Series 1936, No. 11 Issued January 1942

Soil Survey

Roseau County Minnesota

By
P. R. McMILLER, in Charge, E. A. FIEGER, HAROLD ARNEMAN,
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University of Minnesota

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
In cooperation with the
University of Minnesota Agricultural Experiment Station

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UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Plant Industry

CORRECTION

SOIL SURVEY OF ROSEAU COUNTY, MINNESOTA

On page 2, in the fifth line under the heading "County Surveyed," "3 miles" should be "32 miles," making the sentence read: "The county is approximately rectangular, extending 60 miles from east to west and 32 miles from north to south."

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Area inspected by MARK BALDWIN, Inspector, District 1, Division of Soil Survey,[1] Bureau of Plant Industry, United States Department of Agriculture

United States Department of Agriculture in cooperation with the University of Minnesota Agricultural Experiment Station

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[1] The field work for this survey was done while the Division was a part of the Bureau of Chemistry and Soils.

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COUNTY SURVEYED

Roseau County is in the northwestern part of Minnesota, bordering on Canada and Lake of the Woods (fig. 1). Roseau, the county seat and principal trading center, is about 300 miles by air line northwest of Minneapolis and St. Paul. The county is approximately rectangular, extending 60 miles from east to west and 3 miles from north to south. It comprises an area of 1,670 square miles, or 1,068,800 acres.

The surface of Roseau County is a flat plain that slopes gently to the northwest. It is crossed by a series of low ridges, ranging from 6 to 20 feet in height, which extend in a northeast-southwest direction. These are beach ridges marking the successive shore lines of the ancient glacial Lake Agassiz, whose waters occupied the basin of the Red River for thousands of years during the close of the last ice age.[2] As the ice melted and receded northward, water accumulated in the southern part of the basin and the lake expanded northward and eastward until it covered a total area estimated at more than 100,000 square miles. The outlet of Lake Agassiz in its earlier stages was across the low divide in the southern part of Traverse County and southeastward down the valley of the Minnesota River.

[2] UPHAM, WARREN. THE GLACIAL LAKE AGASSIZ. U. S. Geol. Survey Monog. 25, 658 pp., illus. 1895.

As the outlet was gradually cut down, the lake waters fell to lower levels, as shown by the succession of former beaches. Later, lower outlets were opened to the north, and the lake eventually was drained

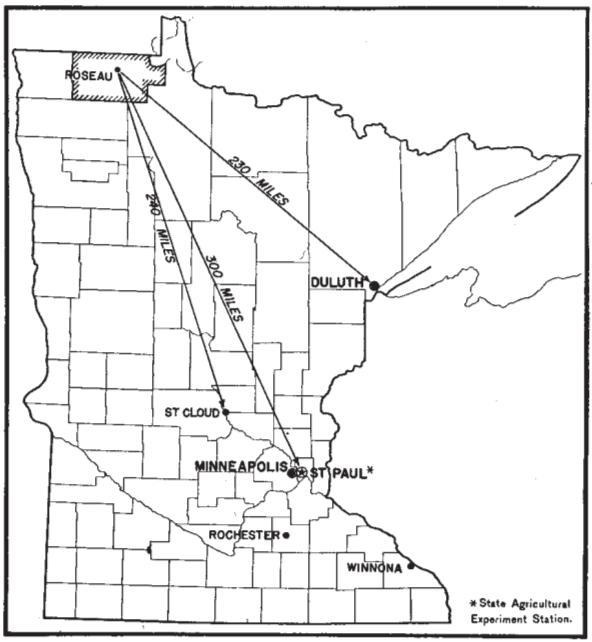

FIGURE 1.—Sketch map showing location of Roseau County, Minn.

through its natural river channel, the Red River, and the water disappeared. Finally, most of the water that remained in shallow basins throughout the area evaporated.

The most prominent ridge, known to geologists as the Campbell Beach, enters the county near Pelan, in the western part, and extends in a northeasterly direction through the towns of Greenbush, Badger, Fox, and nearly to Roseau, where it turns sharply to the south, paralleling the Roseau River for some distance. It occurs again several miles east of Roseau, and continues eastward in a more or less interrupted line until it leaves the county. This pronounced break in the ridge resulted when the Roseau River, a rapidly flowing stream, forcing its way northward, broke through the ridge and discharged its silt-laden waters into the lake. The alluvial material deposited by this river covered much of the silt and clay deposited earlier in the quiet waters of Lake Agassiz.

Aside from the mineral soils, there are extensive areas of peat in the county, many of which are at slightly lower levels than the surrounding upland. They are covered with both tree and grass vegetation.

Inasmuch as the entire county was once the bottom of a lake, the surface, aside from the sand and gravel ridges, ranges from nearly level to gently undulating. No prominent bottom lands occur along

the streams, except the narrow flood plains along parts of the Roseau and Warroad Rivers in the southern and eastern parts of the county. Large bogs occupy the northwestern, northeastern, and southeastern parts. The great marsh in the northeastern part of the county, between Roseau and Warroad, occupies more than 60,000 acres. Parts of it are covered with spruce and tamarack trees. The great marsh in the northwestern part is nearly as large and is covered with grass, from which hay is cut in dry years. Large and small bogs, some covered with trees and others with grass and sedges, occupy parts of practically every township.

The drainage waters of the county flow into Hudson Bay, principally through the Roseau River, the Two Rivers, and the Warroad River. The Roseau River drains about one-half of the country—the central, northwestern, and a part of the southeastern districts. The Two Rivers and Warroad River together drain the other half. West of Roseau Lake, which has now been drained, the Roseau River, to a point where it leaves Roseau County at the Kittson County line, is a meandering stream with low banks, which passes through large open swamps. Above Roseau Lake this river has a better defined channel and a more rapid current. Seldom does the river overflow its higher banks. From Roseau Lake to the Kittson County line, a distance of 30 miles, the fall is only 13 feet. A winding stream, the Two Rivers, drains the southwestern part of the county, flowing sluggishly through many marshes. It rises in the swamps near Greenbush and closely parallels the Campbell Ridge from Greenbush to Pelan. The Warroad River, which drains the most easterly part of the county, flows into Lake of the Woods at Warroad. This river has a well-defined, rather deep channel and seldom overflows its banks. It rises in the swamps in the southern part of Lake of the Woods County. Several small tributaries join it. The channels of the Roseau River and Two Rivers have been dredged and straightened to facilitate removal of surplus surface water; but in times of high water the Roseau River frequently overflows its banks in the area west of Roseau Lake. Deepening of the channel was carried only to the point where the river crosses the international boundary in Kittson County; consequently, in Canada it is not deep enough to take care of the great volume of water flowing in it during flood periods. As a result, farms in Blooming Valley Township and parts of adjacent townships have been flooded frequently, and many farmers have been forced out of the district.

Most of Roseau County lies at elevations between 1,000 and 1,200 feet above sea level. The lowest point is in the extreme northwestern part of the county, where the elevation is 1,011 feet, and the highest point is 1,200 feet, in the southern part of T. 161 N., R. 37 W., on a glacial lake beach, known locally as Blueberry Ridge. Minnesota Hill, in T. 164 N., R. 40 W., north of Roseau, occupies about 640 acres and has an altitude at its highest point of more than 1,100 feet, or 50 feet above the level of the large peat bog completely surrounding it. Lake of the Woods, which forms part of the northeastern boundary of the county, is 1,060 feet above sea level, and Warroad, situated on the estuary of the Warroad River, lies only 6 feet above this lake. The land rises perceptibly in the southern part

of the county from west to east. At Strathcona the altitude is 1,125 feet; at Wannaska it is 1,096 feet; and at Badger, situated on the Campbell Beach, it is 1,082 feet. Roseau, off the beach and on the level plain, is only 1,048 feet above sea level.

Roseau County has no lakes within its borders. Before the extensive dredging program was undertaken, a shallow body of water, known as Roseau Lake, was northwest of Roseau. The site of this lake—an area of about 4 square miles—has now been drained and yields an annual cutting of wild hay. Great peat and forest fires, sweeping repeatedly over parts of the county, have in some places burned off the peat to a depth of more than 3 feet. They have left some basins or depressions that collect water from melting snows and rains, forming temporary ponds or lakes. In dry years, however, the water disappears entirely, and many of these areas are plowed and seeded to small grains. In favorable seasons such areas produce remarkably high yields. At the time of this soil survey, in 1934 and 1935, much of the land from which the peat cover had been burned was in crops; but in 1937, excessive rainfall in July caused much of the crops on these lands to fail.

The early settlers of Roseau County found the greater part a mixed grass-covered and forest-covered plain. The forests consisted of aspen in the central and western parts; a mixture of aspen, birch, balm-of-Gilead poplar, balsam fir, and jack pine on the sands in the eastern part; and spruce and tamarack in some of the swamps. Many of the peat bogs in the western and northern parts are treeless areas covered with grasses and sedges. Part of the great marsh, north of the railroad between Roseau and Warroad, originally was tree-covered but is now open grassland. The trees were destroyed by numerous fires, which formerly swept over the district periodically. The rest of the bog has a thick stand of spruce and tamarack. East of a north-and-south line through Roseau, the land supports a more mixed forest vegetation, although aspen is still the dominant tree. On the light sandy knolls and ridges jack pine grows in nearly pure stands. West of the line above referred to, aspen is the only species, except for a few paper birch or white birch trees and, on the drier soils, such as those of the sand and gravel ridges, small oak trees. Since settlement began, however, many of the trees have been removed in clearing operations, and much of the land in forest at the time of settlement is now in cultivated fields.

Owing to the flatness of the land and the naturally poor surface drainage prevailing before settlement began, much of the land was very wet for the greater part of every year, the drier parts being confined to the sand ridges. This resulted in conditions favorable for the formation of peat, which accumulated as deposits ranging from 3 inches to as much as 8 feet in thickness, the thickness depending on the prevailing moisture conditions. In many places the farmers have intentionally burned off this peat layer, and areas in which the original layer was not too thick now have a mineral soil not unlike that occurring outside of the lake basin on the rolling upland.

