sandy loam, excepting the low ridges and slight swells, originally was subject to inundation, in common with most of the other soils of the county. Since the construction of the large drainage ditches in the county practically all the type is sufficiently drained for crop production. Owing to its lighter texture and more open structure, the type naturally drains more rapidly and warms up

earlier in the spring than do the other Fargo soils. The native vegetation consisted of grasses and other plants and shrubs.

Owing to its open, sandy texture, this type is easily cultivated under a wide range of moisture conditions. It is a better corn soil than the heavier types of the series, and other crops common to the region, including potatoes, small fruit, and garden vegetables, do well. It is productive and responds readily to good cultivation. The occasional growing of clover and the application of barnyard manure are beneficial. The present methods of farming on this type are not such as tend to conserve or increase its crop-producing power.

The Fargo fine sandy loam has about the same value as the adjoining types of the series.

FARGO LOAM.

The Fargo loam consists of a dark-brown to black loam, underlain at about 12 to 18 inches by a rather heavy, gray, calcareous clay or silty clay, which extends to a depth of 3 feet or more. The subsoil is plastic when wet and hard and compact when dry. Boulders, cobblestones, and gravel, mainly of limestone origin, are scattered over the surface and throughout the 3-foot section. As a rule the boulders and cobblestones do not interfere with cultivation; in some fields they are removed after plowing. The texture of the surface soil varies from rather heavy loam to rather coarse, open loam. Another local variation in the type consists of gravelly strata 2 to 6 inches or so in thickness lying between the surface soil and clay subsoil. With proper cultivation the type is retentive of moisture. The subsoil material on the whole shows rather more modification from glacial lake action than that of the Fargo clay loam. The substratum consists of gray, calcareous boulder clay similar in all respects to that of the subsoil, except that it apparently is less modified.

The Fargo loam is extensively developed in the western part of the county; less so in the eastern part. Its total area is less than half that of the clay loam. The topography is the same as that of the clay loam, ranging from level to gently undulating. Owing to its level surface, the type has poor natural drainage, and prior to the construction of drainage ditches much of it was covered with standing water until late in the summer. The soil remained cold and wet so long that field crops could not be grown satisfactorily and it was used for the production of hay and for pastures. Under present conditions most of the type is available for crop production, though some additional ditching is needed. The native vegetation is practically the same as that of the Fargo clay loam. Since the

surface soil of the Fargo loam is more open and loamy than that of the clay loam, the type can be cultivated under a somewhat wider range of moisture conditions. It is naturally a strong, productive soil, well suited to the staple crops of the region. But little attention is paid to maintaining or increasing its crop-producing power.

Land values range from about \$10 to \$80 an acre, according to location and improvements.

FARGO CLAY LOAM.

The Fargo clay loam consists of about 6 to 18 inches of dark-brown to black clay loam, underlain by a rather heavy, gray, gravelly, calcareous silty clay or clay extending to a depth of 3 feet or more. The subsoil is a clay to silty clay, and is highly calcareous. Its color is gray to light gray. When dry it forms a rather hard, compact mass with wide cracks extending down to a point where the material becomes moist. When wet the subsoil is rather soft and plastic. Boulders, cobblestones, and gravel, mainly of limestone origin, are distributed over the surface and throughout the soil section. The larger boulders are mainly crystalline. The boulders and cobblestones, however, are seldom sufficiently numerous to interfere with cultivation. In some cases they are removed from the field after plowing.

In native sod land and in grain fields the soil becomes hard and compact in dry weather, with wide cracks showing in the surface material. In cultivated fields, especially under normal moisture conditions, a loose, mellow structure is easily maintained. The type is subject to some local variations. In patches the surface soil is quite clayey and comparatively free from gravel. In other local areas gravelly layers about 2 to 6 inches thick occur between the surface soil and the clay subsoil. The substratum consists of gray, calcareous boulder clay. Where properly drained and cultivated the type is retentive of moisture and is easily kept in good physical condition.