The first settlers came into the county about 1886, and the county was organized December 31, 1894, from territory included in Kittson County. The county was named for Roseau Lake and the Roseau

River. As originally established, it was only about two-thirds of its present size, as its former eastern boundary ran just east of Roseau village between Rs. 38 and 39 W. In February 1896 it was enlarged to its present size when 4 tiers of townships were taken from the unorganized part of Beltrami County, placing the eastern boundary on the line where it now is. The population of the county, as reported by the census of 1930, was 12,621, of which 10,079 were native whites. Norwegians were the most numerous among the foreign born; the rest were mainly Swedes and Germans. The largest village is Warroad with a population of 1,184. Second in size is Roseau, the county seat and principal market for agricultural products, with a population of 1,028. Greenbush has 387 inhabitants, Badger 325, Roosevelt 287, and Strathcona 112. Other trading centers are Wannaska, 12 miles south of Roseau, and Ross, 5 miles north of Fox, where creameries and stores are located.

Lines of two railroad systems—the Great Northern and the Canadian National—cross parts of Roseau County. A branch of the Great Northern Railway from Crookston crosses in a northeast direction. It enters the county south of Strathcona and terminates at Warroad. A line of the Canadian National Railways, from Winnipeg, Manitoba, to Port Arthur and Fort William, Ontario, on Lake Superior, crosses the extreme northeastern corner of Roseau County, passing through Warroad, Swift, and Roosevelt. It enters Canada again near Baudette, Lake of the Woods County, about 35 miles east of Warroad. Transportation facilities in the south-central and southeastern parts of the county are inadequate.

Water transportation on Lake of the Woods offers facilities for mail, freight, and passenger service from Warroad to the Northwest Angle and to island and mainland points in Canada and the United States.

In general, well-maintained graveled roads radiate from all the main towns connecting the villages with the surrounding farming districts and smaller trading centers. A hard-surfaced State highway parallels the Great Northern Railway for most of its distance across the county. Another State highway runs north and south through Roseau. Very few good roads are in the sparsely settled districts, and they receive little, if any, attention, many of them being impassable to automobile travel during wet periods. In winter, the main-traveled roads are generally kept free of snow, and they are open for travel the year around.

The public-school system is well established in most parts of the county. Consolidated schools are in the larger towns, and children are transported to and from them by bus. One- or two-room schools are, in general, well distributed in the country districts. All the villages have one or more churches, and some are in the rural areas. Telephone service is available to nearly all parts of the county. Rural mail deliveries are made at regular intervals. Each of the larger towns has a creamery, one each also being located at Wannaska and Ross. Much of the cream produced on the farms is collected regularly by trucks and transported to the creameries along established routes.

Farm products, chiefly livestock and livestock products, find a market at Fargo, N. Dak., and in Minneapolis and St. Paul. Grain ele-

vators are located in Greenbush, Badger, Roseau, and Warroad. Poultry and poultry products are marketed locally and shipped to points in and outside the State. Clover seed and alfalfa seed are purchased by outside and local buyers, and much of it is moved out of the county. Some of the certified seed potatoes produced are used as foundation stock in other sections of the State.

At one time lumbering was carried on in the central and eastern parts of the county, but, as practically all of the merchantable timber has been removed, only a few portable sawmills remain. Two stationary sawmills, one at Swift and the other north of Roosevelt, operate periodically. Warroad, on the south shore of Lake of the Woods, has important fish industries. A feldspar-grinding plant also is located there.

CLIMATE

Short warm summers with an abundance of sunshine and long cold winters with considerable snow are the outstanding features of the climate of Roseau County. Snow covers the ground throughout most of the winter. Freezing temperatures usually prevail from the middle of October to late in April, and occasionally killing frosts occur in mid-August.

The climate is favorable for the production of small grains and forage crops. The growing season is too short and too cool to produce corn for grain, except in an occasional year when some early-maturing varieties may ripen. Danger of frosts in any month of the year prohibits the growing of tender crops in the peat bogs, but clovers and tame grasses do very well in properly fertilized bogs.

The mean annual precipitation, as recorded at Roseau, is 20.34 inches, nearly two-thirds of which falls during the months of April, May, June, July, and August. Cold wet springs delay planting in some years, but crops commonly mature before they are injured by early frosts.

The mean seasonal temperatures range from 4.8° F. for the winter to 64.3° for the summer. Intensely cold days with the temperature dropping to −40° are not uncommon in the winter, but the periods of such extreme cold are generally short. Temperatures above 90° are not uncommon in the summer, although milder weather ordinarily prevails. The highest temperature ever recorded for the county is 103° and the lowest −52°.

Prevailing winds blow from the northwest except in summer, when they are from the south. Seldom is the wind velocity strong enough to cause any great amount of soil drifting or damage to growing crops. The annual snowfall averages 33.7 inches, the greatest amount falling in December.

The average frost-free season covers a period of 104 days, from the average date of the last killing frost, May 31, to the average date of the first, September 12. Frost has been recorded as late as June 22 and as early as July 18.

Table 1, compiled from the records of the United States Weather Bureau station at Roseau, gives the more important climatic data for Roseau County.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Roseau, Roseau County, Minn.*

[Elevation, 1,040 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1933)	Total amount for the wettest year (1925)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	8.2	50	−45	0.60	1.34	0.20	6.5
January	.9	50	−48	.57	1.24	.75	6.1
February	5.2	50	−52	.50	.15	.13	5.5
Winter	4.8	50	−52	1.67	2.73	1.08	18.1
March	20.3	81	−44	.95	.22	1.27	6.0
April	40.3	82	−10	1.26	.61	2.81	2.0
May	52.4	94	12	2.29	1.46	.74	.1
Spring	37.7	94	−44	4.50	2.29	4.82	8.1
June	62.7	100	21	3.17	1.69	8.28	.0
July	66.5	103	31	3.26	.76	2.42	.0
August	63.8	98	23	2.85	.84	3.00	.0
Summer	64.3	103	21	9.28	3.29	13.70	.0
September	55.1	92	12	2.55	2.53	4.72	.1
October	42.5	87	−6	1.45	.19	1.01	1.8
November	24.4	62	−36	.89	1.00	.64	5.6
Fall	40.7	92	−36	4.89	3.72	6.37	7.5
Year	36.9	103	−52	20.34	12.03	25.97	33.7

AGRICULTURAL HISTORY AND STATISTICS [3]

Long before Roseau County became the prosperous farming community it is today, the vast country northwest of Lake Superior was an unexplored wilderness in which hunters and trappers plied their trade. Historical records note the arrival in 1688 of Jacques de Noyan, a French Canadian, at Lake of the Woods. He probably was the first white man to see this large inland lake. He named it Lac aux Isles. It was not until 1732, however, that La Verendrye, an intrepid French Canadian, explored this region in detail and established a fort at the Northwest Angle for the purpose of commanding the western fur trade. For about 15 years this fort, named Fort St. Charles, served as a trading post, until the close of the French and Indian Wars, when it passed out of existence. About 1820, the American Fur Co. established a trading post at Warroad, and later, in 1848, the Hudson's Bay Co. established one on the Roseau River a short distance from Roseau Lake, in what is now Roseau County. Indian villages occupied the present sites of Ross, in Dieter Township, and Warroad, the principal Lake of the Woods port on the American side. Warroad (a translation of the French name Chemin de la Guerre) was the battleground of two hostile Indian tribes, the Cree and the Sioux.

According to reliable information, the first white settler in what is now Roseau County was Seward A. Wood, who, in 1885, built a cabin

[3] Much of the historical matter in this section was furnished by P. O. Fryklund, of Roseau, Minn.

on the Roseau River in section 24, Jadis Township, the present site of Roseau village. Wood, however, was a trapper rather than a farmer and did little or no actual farming. Later, in 1887 and 1888, other homeseekers, attracted by the fertile land and other natural advantages of the district, came from the prairies of the Red River Valley and the Dakotas to the Roseau River Valley to settle.

During the first years of settlement travel was extremely difficult because of the lack of passable roads and trails. Owing to the level character of the land and the number of peat bogs, most of the trails were too wet to be passable for long periods. The nearest railroad station was Stephen, a town in Marshall County on the main line of the Great Northern Railway to Winnipeg, about 75 miles west of Roseau. Travel to and from Stephen was by the sand ridge, the width of which ranges from a few hundred feet to more than three-quarters of a mile. It lies from 8 to 12 feet above the surrounding nearly level plain. Some of the first farms were situated on this ridge, and at present it is used as building sites by many farmers who farm the adjacent lower lying land.

Construction of the railroads stimulated agricultural development. The Canadian National Railways built the first railroad in 1900. This railroad, which connects Winnipeg with the Lake Superior ports of Fort William and Port Arthur in Ontario, enters Minnesota at Longworth in Roseau County, about 8 miles north of Warroad, follows the shore of Lake of the Woods, and leaves the county at Roosevelt, entering Canada again near Baudette in Lake of the Woods County. In 1904 the Great Northern extended its line north from Thief River Falls, Pennington County, to Greenbush, which was its terminus until 1908, when it was again extended northeastward, through Badger, Fox, and Roseau, to Warroad, its present terminus.

Before the railroads were built, the lack of facilities for transportation of needed commodities and for marketing the agricultural products produced was a rather serious handicap to rapid development. Provisions were brought in by horse and ox teams from Stephen, and stagecoaches carrying mail and passengers made regular trips between Stephen and Roseau.

The public lands were surveyed by the Federal Government during the period 1876 to 1904, and in 1890 some were opened for homestead entry. This resulted in a great influx of land seekers, who came from the prairie districts of western Minnesota and North Dakota and from the older settled districts of central and southern Minnesota. In 1892 James Jester made the first final homestead proof to 80 acres of land. The present town site of Roseau now includes this homestead. Settlement began in the central part of the county, in the townships of Jadis, Stafford, and Dieter, and in 1890 these townships were organized as political subdivisions.

The large peat bogs, the generally wet condition of the soils, and the more or less heavily forested character of the land, combined with the inferiority of some of the soils, discouraged settlement in the northern and southern parts of the county. At present, settlement is most dense in the central and western parts and in the district immediately surrounding Warroad. All the northern townships except Dieter are rather sparsely populated, because of the large areas of swampland. The southern and southeastern townships likewise

have a rather small number of inhabitants, owing to the extensive peat bogs and large tracts of inferior land.

After 1890, trading posts, stores, flour mills, churches, schools, and post offices sprang up rather rapidly in several parts of the county. The first general store was opened in 1888 near the present site of Roseau, and the first church was built in 1891, 3 miles east of Roseau. The first schoolhouse, still in use, is north of Roseau, in Jadis Township.

It was not until after 1908, the year the Great Northern Railway was built, that the towns made any substantial growth. Prior to this they were scarcely more than trading places, and little thought was given to planning for their future growth. Badger at one time was the largest and most thriving town, followed by Greenbush and Roseau. Roseau was incorporated as a village in 1894, and Warroad in 1901.

Nearly 100,000 acres in the southeastern part of the county are now included in the Beltrami Island State Forest. With its larger area within the adjoining Lake of the Woods County, this State forest comprises 760,000 acres, mainly of soils of low agricultural value. Practically all of the settlers formerly living in this area have relocated outside the forest reserve in either Roseau or Lake of the Woods County on farms having better soils. Financial aid is furnished to them by the Federal Government.

The early settlers supplemented their meager income from agricultural products by trapping and fishing. Some lumber was produced, and for many years lumber served as a medium of exchange. Portable sawmills were moved from place to place, and the operators sawed lumber on shares. To bring in additional income, settlers labored in the grainfields of the Red River Valley during the harvesting and threshing season and left the local farm work to be done by their families.

In the early days farming was confined to the better drained and drier lands, and the lower, more fertile land was avoided because of its wet condition. It was not long, however, before agitation for drainage started, not only in Roseau County but also in adjoining counties. The State legislature, influenced by the demands of the settlers, enacted laws providing easy methods for the institution of district projects and providing for payment of construction costs by a levy of an annual special tax on land benefited. With the passage of these enabling laws, drainage of the land began in earnest.

The earlier drainage projects were designed to drain land best suited for agriculture, and time has proved them to be financially successful. Many of the later projects, however, were designed to drain the peat lands, which could not be made to produce profitably by ordinary methods of farming. As a result, the owners found themselves unable to meet the drainage assessments levied against the land, and the county became financially embarrassed by the heavy burden of indebtedness for ditches. Within recent years, however, the legislature has granted some temporary relief by permitting the issuance of refunding bonds to pay up both principal and interest in arrears. Additional relief measures probably will have to be made soon, before the county can again be put on a self-sustaining basis.

Thirty-three drainage districts, in which more than 900 miles of

open ditches were constructed, affecting nearly 900,000 acres of land, have been established in this county. As an example of one of the ill-advised projects, mention may be made of the drainage of the large marsh comprising more than 100,000 acres in the northeastern part of the county.

During the first 15 or 20 years of farming in the county, the small grains—wheat, oats, barley, and flax—were the principal crops. Later, as the yields of these crops declined and grain growing became less profitable, the type of farming changed to mixed farming, in which dairying was most prominent. When it was learned that the soils were well adapted to tame hay, such as timothy, medium red clover, and alsike clover, a steadily increased acreage was devoted to these hay crops. Still later, with the introduction of sweetclover and alfalfa, both of which do well on most of the better drained mineral soils, the land devoted to tame-hay crops increased until, in 1934, more than one-third of the improved land was devoted to hay crops. In that year small grains were grown on about 93,000 acres, whereas the land devoted to hay crops exceeded 100,000 acres, including the acreage of wild hay. Table 2, compiled from the reports of the Federal census, gives the acreage of the leading crops and shows the general trend in the agriculture of Roseau County from 1899 to 1934, inclusive.

TABLE 2.—*Acreage of the principal crops in Roseau County, Minn., in stated years, as reported by the Federal census*

Crop	1899	1909	1919	1929	1934
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
All corn	[1] 26	[1] 148	1,098	937	6,110
Oats	3,276	11,650	23,409	24,460	31,967
Wheat	5,894	18,172	25,920	4,669	8,401
Barley	2,620	8,201	6,397	8,514	9,073
Rye	141	131	17,272	2,792	3,713
Flaxseed	412	7,600	7,255	11,213	39,537
Potatoes	308	777	1,495	1,298	1,756
Hay, all kinds	29,900	50,196	56,287	97,861	100,964
Timothy and clover mixed	----------	3,424	18,218	55,131	25,909
Clover alone	----------	66	643	2,975	5,066
Alfalfa	----------	10	345	3,289	10,800
Other tame hay	72	1,132	2,951	4,514	----------
Wild hay	29,828	45,564	34,130	31,952	[2] 59,189

[1] For grain only.

[2] Includes other tame hay.

It will be seen that the acreage of wheat increased up to 1919, then sharply decreased in the following decade. All other small grains have shown substantial increases in acreage. Rye is grown rather extensively on the coarser textured soils, but it is not an important small grain in the county. Some potatoes are grown, largely for local consumption. In recent years rather large plantings have been made on low-lying land, especially where a shallow layer of peat has been burned off, but the yields generally have been disappointing, owing to the early frosts to which the peat land is subject.

The acreage devoted to flaxseed has been increasing annually during the last 7 years. The 5-year period from 1929 to 1934 showed an increase of more than 300 percent. The yields have been surprisingly good, in many years 18 to 20 bushels an acre.

Corn is not adapted to the climatic conditions in this northern county, as the growing season is too short and the nights too cool to make its production practicable. Some early-maturing varieties, however, find a place in the cropping systems on many farms, although in most years it is an uncertain crop for grain. Even in the most favorable years practically none of it is allowed to ripen; instead it is cut green and used as fodder for livestock. A small quantity is put into the few silos in the county.

The production of tame hay has shown the greatest expansion of any crop. Climatic conditions are favorable to the production of tame hay, and abundant pasture is provided for in the uncleared brushland and the small open swamps. Each census period has shown a marked increase in the acreage used for hay. Alfalfa is gaining in popularity. In 1909 alfalfa was practically unknown in the county as a forage crop, but in 1934 it was grown on more than 10,000 acres, on 671 farms. Wild hay is harvested on a large acreage and supplements the tame grasses grown in rotation. In years when hay is scarce a large part of the crop is baled and shipped to points outside the county.

The number of livestock increased steadily until 1935, but in the last few years the number has remained about stationary. More than 39,000 sheep are kept on farms. Roseau County ranked third throughout the State in the number of sheep in 1935, being exceeded only by Murray and Marshall Counties, which reported 41,791 and 40,154 head, respectively.

Table 3 shows the number of livestock on farms in Roseau County in the census years 1900 to 1935, inclusive.

TABLE 3.—*Number of principal kinds of livestock on farms in Roseau County, Minn., in stated years*

Kind of livestock	1900	1910	1920	1930	1935
	Number	*Number*	*Number*	*Number*	*Number*
Cattle	9,736	19,715	20,049	28,900	29,014
Hogs	1,782	2,424	4,340	2,430	2,649
Sheep	4,562	7,059	11,712	39,074	39,061
Horses	3,129	4,002	7,479	6,259	6,853
Mules	82	50	161	184	193
Chickens	19,512	[1] 42,492	65,269	73,410	69,959
Turkeys	246			[2] 45,618	9,904

[1] All poultry.

[2] Raised during 1929.

Dairying is the chief farm enterprise, although many farmers combine dairying with grain growing. According to the 1930 Federal census, 675 farms were classed as dairy farms; 700 as general farms, on many of which dairy products were undoubtedly the largest single source of income; 96 as crop-specialty farms; 70 as cash-grain farms; and 58 as animal-specialty farms.

The income derived from the sale of butterfat is supplemented by that received from the sale of small grains, poultry products, livestock, and wool. Much of the grain produced, however, is fed to livestock on the farms, and only the surplus is sold. Considerable wild hay is cut every year from land that belongs to owners residing outside the county or from land owned by the State. It is a common

practice for individuals to buy the hay on an acreage basis, move in their machinery, employ their own labor, and bale the hay. It is then trucked to points outside the county where it generally finds a ready market.

The importance of dairy farming in this county may be seen by referring to table 4, which gives the annual production of butter from 1929 to 1936, inclusive.

TABLE 4.—*Butter manufactured in Roseau County, Minn., in stated years*[1]

Year	Quantity	Year	Quantity
	Pounds		*Pounds*
1929	1,773,000	1933	2,156,000
1930	1,895,000	1934	2,177,000
1931	2,138,000	1935	2,284,000
1932	2,267,000	1936	2,216,000

[1] Data from the Minnesota Department of Agriculture.

The 1900 Federal census reported 1,444 farms in the county, comprising a total of 236,681 acres, an average of 163.9 acres to the farm. Of this, about 52 acres per farm was improved land. The 1935 census reported the number of farms as having increased to 2,287, with an average of 233.6 acres per farm, of which 123.4 acres was improved. In table 5 are given selected data concerning the acreage of improved and unimproved land in farms and land tenure.