This type is extensive in Pennington County. It is developed only to a small extent, however, in the two western tiers of townships. The topography varies from level to gently undulating, the generally level surface being modified by low knolls and ridges. The type has poor natural drainage. Before artificial drainage was provided this soil was subject to standing water until late in the season, the soil remaining cold and wet so long that it could not be used for cultivated crops. It was utilized mainly for the production of wild hay and for pasture. Under present conditions, however, most of the type is well suited to cultivation. Some additional ditching, to connect the individual farms with the main ditches, would make practically all the type available for crop use.

A large part of the Fargo clay loam originally was covered with native prairie grasses and wild vetches, which made good hay and pasturage. Owing to the continued cutting of hay, the vetches have largely disappeared. Other parts of the type supported a native forest growth, consisting largely of second-growth poplar, with some elm, oak, and various bushes, mainly hazel. The forested areas also supported a growth of wild grasses. Some low, wet areas of the type still bear a growth of willow. Wild plums, red raspberries, and wild strawberries are found in some areas of the type.

The Fargo clay loam is regarded as one of the best soils for general farm crops. The part of the type in native prairie grasses is more easily brought under cultivation than the forested part. New land is usually sowed to flax, though in some instances oats are used as the first crop. Early fall plowing of stubble fields is deemed advisable, as this tends to destroy weed seeds and favors the decay of vegetable matter before frost. The severe freezing and thawing that follow in the fall, winter, and spring improve the physical condition of the soil. Disking and harrowing in the spring hasten the warming of the soil, which is important where corn is grown.

All the small grain, except rye, is seeded in the spring. Wheat, according to local estimates, yields about 10 to 40 bushels, and oats 20 to 50 bushels per acre. The yield of flax seems to be rather low, about 5 to 15 bushels per acre being obtained. Corn is not extensively grown as yet, though the yields obtained in some instances are encouraging. Potatoes receive but little attention, although they seem to do fairly well. Small fruits and various garden and truck crops succeed. This is a naturally strong soil, but as yet little effort has been made to maintain or increase its productiveness.

The value of this land ranges from about \$10 to \$80 an acre, depending on location and improvements. On the whole, land values appear to be increasing.

BENOIT SERIES.

The surface soils of the Benoit series are characteristically dark brown to black and are underlain by clean, more or less stratified, sandy and gravelly material about 3 to 5 feet in thickness, which in turn rests on gray, calcareous boulder clay. The boulder-clay substratum is identical in character with that underlying the Fargo soils. Boulders and cobblestones are almost entirely absent in the Benoit soils. The gravel of the subsoil and substratum is largely of limestone origin. This series comprises four types in Pennington County, the Benoit fine sand, fine sandy loam, loam, and silt loam, and occupies about one-fifth of the area of the county.

BENOIT FINE SAND.

The Benoit fine sand consists of about 10 to 15 inches of brown to dark-brown fine sand, underlain by a layer of gray to brownish fine sandy material about 3 to 6 feet or more in thickness, which in turn rests on gray, calcareous boulder clay. The surface soil consists mainly of medium to fine sand, with some admixture of silt and organic matter. Small pebbles and gravel are present locally. The color ranges from light brown to rather dark brown, according to the organic-matter content. In native sod land the structure is fairly compact, but in cultivated fields it is rather loose and open, and in exposed places the material is more or less subject to drifting. The subsoil shows evidence of stratification, including cross bedding. Some local variations in texture occur, the material in places including coarser sand and some gravel. The subsoil has a fairly compact structure, though it is not so compact as to retard the free movement of ground water, and in some areas crops are subject to injury by drought. Owing to the underlying clay substratum, a high water table is maintained.

The Benoit fine sand occurs in the southwestern part of the county, where it is associated with other types of this series. It is developed in scattered areas. The surface differs from that of the other soils of the series in that the greater part of the type forms elongated low ridges and broad swells 2 to 6 feet above the general level of the adjoining soils. The drainage of this type is adequate, and in dry seasons excessive.

The native vegetation is similar to that of the Fargo soils. The Benoit fine sand produces good yields of the staple crops of the county in seasons of abundant rainfall, but owing to its rather leachy character, crops suffer in dry seasons. Of the grain crops, rye is the most certain, owing to its earlier maturity. The type warms up quickly in the spring and is well suited to the growing of corn, potatoes, and garden vegetables.