TABLE 5.—*Statistics on farm land in Roseau County, Minn., in stated years*

Year	Farms				Land in farms			Improved land in farms		
	Total	Operated by—			All land	Percentage of county area	Area per farm	Total	Percentage of farm land	Area per farm
		Owners	Tenants	Managers						
	Number	*Percent*	*Percent*	*Percent*	*Acres*	*Percent*	*Acres*	*Acres*	*Percent*	*Acres*
1900	1,444	98.5	1.4	0.1	236,681	22.1	163.9	74,336	31.4	51.5
1910	1,602	93.6	6.2	.2	315,106	29.5	196.7	157,332	49.9	98.2
1920	1,854	90.8	8.6	.6	416,294	38.9	224.5	212,214	51.0	114.5
1930	1,922	79.3	20.5	.2	416,297	39.0	216.9	221,790	53.3	115.4
1935	2,287	71.6	28.3	.1	534,169	50.0	233.6	282,138	52.8	123.4

The census of 1930 reports 683,000 board feet of sawlogs cut and sold on 78 farms, and 15,123 cords of firewood cut on 1,003 farms. Fence posts numbering 8,164 were cut on 42 farms, and several farms produced railroad ties. Many farmers derive some income from the sale of forest products cut on their farms or on purchased stumpage.

The 1930 census reports 181,554 pounds of wool shorn and more than half a million dozen chicken eggs and 26,684 pounds of honey produced in 1929.

Commercial fertilizer is not used to a great extent. On less than a dozen farms, where special crops are grown, a small quantity is used. None of the soils are acid enough to justify the use of ground limestone, even for alfalfa and sweetclover—crops most sensitive to

a lack of it. On the Hiwood and Faunce soils in the eastern part of the county, lime may be beneficial to alfalfa and sweetclover, but experimental evidence is needed before definite recommendations can be made regarding the use of lime on these sandy soils.

About one-third of the farmers employ labor, the average cost per farm in 1929 being $151.48 for each of the farms reporting such an expenditure. On some of the larger dairy farms labor is employed throughout the year and on other farms only for shorter periods during haying and harvesting. Most of the farm labor is performed by the farmer himself and members of his family, and on farms where no labor is employed arrangements are made with neighbors for an exchange of help. Many of the small farmers supplement their income by outside work, such as work in the forests and in road maintenance and construction.

According to the 1935 census, the average size of farms is 233.6 acres. In the eastern part of the county the farms are smaller than they are in the western part, where there are large areas of open grassland and where preparation of the land for crops involves less labor. Many of the large farms are equipped with tractors, and considerable grain farming is carried on, as power machinery can be used more advantageously. The trend during the last few years is toward an increase in the size of farms. Grain growing is declining gradually, and much of the acreage formerly devoted to small grains is planted to hay crops.

As with all farming areas, the proportion of farms operated by owners has greatly decreased since the land was first settled. The census of 1935 shows that about three-fourths of the farms are operated by owners. Nearly all farms operated by tenants are under some form of a share system. The common arrangement is that one-third of the grain grown goes to the owner of the land and in addition the tenant pays a cash rental for pasture and hay land. This rental varies greatly from farm to farm, but some lump sum is agreed on annually between landlord and tenant. Uncleared and unfenced brushland and peat bogs, which generally are too poor for grazing, bring little or no returns, and the tenant makes what use he can of such land without charge.

Many of the farms are well improved and are equipped with modern labor-saving machinery. In the more sparsely settled districts the homes are temporary structures, to be replaced later by more permanent ones. Horses perform the power work on many farms, and many tractors are used in conjunction with them. The 1930 census reported 398 tractors on 367 farms. Less than 7 percent of the farms had motortrucks, but 61 percent reported 1 or more passenger automobiles.

Good water is plentiful at depths ranging from 50 to 200 feet. Nearly every farm of any size has a drilled well, and gas engines and windmills are used for pumping water. Flowing wells occur on many farms in all parts of the county, but they are most numerous north of Roseau in the vicinity of Pinecreek. In general the quality of the water is excellent.

The value of the agricultural products produced in this county in 1929 is shown in table 6.

TABLE 6.—*Value of stated agricultural products, by classes, in Roseau County, Minn., in 1929*

Product	Value	Livestock products	Value
Cereals	$392,803	Dairy products sold	$796,954
Other grains and seeds	329,963	Poultry raised and eggs produced	332,266
Hay and forage	723,095	Honey produced	2,935
Vegetables (including potatoes)	89,889	Wool shorn	52,651
Fruits	1,590		
Farm garden vegetables (excluding potatoes and sweetpotatoes) for home use	39,791	Total	1,184,806
Forest products	108,198	Total agricultural products listed	2,870,135
Total	1,685,329		

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road and railroad cuts, are studied. Each excavation exposes a series of distinct soil layers or horizons, called collectively the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail, and the color, texture, structure, consistence, porosity, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [4] and its content of lime and salts are determined by simple tests.[5] Drainage, both internal and external, and other external features, such as the relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for growing crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal units are (1) series, (2) type, and (3) phase.

The most important of these units is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may differ within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Kittson, Bearden, Ulen, and Poppleton are names of important soil series in Roseau County.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam,

[4] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values indicate alkalinity, and lower values indicate acidity.

[5] The total content of readily soluble salts is determined by the use of the electrolytic bridge. The presence of lime ($CaCO_3$) is detected by effervescence on the application of dilute hydrochloric acid.

clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Kittson silt loam and Kittson clay loam are soil types within the Kittson series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of the soil type is a subdivision within the type, differing from the type in some minor soil characteristic that may, nevertheless, have an important practical significance. Differences in relief and stoniness frequently are shown as phases. For example, within the normal range of relief for a soil type, certain parts may be adapted to the free use of machinery and the growth of cultivated crops and other parts may not. Even though there may be no important differences in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance, the more sloping parts of the soil type may be segregated on the map as a slope phase, and, similarly, a soil that carries many stones on the surface may be designated as a stony phase.

The soil surveyor makes a map of the county, showing the location of each of the soil types and phases, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS [6]

The agriculture of Roseau County consists of dairy farming, grain farming, and mixed dairy and grain farming. The soils and the climate are of such a character as to favor the growth of small grains and forage crops, making conditions suitable to a general and diversified system of farming. Because of the fertility of the soil and a relief suitable to the use of farm machinery, small grains are well adapted. The common clovers, sweetclover, and alfalfa grow well without the use of lime. Within recent years considerable income has been derived from the sale of sweetclover, timothy, and alfalfa seed. With an annual increase in the amount of feed crops grown, livestock enterprises, especially dairying, are growing rapidly. During the last half-dozen years the quantity of cream produced has increased about 30 percent. Owing to the comparatively short time since settlement began, the agricultural practices are not yet completely stabilized, and much land suitable for farming has not been improved. About 50 percent of the total area of the county is in farms, and of this, slightly more than one-half has been improved.

Originally, practically all of Roseau County was naturally poorly drained, owing to its flatness. It was not until after the extensive drainage program was well on its way to completion that considerable agricultural development took place.

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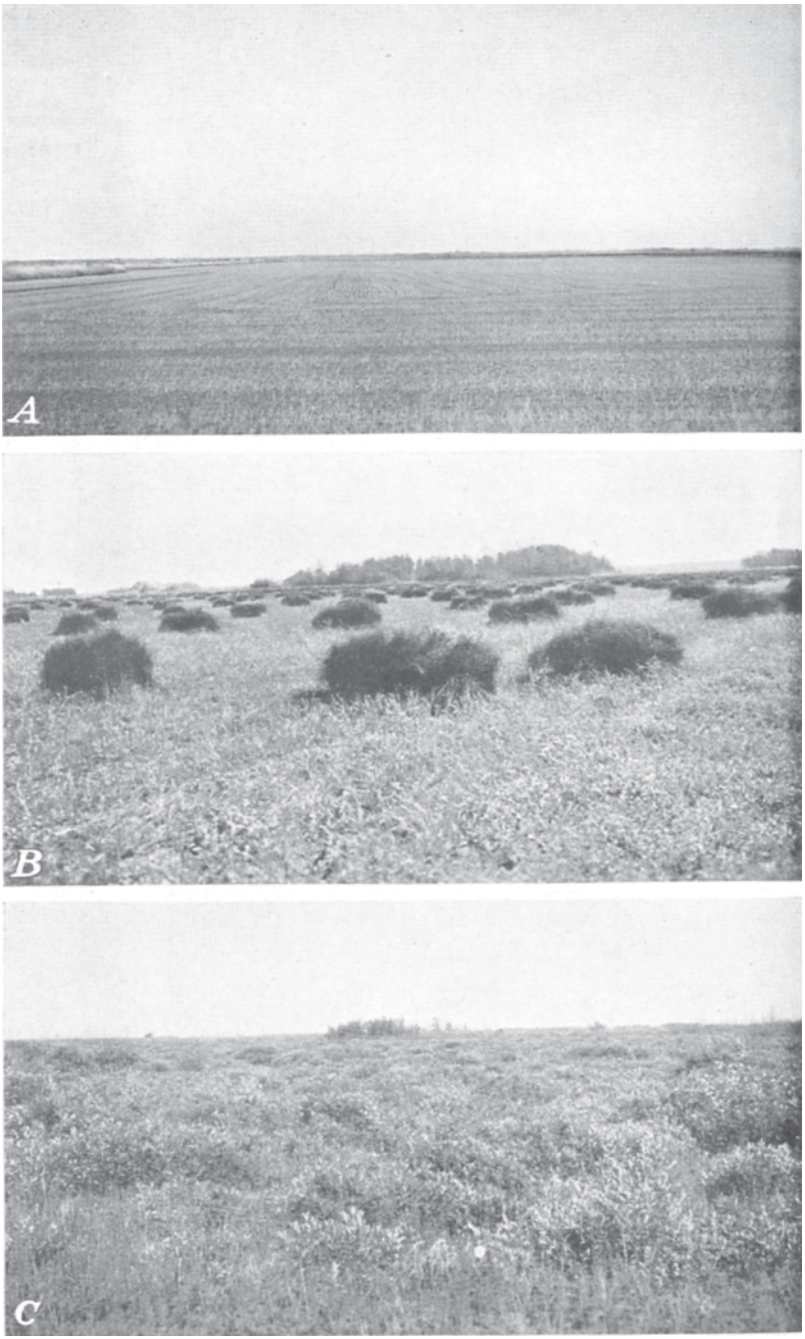
[6] The soil map of Roseau County, Minn., joins the maps of Kittson, Marshall, and Lake of the Woods Counties. The soil boundaries and nomenclature, however, do not everywhere agree along the county lines, as the soil survey of Roseau County is much more detailed and more recent than the soil surveys of the other three counties.

A, Groves of trees (mostly aspen) with patches of grassland among them, typical of much of the undeveloped land in the central and western parts of Roseau County, Minn.; *B*, soil profile of Kittson silt loam.



A, Typical topography of Kittson silt loam; *B*, small grains, the principal crops on the finer textured soils; *C*, imperfectly drained phases and poorly drained phases of dark-colored soils in a native condition, supporting willow and other shrub vegetation.

Drainage of the better land was absolutely necessary as an initial step in making the land productive, and time has demonstrated the practicability and economic soundness of those drainage projects. In addition to the good land, however, much inferior land, including all the large swamps, was included in the drainage program, with the result that after drainage much of it could not be farmed profitably. Some of the better land still is inadequately drained, because it has never been possible to drain away all the surface water from this flat land. Inadequate drainage, therefore, is one of the limiting factors to a fuller development of the agricultural possibilities of the county.

The soils have developed under the influence of a vegetative cover of both wild grasses and trees. The eastern one-third of the county is typically forest land, the native trees on the upland consisting largely of hardwoods, with aspen predominating on the heavier soils and jack pine on the well-drained lighter soils. Many years ago, long before settlement began, the entire central and western parts of the county were open prairie, as shown by the dark color of the surface soils—a characteristic feature of prairie soils. Gradually the forest encroached on the prairie, but the trees were not established long enough to change to any extent the soil characteristics. The early settlers, therefore, found many small groves, consisting almost entirely of aspen trees, with open prairie patches among them (pl. 1, *A*), but the soils in these areas were similar to those of the surrounding grassland.

The character of the native vegetation has a marked influence on the character of the soil that develops under it. Where trees have grown for a long time, the soil has features markedly different from those of soils under a cover of grass. In prairie sections the surface soil is black, owing to the high content of organic matter resulting from decay of the great number of fibrous roots of the wild grasses, whereas under a forest cover the color of the surface soil is invariably light gray, because of a very low content of organic matter.

Practically all of the land in the western part of the county has a black surface soil, even where it occurs under the aspen forest. As previously mentioned, the forest has not existed long enough to modify or change appreciably the color of the surface soil.

Between the area in the eastern part, where the surface soils are light-colored, and the area in the western part, where the surface soils are prevailingly dark-colored, lies an irregular belt of transitional soils. Here the soils have developed under the influence first of grass and later of trees, and they show some of the characteristics of those occurring on both sides of the belt. The soils of this transitional belt, in general, have thinner and less black surface soils than those of the typical soils of the prairies, but these layers are not so light-colored as those of the typical forest soils. These three belts may be termed the forest belt, the prairie belt, and the transitional belt. Their presence explains, in part, the great number of soil types in the county. Many of the soils have the same parent materials, but differences in the native vegetation have produced differences in the surface soils and in the upper part of the subsoils.

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The soils of Roseau County are derived from the lake sediments of clay, silt, and sand, deposited in the basin of glacial Lake Agassiz; from sand and gravel of the ridges of the ancient shore lines; and from glacial till in the lake bed, which was only slightly reworked by wave action. Large areas of the county have only a shallow covering of lake-laid material, containing some cobbles and boulders, on top of the glacial till. In some places, however, notably adjacent to the Roseau River, deposits of lake-laid clay and silt are rather extensive and are of considerable thickness. For a long time much of the land was covered with shallow water, which modified to only a very slight extent the material previously laid down by the glaciers.

In table 7 the prominent soil series are shown for the three vegetation belts referred to. In the first column are listed the parent materials from which the soils have formed. Directly opposite are the corresponding series for the three belts. It will be noted that from the different parent materials of each belt, both better drained soils and poorly drained soils developed, most of which are represented by different series of soils.

TABLE 7.—*Grouping of the soils of Roseau County, Minn., by series, for the three vegetation belts*

Parent materials from which soils have developed	Prairie belt		Transitional belt		Forest belt	
	Better drained soils	Poorly drained soils	Better drained soils	Poorly drained soils	Better drained soils	Poorly drained soils
Glacial till	Kittson	Barnett	Nereson	Barnett	Chilgren	
Modified till with gravel and pebble layer.	Foxhome	Foxhome [1]	Pelan	Pelan [1]	Gudrid	
Lake-laid clays	Fargo	Fargo [1] and Maple.	Fargo	Fargo [1] and Maple.	Taylor	Wildwood.
Lake-laid silts and very fine sands.	Bearden	Bearden [1]	Malung	Malung [1]	Baudette	Spooner.
Lake-laid deep sands	Ulen	Arveson	Poppleton	Arveson	Hiwood and Faunce.	Potamo.
Lake-laid shallow sands.	Grimstad	Tanberg	Enstrom	Tanberg	McDougald and Gudrid.	Salol.
Gravel deposits on ridges.	Sioux		Sioux		Mahnomen	

[1] No separate series recognized, but regarded as a poorly drained phase of the related better drained soils of the same series.

Figure 2 is a generalized soil map of these soils.

Roseau County lies in the bed of glacial Lake Agassiz. The land for the most part is nearly level, with extensive areas of swamps lying at about the same elevation as the surrounding land composed of mineral soil. Wet conditions, prevailing for years, have hindered soil development to a marked extent, so that many of the soils do not show the well-defined characteristics of soils that lie just outside of the lake bed on the naturally better drained land. Since settlement began, much of the county has been drained by large open ditches, with the result that extensive areas, formerly too wet for cultivation, are now dry enough to be farmed without danger of excessive moisture entirely ruining the crops, although during abnormally wet years some of the drained land remains too wet for cultivation.

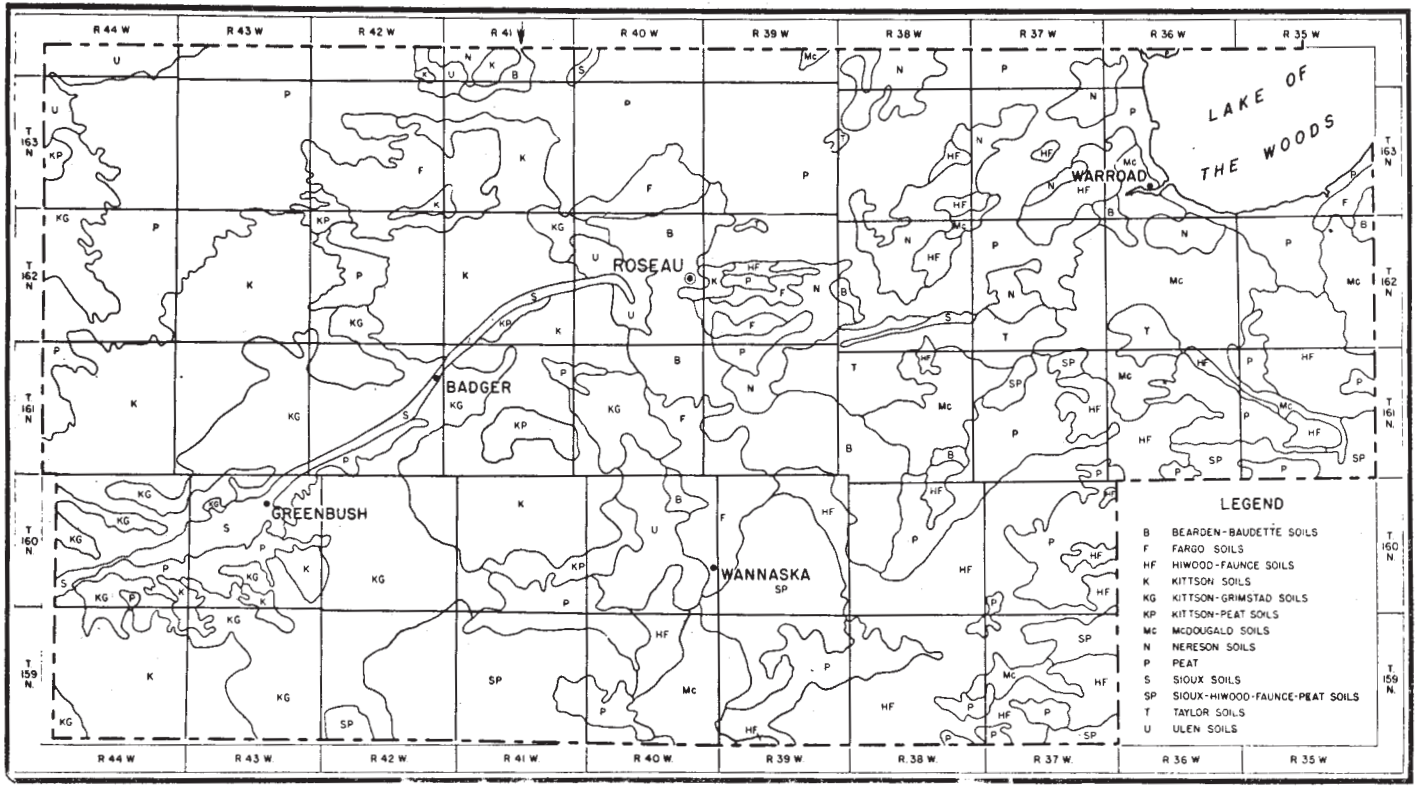

FIGURE 2.—Generalized soil map of Roseau County, Minn.