Land of this type has a somewhat lower value than the other soils of the Benoit series.

BENOIT FINE SANDY LOAM.

The Benoit fine sandy loam consists of about 12 to 18 inches of dark-brown to black fine sandy loam, underlain by gray to brownish fine sandy material. Gray, calcareous boulder clay is encountered at depths of 4 to 6 feet or more. The surface soil is composed of medium to fine sand, with sufficient silt, clay, and organic matter to give a fine sandy loam texture as a whole. There is some admixture in places of small limestone pebbles and gravel. There are local variations in texture, the material ranging to a silty fine sandy loam in some places and having a considerably lighter texture in others.

The color in places ranges to light brown. The organic-matter content is somewhat higher than in the fine sand of this series. On native sod land the structure is fairly compact, but in cultivated fields the material is rather loose and open, exposed areas being more or less subject to drifting. The material underlying the fine sandy loam surface soil is composed of medium to fine sand, free from organic matter, and showing evidences of stratification. Local areas show more or less cross bedding with alternate thin layers of fine sand and coarse sand, pebbles, and gravel. The material has a fairly compact structure, though ground water circulates freely, and some areas are more or less subject to drought. In seasons of abundant rainfall, owing to the underlying clay substratum, the water table is high.

Several areas of the Benoit fine sandy loam are mapped in the western part of the county, adjoining the "sand ridges" classed with the Sioux soil, while other areas occur in the east-central part of the county, in association with other Benoit soils. The surface of the type varies from level to gently rolling, some areas including low swells or elongated low ridges. The type is rather poorly drained naturally, but under the present systems of artificial drains is well to excessively drained.

The native vegetation is similar in character to that of the other Benoit soils. The type is fairly productive of the staple field and truck crops in seasons of sufficient rainfall. On account of its susceptibility to drought, earlier maturing grain crops, such as rye, are rather more certain than grains maturing later in the season. With good cultural methods and the use of some practical means of preventing excessive drainage, reasonably good yields can be obtained under a wide range of climatic conditions. Land values are about the same as on adjoining soils.

Benoit fine sandy loam, heavy-substratum phase.—The Benoit fine sandy loam, heavy-substratum phase, consists of about 10 to 15 inches of medium-brown to dark-brown fine sandy loam, underlain by a layer of gray to brownish, clean, partially stratified fine sandy and gravelly material 1 to 2 feet thick, which in turn rests on gray, calcareous boulder clay. Some boulders and cobblestones occur on the surface and throughout the 3-foot section, but these do not interfere with cultivation.

The surface soil is composed chiefly of fine sand, with enough organic matter, silt, and clay to give a fine sandy loam texture. In its natural condition it has a fairly compact structure, while in cultivated fields it is loose and mellow. The underlying material includes medium to fine sand and some gravel. It has a gray to brown color and a fairly compact structure. On the whole the texture is coarser than that of the surface soil. The material is rather free from organic matter and contains very small quantities of silt and

clay. The texture is such as to permit the free movement of soil water. The material is not retentive of moisture and capillarity is not well developed. In dry seasons or near drainage ditches, the phase is droughty. The substratum consists of a gray, calcareous boulder clay similar to that underlying the main type.

The Benoit fine sandy loam, heavy-substratum phase, is not extensively developed. A few relatively small areas are encountered in the east-central part of the county. The surface varies from level to gently undulating. Prior to the establishment of artificial drainage the soil was poorly drained, but under present conditions drainage is adequate to excessive.

The native vegetation is similar to that of the main type. The phase is fairly productive of the staple crops in seasons of abundant rainfall. On account of its susceptibility to drought, rye is the most certain crop, as it matures before the dry season begins. However, the soil warms up quickly in the spring, and is well suited to growing corn and potatoes and other truck crops, which do well with abundant rainfall as well as where good cultural methods are used. The land values at present are about the same as on adjoining soils.

Results of mechanical analyses of samples of the soil and subsoil of the typical Benoit fine sandy loam and of the heavy-substratum phase follow:

Mechanical analyses of Benoit fine sandy loam.