Agricultural development is centered chiefly in the western two-thirds of the county, where most of the soils are black silt loams and clay loams. The extreme western and eastern parts include large and small areas of peat. Much of the land in the eastern part, aside from that occupied by peat, supports a tree cover, and clearing the land of trees adds to the cost of its reclamation. The farms are smaller in the eastern part, and less of the land is used for crops.

Productivity is influenced to a large extent by the texture of the surface soil and subsoil and by the organic-matter content of the surface soil, which also determines the color of the soil. On the basis of productivity, the soils of this county are placed in seven groups: (1) Dark-colored medium- and fine-textured soils with heavy subsoils; (2) dark-colored coarse- and medium-textured soils with heavy subsoils; (3) dark-colored silty and sandy soils with sandy subsoils; (4) light-colored fine-textured soils with heavy subsoils; (5) light-colored sandy soils with heavy subsoils; (6) light-colored sandy soils with sandy subsoils; and (7) organic and alluvial soils.

The soils of five of the groups are further divided into subgroups of better drained soils and poorly drained soils. Included with the better drained soils are those that are somewhat imperfectly drained. It must be borne in mind that in this county most of the better drained soils are not perfectly drained, owing to the flatness of the land; but in order to differentiate the soils on the basis of drainage they have been classed as better drained soils.

In seasons of normal rainfall the crops on the better drained soils are not injured by excessive moisture, and this, in general, is true also of the imperfectly drained soils that are included with the better drained soils. In mapping the soils, it was, in places, extremely difficult to separate the better drained soils from the imperfectly drained soils, particularly on the unimproved land that supports some tree growth.

The poorly drained soils include soils that are too wet in normal seasons to allow their use as cropland unless provision is made for better drainage. Generally, these soils occupy large and small depressions where water collects from the surrounding slightly higher land. Numerous large flat or slightly depressed areas, some from 2 to 3 square miles in extent, are poorly drained.

The naturally productive soils of the western two-thirds of the county with their rather high content of organic matter and nitrogen are adapted to the production of wheat, oats, flax, barley, and tame-hay crops, such as sweetclover, alfalfa, and timothy. These soils are also adapted to corn, but the cool nights and the short growing season limit the production of this crop, and corn from the small acreage planted is generally cut green and used for feed.

In much of the central and eastern sections of the county, where the surface soils are light-colored, practically no spring wheat is grown, but a larger acreage is devoted to oats, alfalfa, sweetclover, and mixed timothy, red clover, and alsike clover.

In the following pages the soils of Roseau County are described in detail, and their agricultural importance is discussed; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are given in table 8.

TABLE 8.—*Acreage and proportionate extent of the soils mapped in Roseau County, Minn.*

Soil type	Acres	Percent	Soil type	Acres	Percent
Kittson silt loam	105,664	9.9	Enstrom silt loam	704	0.1
Kittson clay loam	54,400	5.1	Tanberg silt loam	256	(1)
Kittson clay loam, imperfectly drained phase	22,592	2.1	Tanberg loam	5,760	.5
Kittson sandy loam	2,112	.2	Tanberg clay loam	704	.1
Kittson sandy loam, imperfectly drained phase	64	(1)	Tanberg loamy fine sand	1,728	.2
Kittson gravelly silt loam	3,008	.3	Ulen loamy fine sand	13,888	1.3
Kittson gravelly clay loam	2,112	.2	Ulen loamy fine sand, undulating phase	128	(1)
Kittson gravelly sandy loam	576	.1	Ulen loamy fine sand, gravelly phase	1,920	.2
Nereson silt loam	9,472	.9	Ulen very fine sandy loam	2,304	.2
Nereson clay loam	15,168	1.4	Ulen very fine sandy loam, gravelly phase	704	.1
Nereson clay loam, imperfectly drained phase	7,360	.7	Ulen very fine sandy loam, imperfectly drained phase	4,928	.5
Nereson sandy loam	1,920	.2	Poppleton loamy fine sand	18,816	1.8
Nereson sandy loam, imperfectly drained phase	256	(1)	Poppleton loamy fine sand, undulating phase	1,152	.1
Nereson gravelly sandy loam	64	(1)	Poppleton loamy fine sand, gravelly phase	1,920	.2
Nereson gravelly clay loam	64	(1)2	Poppleton very fine sandy loam	2,368	.2
Foxhome sandy loam	2,432	.	Poppleton very fine sandy loam, gravelly phase	128	(1)
Foxhome loam	12,480	1.2	Poppleton very fine sandy loam, imperfectly drained phase	5,056	.5
Foxhome loam, imperfectly drained phase	4,608	.4	Poppleton silt loam	128	(1)
Foxhome clay loam	2,944	.3	Sioux loamy sand	12,608	1.2
Pelan clay loam	192	(1)	Sioux loamy sand, smooth phase	704	.1
Pelan sandy loam	128	(1)	Arveson loamy fine sand	10,048	1.0
Pelan loam	896	.1	Arveson very fine sandy loam	1,536	.1
Pelan loam, imperfectly drained phase	384	(1)	Arveson silt loam	9,536	.9
Fargo clay	29,312	2.8	Taylor very fine sandy loam	19,072	1.8
Fargo clay, poorly drained phase	5,376	.5	Baudette very fine sandy loam	4,288	.4
Fargo clay loam	4,288	.4	Chilgren clay loam	2,560	.2
Bearden clay loam	9,984	.9	Spooner very fine sandy loam	192	(1)
Bearden fine sandy loam	5,824	.6	McDougald loamy fine sand	18,112	1.7
Bearden loam	7,616	.7	Gudrid fine sandy loam	960	.1
Bearden loam, imperfectly drained phase	128	(1)	Salol loamy fine sand	576	.1
Malung loam	10,176	1.0	Hiwood loamy fine sand	66,752	6.3
Malung loam, imperfectly drained phase	3,712	.4	Hiwood loamy fine sand, imperfectly drained phase	5,120	.5
Malung clay loam	2,368	.2	Hiwood loamy fine sand, gravelly phase	704	.1
Malung fine sandy loam	4,160	.4	Faunce sand	39,104	3.7
Barnett clay loam	8,896	.8	Faunce sand, imperfectly drained phase	2,624	.2
Barnett silt loam	6,464	.6	Faunce sand, stony phase	2,368	.2
Barnett sandy loam	128	(1)	Faunce gravelly sand	64	(1)
Maple clay loam	6,336	.6	Mahnomen loamy sand	9,536	.9
Wildwood silty clay	1,600	.2	Mahnomen loamy sand, smooth phase	704	.1
Grimstad loamy fine sand	14,912	1.4	Potamo loamy sand	2,496	.2
Grimstad loamy fine sand, gravelly phase	4,032	.4	Peat	159,232	14.9
Grimstad loam	14,912	1.4	Peat, shallow phase, over sand	49,408	4.0
Grimstad loam, imperfectly drained phase	5,888	.6	Peat, shallow phase, over clay	103,424	9.7
Grimstad loam, gravelly phase	5,440	.5	Burned peat over sand	15,744	1.5
Enstrom loamy fine sand	7,488	.7	Burned peat over clay	31,872	3.0
Enstrom loamy fine sand, gravelly phase	192	(1)	Alluvial soils, undifferentiated	18,368	1.7
Enstrom very fine sandy loam	3,008	.3			
Enstrom very fine sandy loam, imperfectly drained phase	7,360	.7	Total	1,068,800	

[1] Less than 0.1 percent.

DARK-COLORED MEDIUM- AND FINE-TEXTURED SOILS WITH HEAVY SUBSOILS

The group of dark-colored medium- and fine-textured soils with heavy subsoils occupies a large proportion of the central and western parts of the county and includes some of the most productive soil types, which have black or very dark gray surface soils and are rich in organic matter and nitrogen. Some of the soils are stony and

others are practically free of stones on and below the surface. They are productive soils, and, under favorable climatic conditions and good management, they yield well. All the common farm crops suited to the region are grown, with good results. The areas are nearly level but in many places have a slight slope to some drainageway.

This group includes some of the most extensive soils in the county, and a large part of them is improved. The largest farms are located on these soils, and all the crops common to the county are grown. Although carbonates are present in a few of the surface soils, most of these soils have slightly acid surface soils, but in them all the subsoils are sufficiently supplied with lime to meet the lime requirements of all crop plants. The fine texture of the subsoils provides storage for sufficient moisture to withstand short periods of drought, which are rather common in July and August.

BETTER DRAINED SOILS

The better drained soils of this group are members of the Kittson, Nereson, Foxhome, Pelan, Fargo, Bearden, and Malung series. They differ from one another chiefly in the intensity of color of the surface soils and in the character of the material from which the soils have formed.

The better drained soils of this group occupy a large part of the central and western parts of the county and include some of the most productive and extensive soils in the county. The surface soils are black or very dark gray and are high in organic matter. These are productive soils, and, under the prevailing climatic conditions, together with good management, they yield well. They are, for the most part, nearly level, except near some of the streams, where, in places, they have a slight slope to the lower land. Surface drainage in most places is adequately provided for by large open ditches. All the general farm crops suited to the region are grown on them. In general, stones are not very numerous either on or below the surface.

The Kittson soils have developed on glacial till under grass vegetation and have dark-colored surface soils. The Nereson soils have formed in areas originally grass-covered, but trees encroaching on them have to a certain extent altered the upper part of the soil, with the result that the surface soils are not nearly so dark as those of the Kittson soils. They have developed on the same kind of material as the Kittson soils. The Foxhome soils are similar to the Kittson soils, with the exception that just below the dark surface soil a 4- to 6-inch layer of coarse gravel and pebbles occurs. They, too, have developed from the same kind of material. The Pelan soils are like the Foxhome soils with the exception that the Pelan soils have somewhat lighter colored surface soils, as they have developed in areas where trees have invaded the prairie land. The Fargo soils have very black surface soils and have developed on heavy clays of lacustrine origin. The Bearden soils are black and are composed mainly of silt and very fine sand. Their parent materials are silty deposits laid down in glacial Lake Agassiz. The Malung soils are closely related to the Bearden soils, having developed on the same kind of material but having somewhat lighter colored surface soils.

KITTSON SERIES

Kittson silt loam.—The surface of Kittson silt loam in a virgin condition is covered by a 1- or 2-inch layer of partly decayed matted grass. Beneath this is black or very dark gray finely granular silt loam, ranging from 4 to 8 inches in thickness, high in organic matter, and filled with many fine rootlets of native grasses. The surface soil is slightly acid or neutral in reaction. Below this is a 4-inch layer of gray calcareous friable silt loam, which is transitional between the very dark layer above and the more compact layer immediately underneath. Some pebbles of granite and limestome are embedded in it, and many narrow tongues of black soil from the surface layer project into it for 2 or 3 inches. This layer passes into rather compact very light gray calcareous silty clay loam, from 4 to 6 inches thick, which rests on light grayish-yellow silty clay loam that continues to a depth of several feet. This material is somewhat finer textured than the surface soil, is slightly compact, and contains many pebbles of limestone. No pronounced structure is evident, but the soil aggregates consist of small angular and subangular fragments. Roots penetrate the soil freely, and the permeable character of the material allows easy percolation of water. Plate 1, *B*, shows a profile of this soil.

Important variations within this soil, as mapped, are the thickness of the surface soil, which in some places is as much as 12 inches thick, the occurrence of boulders on and below the surface, and the color of the subsurface layer, which ranges from grayish brown to grayish yellow.

This is the most important and extensive soil of its group. Most of the land on both sides of the railroad from Strathcona to Roseau consists of Kittson silt loam, and a large part of the land is under cultivation.

The land is nearly level (pl. 2, *A*), although a few places near some of the streams and drainageways have a slight slope toward the stream channel or to small wet depressions. Surface drainage is naturally poor, owing to the flatness of the land surface, but large ditches remove much of the surface water resulting from melting snow in the spring and from heavy rains. Considerable moisture is absorbed by the soil, and some is lost through surface evaporation. Internal drainage is generally good.

Much of the undeveloped land is covered with wild grasses and a rather thick stand of poplar trees, ranging from 1 to 4 inches in diameter, along with willow and hazel brush, which is abundant in some places (pl. 1, *A*).

Most of this soil is devoted to general farming in which small grains, wheat, barley, and oats are the dominant crops (pl. 2, *B*). Generally sweetclover is seeded with the grain and in some seasons is pastured after the grain crop is removed. The following year it is commonly pastured early; but in some years a cutting of hay is taken first, and the crop is then allowed to stand for seed. The land is plowed in the fall preparatory for cropping again the following year. Corn is grown to a small extent, but only occasionally does it reach maturity, as it is generally cut green in August and fed to

livestock. Alfalfa is grown rather extensively, but no farm has a large acreage devoted to this crop.

Kittson clay loam.—The surface soil of Kittson clay loam in a virgin condition has a 1- to 2-inch layer of matted grass overlying a 6- to 8-inch layer of black or very dark gray granular clay loam. This, in turn, rests on a layer of dull grayish-black coarsely granular silty clay loam ranging from 4 to 6 inches in thickness. Beneath this is light olive-gray slightly granular silty clay loam, which grades into grayish-yellow calcareous friable silty clay loam. Many limestone pebbles are distributed through the soil. The surface soil is very slightly acid, but the upper and lower parts of the subsoil have a large content of carbonates.

Kittson clay loam is an extensive soil, although it does not occupy nearly so large an area as the closely associated Kittson silt loam. Drainage, both surface and internal, are about the same as in Kittson silt loam, although percolation through this soil is a little slower than in the silt loam, owing to the somewhat finer texture of the soil material.

Farming practices and crops grown on Kittson clay loam are similar to those on Kittson silt loam.

Kittson clay loam, imperfectly drained phase.—The imperfectly drained phase of Kittson clay loam differs from typical Kittson clay loam chiefly in that it is flatter, surface drainage is poorer, and the surface soil is thicker. This soil occupies large flat areas where water runs off the surface very slowly, and that which cannot penetrate the soil because of saturation must be removed by surface evaporation. Owing to a more abundant moisture supply, a luxuriant growth of wild grasses prevailed, which resulted in a darker colored surface soil with a thickness ranging from 8 to 14 inches. The type of farming practiced on this soil is, in general, similar to that on Kittson silt loam and Kittson clay loam.

Kittson sandy loam.—Kittson sandy loam has a 6- to 8-inch surface soil that ranges from black medium sandy loam to very fine sandy loam. The color, texture, and other characteristics of the upper and lower parts of the subsoil are like those of other Kittson soils.

Kittson sandy loam is closely associated with other Kittson soils, although it occupies only a small total area. Owing to the sandiness of the surface soil, this soil is worked a little more easily than Kittson silt loam, but in general it is managed and farmed in the same manner as that soil.

Kittson sandy loam, imperfectly drained phase.—Kittson sandy loam, imperfectly drained phase, differs from typical Kittson sandy loam chiefly in that it is flatter and has poorer surface drainage. As in the other imperfectly drained Kittson soils, the removal of surface water by run-off is slower, but the absorption of water is rather more rapid, owing to the coarser texture of the surface soil. The land is farmed in the same manner as the other imperfectly drained soils of the series.

Kittson gravelly silt loam.—Kittson gravelly silt loam, in a virgin condition, has a 1-inch grass mat overlying black or very dark gray finely granular friable silt loam ranging from 5 to 8 inches in thickness. Beneath this is a 3- or 4-inch layer of limy coarse gravel

and small pebbles mixed with various quantities of sand. This layer is sharply separated from the overlying surface soil and the upper part of the subsoil and is more or less continuous throughout the extent of the soil. Beneath this is the typical subsoil material consisting of light grayish-yellow mellow clay loam, similar to that in all the Kittson soils. The subsoil is very permeable, does not hinder the movement of moisture, and is easily penetrated by roots. The surface soil is slightly acid, but the underlying gravel layer and the subsoil are rich in carbonates.

The thickness of the gravel stratum in this soil and the thickness of the dark soil layer above the gravel vary from place to place. Within short distances, variations in thickness of the surface soil, ranging from 1 to 5 inches, commonly occur. Probably in most of this soil the gravel layer is not more than 2 inches thick.

This soil is not extensive. It is closely associated with the other Kittson soils. The land is nearly level. Natural surface drainage is fair, and probably water enters the surface soil more rapidly than it does in the other Kittson soils.

The general farm crops suited to the county are grown on this soil, and the farming practices on it do not differ from those used on the other Kittson soils. The occurrence of the thin gravel layer does not seem to be detrimental to crops.

Kittson gravelly clay loam.—This soil has all the characteristics of Kittson gravelly silt loam except that the surface soil is black granular clay loam, ranging from 5 to 8 inches in thickness. It is distributed among the other Kittson soils and has a slightly smaller total area than Kittson gravelly silt loam.

Kittson gravelly sandy loam.—This soil differs from Kittson gravelly silt loam in the texture of the surface soil, which consists of black or very dark gray finely granular sandy loam ranging from 4 to 7 inches in thickness. This soil is associated with the other Kittson soils.

NERESON SERIES

The Nereson soils differ from the Kittson soils in that the surface soils are not so black. The Nereson soils occupy a comparatively large area and form an irregular transitional zone between the dark-colored soils in the western part of the county and the light-colored forested soils in the eastern part. The material from which they have developed is the slightly modified glacial till identical in character with that from which the Kittson soils have developed. The land is nearly level, with a slight slope to the natural drainageways. The uncleared land, where it has not been burned over, is covered with a stand of poplar and a moderate growth of underbrush.

These soils are farmed in the same way as the Kittson soils, and the crops grown on them are similar. Where the land is cultivated, the surface soils do not differ markedly in appearance from those of the Kittson soils, except that the color is not so nearly black. Five soil types and two phases are recognized in this county.

Nereson silt loam.—In uncultivated areas of Nereson silt loam, a 1- to 2-inch layer of forest litter covers the surface soil. Beneath this is dark-gray or grayish-brown granular silt loam 3 to 4 inches thick. The upper part of this layer is somewhat darker than that

below, owing to the incorporation of some organic matter in it from the overlying decomposed leaf litter. The material in this layer grades into light-gray rather loose silt loam, which ranges from 4 to 6 inches in thickness. A few pebbles, mostly granite and limestone, are concentrated in the lower part of the layer, which in turn grades into light grayish-yellow silty clay loam, ranging from 3 to 6 inches in thickness, rich in carbonates, and having a friable consistence with little tendency to pack. The material is highly calcareous, and when moist it is rather sticky. Below this is the unweathered soil material of light grayish-yellow mellow clay loam. Rust-brown and orange-colored stains give it a mottled appearance. Pebbles, many of dolomite, are distributed freely through the subsoil, and in some places pockets of sand and fine gravel occur. Some boulders occur on and below the surface. In many areas they are not sufficiently numerous to interfere seriously with cultivation, although in some areas they are thickly strewn over the surface and prevent the land from being farmed. Most of the latter areas are used for the grazing of livestock.

The surface ranges from nearly level to very gently undulating. The forest growth consists almost entirely of aspen, much of which does not reach a very great age but dies and is replaced by natural reproduction.

Nereson clay loam.—Nereson clay loam is similar to Nereson silt loam except that its surface soil is very dark gray clay loam. Other features of the profile, as well as of relief and natural surface drainage, are very similar to these features of Nereson silt loam. This is the most extensive member of the Nereson series.

Nereson clay loam, imperfectly drained phase.—This soil has a profile similar to that of typical Nereson clay loam. It differs from that soil, however, in that it is somewhat flatter and has correspondingly poorer surface drainage. It occurs on extensive flat areas with little or no slope.