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---------------------------|--------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Typical: | | <i>Per cent.</i> |
| 320718..... | Soil..... | 1.8 | 13.2 | 13.6 | 46.2 | 5.0 | 16.0 | 4.2 |
| 320719..... | Subsoil..... | 2.0 | 4.7 | 4.6 | 73.0 | 9.1 | 4.2 | 2.4 |
| Heavy - substratum phase: | | | | | | | | |
| 320720..... | Soil..... | 6.4 | 16.7 | 11.6 | 44.8 | 3.2 | 13.3 | 3.9 |
| 320721..... | Subsoil..... | 7.8 | 17.3 | 12.0 | 51.0 | 2.1 | 6.4 | 3.3 |

BENOIT LOAM.

The Benoit loam consists of about 10 to 16 inches of dark-brown to black loam, underlain by gray to brownish, clean, cross-bedded and horizontally stratified fine sand and gravelly material, which in turn rests on gray, calcareous boulder clay at approximately 4 to 6 feet below the surface. There are some local variations, the type ranging to a rather heavy loam on the one hand and to a lighter loam on the other. The organic content of the surface soil is fairly large. The structure of the top soil is naturally more or less compact, but in well-tilled fields it is open and friable. The underlying material consists of medium to fine sand, with more or less gravel.

In places horizontal and cross-bedded stratification is quite marked, showing alternate thin layers of both finer and coarser textured materials. There is practically no organic matter and very little silt and clay present. The color of the material varies from light gray to various shades of brown. Some gravel, largely of limestone origin, occurs in this type. Ground water circulates freely, and the type is droughty in the vicinity of the large drainage ditches, and in other places in prolonged periods of dry weather.

Some fairly large areas of the Benoit loam are mapped in the western part of the county, adjoining the beaches classed as the Sioux soil. In the east-central part a number of smaller areas are encountered. The surface of the type varies from level to gently undulating. Originally this soil was poorly drained, but with the construction of the large ditches in the county it is well drained and at times excessively drained.

This type supports a native vegetation similar to that of the other Benoit soils. In seasons of abundant rainfall it is fairly productive of the crops common to the region, but since it is susceptible to drought, the early maturing crops, such as rye, are the most dependable. In general the type is in need of good cultural methods, coupled with some practical means of preventing overdrainage. Temporary damming of the large drainage ditches at proper times would doubtless prove beneficial.

The Benoit loam has a somewhat lower agricultural value than the Fargo soils.

Benoit loam, heavy-substratum phase.—The Benoit loam, heavy-substratum phase, consists of about 10 to 15 inches of dark-gray to black, sometimes brownish, loam, underlain by semistratified sandy gravelly material, which in turn rests on gray, calcareous boulder clay at a depth of about 3 feet. Scattered boulders and cobblestones occur in places on the surface and within the soil mass, but are not so abundant as on the Fargo soils. The surface soil is composed of silt and some clay with an admixture of coarse and fine sand, small cobbles, and some limestone gravel. These materials occur in varying proportions, giving a number of minor local variations in texture. The soil has a tendency to compact in its natural state, but an open, friable seed bed is easily maintained. The structure of the gravelly subsoil is such as to permit the free movement of ground water. The substratum of boulder clay is similar to that underlying the Fargo soils.

The Benoit loam, heavy-substratum phase, occurs in irregular areas in various parts of the county. The surface varies from level to gently undulating, with some basinlike depressions. Before artificial drainage was established the phase was flooded during wet seasons. Under present conditions the drainage is adequate, and in

very dry seasons may be excessive, owing to the open character of the underlying material. This condition is especially marked near the main drainage ditches.

The native vegetation is similar to that of other Benoit soils. A part of the phase is in prairie, and a part supports a tree and bush growth. The phase is fairly productive of the staple crops in seasons of adequate rainfall, while in dry seasons the moisture supply is insufficient for crop growth. Rye, owing to its early maturity, is the most dependable crop. Better cultural methods, including good tillage and the prevention of overdrainage, probably by damming the ditches occasionally, are needed.

Land values at present are about the same as on the adjoining Fargo soils.

BENOIT SILT LOAM.

The Benoit silt loam consists of a dark-brown to black silt loam, underlain at about 12 to 18 inches by gray to brownish fine sandy material. This rests upon gray, calcareous boulder clay at approximately 4 to 6 feet below the surface. The entire 6-foot section differs from the other types of this series in the almost total absence of gravel. The surface soil is composed mainly of silt, with some clay and a slight admixture of small limestone pebbles. Locally the type varies from a rather heavy silt loam to a rather light silt loam. In places the material is dark gray. In some small areas a scattering of gravel is present on the surface. The organic-matter content is uniformly high. The surface soil is more or less compact, naturally, but in well-cultivated fields an open, friable tilth prevails. Stratification probably exists in the subsoil, though it is less clear than in the other types of this series. The movement of ground water is free, although somewhat more restricted than in the case of the loam, and for this reason, as well as its more basinlike position, the type is less droughty. It retains moisture well and generally does not suffer from overdrainage near the main ditches. When wet the material has somewhat the characteristics of quicksand; when dry the structure is quite compact. Owing to the underlying boulder-clay substratum, a high water table is maintained under normal conditions of rainfall.

Some large as well as small bodies of this type occur in the southwestern part of the county, adjoining the sand ridges mapped as Sioux soil. The surface varies from level to gently undulating, with some basinlike areas. Before drainage ditches were constructed the type was rather poorly drained, but under present conditions drainage is adequate.

The native vegetation is quite similar to that of the other Benoit soils.

The Benoit silt loam is productive, equaling the Fargo soils in crop-producing power, except possibly in very dry seasons.

Land values are about the same on this type as on adjoining soils, and depend mainly on location and improvements.

Benoit silt loam, heavy-substratum phase.—The Benoit silt loam, heavy-substratum phase, consists of about 10 to 15 inches of dark-brown to black silt loam, underlain by rather clean, partially stratified, light-yellow to gray, fine to very fine sand. Gray, calcareous boulder clay is encountered at approximately 3 feet below the surface. The top soil contains only a few small limestone pebbles and gravel. On unbroken prairie sod or in untilled fields the soil has a rather compact structure, but in well-tilled fields it is friable. There are some local variations in the subsoil, due to the presence of coarser sandy material. As a whole, however, the structure is rather more compact than that of the subsoil of the Benoit loam, so that the phase has a greater water-holding capacity and greater capillary power. The substratum consists of gray, calcareous boulder clay, similar to that underlying the Fargo soils except that in places it may show greater modification from lake action.

The Benoit silt loam, heavy-substratum phase, is not extensively developed in this county. It is encountered in small areas near St. Hilaire. The surface is generally level and the phase originally was subject to inundation during wet seasons. Under present conditions it is well drained.

Some areas of the phase are in prairie and some support a tree and brush growth. The phase is productive of the staple crops of the county. In general it seems to be a better soil than the loam member of this series.

Land values range from about \$20 to \$80 an acre, according to location and improvements.

SIoux SERIES.

The Sioux series typically consists of dark-brown to black terrace soils occurring within the glaciated region of the Central and Northwestern States. They are commonly underlain by a bed of gravel, usually within 3 feet of the surface, and occur as comparatively narrow areas along streams. In Pennington County this series is represented by a beach-ridge phase of the sandy loam type. This soil has distinctive topographic features, occupying elongated beaches or ridges.

SIoux SANDY LOAM, BEACH-RIDGE PHASE.

The Sioux sandy loam, beach-ridge phase, consists of about 10 to 15 inches of dark-brown to nearly black sandy loam, carrying some small gravel, underlain by gray to brownish, highly calcareous gravelly sand consisting mainly of coarse sand, pebbles, and larger

gravel fragments showing strong marks of horizontal and cross-bedded stratification. This rests on gray, calcareous boulder clay at depths ranging from 6 to 16 feet.

There are many local variations in the surface soil, the result of varying composition. The structure is quite compact on native sod land, while in cultivated fields it is rather loose and open. The structure of the subsoil is compact, but the movement of ground water is not retarded, and there is a marked tendency toward droughtiness.

The Sioux sandy loam, beach-ridge phase, occupies the "sand ridges," or old glacial-lake beaches occurring within the two western tiers of townships. They have a general north-south trend and constitute a part of a series of such beaches extending both north and south of Pennington County. These beaches vary in width from about one-eighth to 1 mile, with elevations of about 4 to 17 feet above the surrounding lands. They form a conspicuous topographic feature in contrast to the rather level character of the remainder of the county. The narrower ridges have high centers and smooth, fairly steep slopes on each side, while the wider ridges are rather flat to gently rolling, with abrupt slopes on the west side and long, gentle slopes on the east. The ridges have always stood well above the standing water which originally covered the lower lying lands during wet seasons and were for this reason selected by the earlier settlers. The ridges also afforded excellent means of travel and a part of the old Pembina Trail, from Canada to central Minnesota, lies along one of the western ridges of this county.

The Sioux sandy loam, beach-ridge phase, has ample natural drainage even in wet seasons, and in normal and dry seasons the drainage is excessive.

The central part of the beaches usually is without native grass and forest cover, and some of the ridges are devoid of such growth over all their parts, but as a rule the slopes support a native growth of poplar, oak, wild plum, red and black cherry, wild black currant, hazel, and other bushes, with an undergrowth of native grasses. The forest growth is usually small, the trees ranging from 3 to 8 inches in diameter. Poplar is the most abundant species. It has some value for firewood and for fence posts. The oak trees have been largely cut for this and other purposes. Considerable wild fruit is gathered in some seasons.

The Sioux sandy loam, beach-ridge phase, was the first soil cultivated in this county. It has been used for the staple crops, with varying degrees of success, the farmers depending mainly on the rainfall to supply the immediate needs of growing crops, the type having a low water-holding capacity. The central part of the beaches mainly are cultivated. Of the grain crops, rye is the most

dependable. It is seeded in September and reaches maturity before the hot summer weather begins. The soil warms up early in the spring, favoring the early planting of corn, potatoes, and garden crops, though the yields depend on summer rains, and as a whole are rather uncertain, owing to the droughty character of the soil. The principal need of this soil is good cultural methods designed to maintain the supply of organic matter through the use of barnyard manure and the growing of such crops as clover in the rotation.

Land values for this type range from about \$5 to \$25 an acre, according to location and improvements.

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

Mechanical analyses of Sioux sandy loam, beach-ridge phase.

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|-------------|--------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| | | <i>Per cent.</i> |
| 320708..... | Soil..... | 14.6 | 19.5 | 8.6 | 29.2 | 3.4 | 19.8 | 4.9 |
| 320709..... | Subsoil..... | 14.2 | 21.6 | 13.4 | 46.6 | 2.2 | 1.9 | 0.2 |

MISCELLANEOUS MATERIAL.

PEAT.

The surface 6 to 9 inches of Peat is usually brown in color and is composed of a spongy mass of partially decayed coarse grass, moss, and roots. This is underlain by a black material having a more compact structure and showing a greater advance in decay than the surface layer. Strata of clayey or sandy material, ranging in thickness from about 1 foot to 3 feet are encountered at depths of 2 to 5 feet, and beneath this is found the boulder clay. In places there is a gradation from the peaty material into the clayey or sandy strata, the material having a somewhat mucky character. For the most part the Peat is neutral to quite strongly alkaline.

Peat is not extensively developed in the county, the largest areas occurring in the southeastern part of the county. The areas are basinlike and the surface is level. Originally the drainage was poor. Artificial drainage has improved the conditions somewhat, though some additional large ditches, as well as smaller laterals, are needed to provide adequate drainage for all areas.

Peat occurs for the most part in a locality in which outlets low enough for the large ditches are difficult to obtain. The present ditches have nearly level gradients, and in wet seasons fill to overflowing and fail to effect proper drainage. Deepening of the channels of the Red Lake and Clear Water Rivers along a part of their

courses in order to provide lower outlets for the drainage ditches, as well as control of the discharge from Red Lake by damming, are remedial measures under consideration by local authorities.

Where the ditches are of good depth and have sufficient fall to permit a free flow of water toward their outlets, large areas of the type are quickly drained, as the lateral movement of water through the peat mass, as well as through the sandy layer beneath, is apparently quite rapid. In some places there is danger of overdrainage, but this can be avoided by the use of check dams in the ditches after the removal of the excess water.

Peat is formed through the accumulation and decay of vegetation in shallow ponds and lakes.

Peat is for the most part treeless, the greater part being covered with swamp and prairie grasses. Some small areas support a growth of tamarack and an undergrowth of brush and sphagnum moss. The native grasses afford excellent pasturage at certain times of the year, and in well-drained areas good cuttings of hay are made.

Only a small part of the Peat is in cultivation. Clover and timothy, corn, small grain, and potatoes do well, although the small-grain crops produce rather low yields in proportion to the growth of straw. This indicates a need of potash and phosphate fertilizers.¹ In places the addition of manure has proved beneficial. Compression of the peat by the use of heavy traction engines and heavy horse or ox teams in plowing, as well as thorough trampling by live stock, improves land for cultivation.

Peat, shallow phase.—Peat, shallow phase, to a depth of about 6 to 9 inches, is usually brown and consists of a spongy mass of partially decayed coarse grass, moss, and roots. This is underlain by a black, peaty material, which is more compact and more thoroughly decayed. Beneath the organic soil there is a layer of sandy or clayey material about 6 to 20 inches thick which, as in the typical Peat, is mucky in places in the upper part, owing to admixture of the two materials. Boulder clay is found beneath the sandy or clayey stratum. Boulders occur at or near the surface in a few places.

Peat, shallow phase, occurs in a few scattered areas in the western part of the county and in a large number of areas of varying size in the eastern and southeastern sections. The surface is practically level. The areas are basinlike and originally poorly drained. Artificial drainage has only partially reclaimed these areas. The conditions are very much as upon the typical Peat.

The phase is mainly treeless. It supports a growth of swamp and prairie grasses, with occasional areas of brush. A wild grass known locally as "redtop" thrives. This and other wild grasses are utilized both for hay and for pasturage.

¹ See Bul. 205, Univ. of Wis. Agr. Exp. Sta., p. 15.

Peat, shallow phase, is adapted to the same agricultural uses and requires the same treatment as the typical soil. Flax is usually the first crop grown on new broken areas, though oats, barley, and other grains are sometimes used. In older fields corn, small grains, potatoes, and certain truck crops are grown with a fair degree of success. The small grains make a heavy growth of straw, but give relatively low yields.

The Peat lands occupy nearly one-fifth of the total area of the county. When reclaimed they are valuable for agriculture.

The value of Peat land ranges from about \$5 to \$20 an acre.

SUMMARY.

Pennington County is in the northwestern part of Minnesota. It has an area of 607 square miles, or 388,480 acres. The surface is mainly level to gently undulating, with a general slope toward the southwest. The elevation above sea level is about 1,186 feet in the northeastern part, and somewhat less than 1,000 feet in the southwestern part.

A little less than one-third of the county was in use for crop production in 1910.

The total population is given as 9,376, 60.4 per cent of which is classed as rural.

The natural drainage of the county was poor, large areas being covered with standing water in wet seasons.

An extensive drainage system has been installed, and the greater part of the land in the county is now available for cultivation.

Thief River Falls, the county seat, is the most important town. Its population was reported in 1910 as 3,714. It is a shipping point of local importance.

The winters are long and cold and the summers short and hot. The mean annual temperature is reported as 38.3° F. The annual precipitation averages 23.01 inches. The greater part of the rainfall occurs during the growing season.

The present type of agriculture consists in the raising of live stock in conjunction with small-grain farming. Farm values and farm products have increased materially since 1910.

The census of 1910 reports about 258,000 acres in farms, of which 53 per cent is improved. Wild grasses are reported on about 47,000 acres, and tame grasses on nearly 10,000 acres. Wheat was grown on about 22,000 acres, and oats on about 16,000 acres. Flax is reported on about 8,500 acres, and barley on about 6,400 acres. Other crops are not of economic importance in the agriculture of the county. The acreage of corn has increased materially within recent years.

Totals of 2,477 calves and 8,082 other cattle are reported sold and slaughtered. In addition 2,757 hogs and 1,669 sheep and goats were sold and slaughtered, and 225 horses and mules sold.

The average size of the farms was 207 acres, and the average value of farm land \$16.40 an acre. About 88 per cent of the farms were operated by the owners. An expenditure of \$98,794 for labor is reported, and \$28,085 for feed. Practically no commercial fertilizer is used.

Systematic crop rotation is not practiced in the county.

The soils of Pennington County owe their origin to the weathering of the lake-laid materials derived from calcareous glacial drift. The soils fall naturally into three broad divisions.

The soils characterized by gray, calcareous bowlder clay subsoils, which occupy about three-fifths of the area of the county, are mapped as the Fargo series. The Fargo soils rank first in agricultural value.

The soils underlain by a stratum of rather clean, gravelly sand, more or less stratified, 1 foot to 15 feet thick, and resting on the calcareous bowlder clay of the county are differentiated in mapping on the basis of the thickness of the gravelly sandy layer. They are classed with the Benoit and Sioux series, and in the aggregate comprise only a little over one-fourth of the area of the county.

Peat consists of a layer of partially decayed organic matter about 6 inches to 5 feet in depth, resting on sandy or clayey material, which in turn is underlain by bowlder clay. The Peat lands occupy about one-sixth the area of the county.



[PUBLIC RESOLUTION—No. 9.]

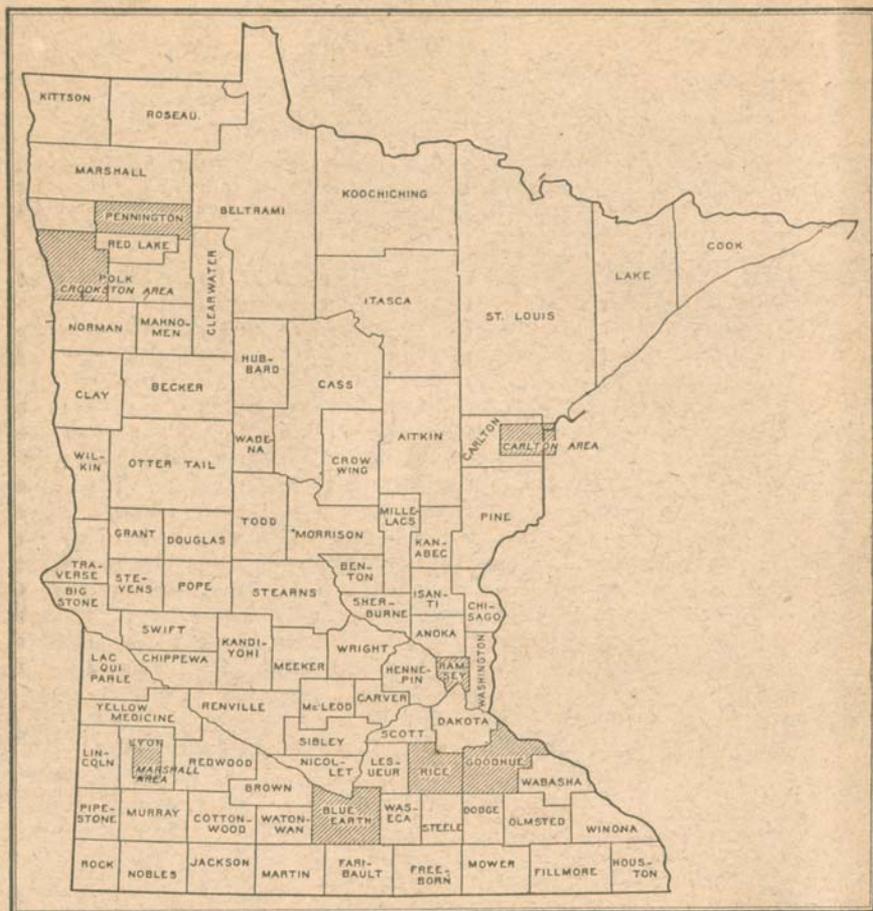
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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.]



Areas surveyed in Minnesota.

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