Nereson sandy loam.—This soil has a 4- to 6-inch surface layer of dark-gray or grayish-brown friable sandy loam; otherwise its profile features are identical with those of Nereson silt loam. The lay of the land and surface drainage are similar on the two soils.

Nereson sandy loam, imperfectly drained phase.—This soil is similar to typical Nereson sandy loam in texture of the surface soil and in tilth properties. The surface soil is slightly darker and higher in organic matter than the typical soil. The areas are generally more nearly flat than those of the typical soil, with very slow drainage. This soil occurs in a few very small bodies, chiefly east of the Warroad River.

Nereson gravelly sandy loam.—This soil is similar to Nereson sandy loam, from which it is differentiated by the presence of a 2- to 4-inch layer of gravel just below the dark-colored surface soil. The gravel consists of pebbles and very small stones of many kinds of rocks. Below the layer of gravel the soil materials are the same kind of friable calcareous glacial till that underlies the other Nereson soils. This soil has the same surface features, agricultural use, and value as Nereson sandy loam except as slightly modified in the plow soil by the gravel, which becomes intermixed with it in cultivation.

The total area mapped is very small. One small body lies in section 3 of Huss Township.

Nereson gravelly clay loam.—Nereson gravelly clay loam is closely related to Nereson silt loam, differing only in the texture of the surface layer, which ranges from gravelly silt loam to gravelly clay loam. The term gravelly in the name of this type indicates the presence, just below the dark surface soil, of a layer of coarse gravel and sand, ranging in thickness from 2 to 4 inches. The soil is developed from mellow calcareous glacial till slightly reworked by waters of glacial Lake Agassiz. In relief and natural drainage conditions this soil does not differ from Nereson silt loam. One small body lies in sections 23 and 24 of Huss Township.

FOXHOME SERIES

The Foxhome soils are developed under a grass vegetation and are characterized by black or very dark gray surface soils. They have formed from lake-washed glacial till, the upper part of which was modified by the lake waters. Just below the black surface soil, which is 6 to 8 inches thick, is a 5- to 16-inch layer of coarse gravel and pebbles. This layer rests on the unmodified glacial till, such as that underlying the Kittson and Nereson soils. In some respects the Foxhome soils are closely related to Kittson gravelly silt loam, Kittson gravelly clay loam, and Kittson gravelly sandy loam, but are differentiated from those Kittson soils by a thicker gravel layer. The Foxhome soils are not very extensive. They occur largely in scattered bodies in the western townships and are associated with the Kittson soils.

Most of the improved Foxhome soils are farmed in connection with the Kittson and other soils, as they occur as parts of farms rather than as constituting entire farms.

No distinction is made in the selection of crops on these soils, because of their rather small extent on any one farm. The same crops grown on the related Kittson soils are grown also on these soils. The presence of the gravel stratum just below the surface soil is detrimental in the effect on root development of some plants. Observations made of the distribution of roots of sweetclover and alfalfa show that the layer of gravel prevents to some extent the penetration of roots through it. Ordinarily, however, yields are not reduced greatly on this account, because the rainfall is generally ample during the growing season, and the rather high water-holding capacity of the surface soil prevents any great diminution in crop yields. During dry seasons, however, yields are somewhat curtailed.

The Foxhome series is represented in this county by three soil types and one phase.

Foxhome sandy loam.—Foxhome sandy loam has a 4- to 6-inch surface layer of very dark gray or black finely granular sandy loam. Beneath this is a 5- to 16-inch layer of fine and coarse gravel, which contains some sand particles and, in places, a few pebbles of granite and dolomite. Owing to the high content of calcareous material in the gravel, this layer in many places appears white. In most places the gravel layer is loose with no evidence of cementation except that some of the smaller particles are held together by lime. This layer,

in general, is sharply separated from the finer textured surface soil above it and the underlying finer textured subsoil, which consists of grayish white clay loam slightly mottled with reddish brown. It is rather compact and contains many calcareous pebbles.

The surface soil is rather high in organic matter, and roots are freely distributed in it. Where the gravel layer is thick it does not contain many plant roots; here the roots are concentrated in the overlying soil layer. In general, rather large quantities of boulders are scattered over the surface, although in many places there are only a few. Most of them lie on the surface, but some are partly or wholly embedded in the surface soil.

The principal variations in this soil occur in the thickness of the dark-colored surface soil and the gravel layer and in the color of the upper and lower parts of the subsoil. In some places, the gravel layer is as much as 18 or 20 inches thick and contains considerable sand.

Many areas of this soil border slight depressions, peat bogs, and natural drainageways, but some rather large areas are situated some distance away from areas of more poorly drained soils. The material underlying the surface soil and the gravel layer is somewhat similar to that in the subsoil of the Kittson and Nereson soils. Natural surface drainage of this soil as a whole is favorable to agriculture except in the areas near depressions and peat bogs. In general, internal drainage is good.

Most of the virgin soil supports a dense stand of wild grass; but, where the land has poorer drainage, willows, sedges, and other brushy growth are prominent. Where this soil is under cultivation, the crops suited to this general region, such as wheat, oats, barley, and sweetclover, are grown.

In dry periods this soil is inclined to be droughty, because of the gravel layer near the surface; and, where the thickness of this layer is greater, the danger of injury from drought is increased. Low yields may be expected on this soil because of the rather limited feeding zone for plant roots. Most of the roots do not penetrate the coarse-textured layer but tend to concentrate in the shallow surface soil. In places where the roots do reach this layer, they either become stunted or grow in a horizontal direction, paralleling the top of the gravel layer. Where the surface soil is comparatively shallow (less than 6 inches thick) some difficulty is experienced in plowing the land, as the plow share tends to slide into the gravel layer. Where the gravel is turned to the surface in plowing it becomes mixed with the finer soil particles on further cultivation and forms a coarser textured soil.

Foxhome loam.—Foxhome loam has the same soil characteristics as Foxhome sandy loam, except for the loam texture of its surface soil. Its gravel layer has the same thickness and lithological composition as that of the sandy loam. Variations in the thickness of both the gravel layer and the dark-colored surface soil occur in both soils.

The same crops are grown and the same difficulties are experienced in cultivation on the two soils.

Foxhome loam, imperfectly drained phase.—As mapped, Foxhome loam, imperfectly drained phase, includes areas of the cor-

responding phases of Foxhome sandy loam and Foxhome clay loam. The soils of these phases differ from the typical soils in having somewhat poorer surface drainage and slower internal drainage.

The surface soil of Foxhome loam, imperfectly drained phase, consists of grayish-black finely granular loam, rather high in organic matter and very slightly acid. Beneath this is an 8- to 12-inch layer of dark-gray compact loam overlying a 5- to 10-inch layer of fine gravel. Various grades of sand, small pebbles, and in places a few small cobblestones are included with the gravel, much of which contains pebbles and rounded and granular fragments of dolomite. Underlying this coarse-textured layer is gray calcareous rather compact silty clay loam.

The areas are nearly level but lie somewhat lower than areas of the better drained soils. Most of them occupy slight depressions, ranging in size from less than 1 acre to more than 300 acres. At times, water from the surrounding higher land drains slowly to these areas, but in few places is the land low enough to allow large quantities of water to accumulate. In most places the water table is somewhat higher than in the typical soils. The more abundant supply of moisture encouraged a more luxuriant growth of native grasses on this soil, compared with the typical soil, with the result that a deep and dark-colored surface soil developed.

Methods of management and the crops grown are much the same as on the better drained typical soils, but yields are somewhat more uncertain, especially when a late spring delays seeding. In seasons of normal and well-distributed rainfall, little difference in yields is noticed on well-prepared land; but when the rainfall is above normal, or when the land is wet in spring as a result of heavy snowfall, the imperfectly drained phases are generally wetter and spring work of preparing the land and seeding the crop is delayed. The late seeding generally results in much poorer yields.

Some areas, chiefly along the streams and drainageways and in the lower depressions, remain wet for long periods, and as a result some peat has formed. This condition is also fairly common on the flatter areas.

Many farmers reclaim this soil for crop use by burning the entire peat layer. It is only in the very driest years that conditions are favorable for satisfactory burning, as ordinarily the peat is too wet to burn freely to an even depth. The destruction of the shallow coating of peat improves the productive capacity of the soil, at least temporarily. Although this practice results in the loss of considerable organic matter and nitrogen, nevertheless sufficient quantities remain in the underlying mineral soil to meet the requirements of plants for some years. Farming the shallow peat itself generally is disappointing, and yields of small grains are small. Peat is deficient in phosphate and, in some places, in potash as well. The seedbed becomes loose and dries out rapidly, thus hindering the proper growth of plants. On the other hand, when moisture is plentiful, peat warms slowly in the spring, and a favorable temperature is not obtained early enough for the proper development of plants.

Foxhome clay loam.—This soil is similar in most features to Foxhome sandy loam, the main difference being the clay loam texture

of the surface soil. This heavier texture is accompanied, however, by favorable structure and tilth properties, owing chiefly to the high content of organic matter. Therefore, the two soils have about the same use and productivity.

PELAN SERIES

The Pelan soils are related to the Foxhome soils. They have developed on the same kind of soil material and under the same conditions of climate, but apparently under a cover of wild grasses, succeeded by trees, which encroached upon these soils. These soils are lighter colored, contain less organic matter and nitrogen, and are less productive than the related Foxhome soils. They occupy the transitional belt lying between the soils developed under a prairie vegetation to the west and the soils developed under forest to the east.

In general, the Pelan soils are rather stony, with boulders occurring on and below the surface, although some areas are entirely free of stones. In some places, however, stones and boulders are so numerous that it is impracticable to prepare the land for crops, and many of such areas included in farms are used for pasture. Some areas of the flatter land contain an excess of soluble salts. As in the Foxhome soils, the gravel layer retards proper development of roots; and during dry periods, crops may suffer from lack of sufficient moisture.

The relief of the Pelan soils is generally flat or nearly level, although in places where these soils border peat bogs, depressions, and drainageways they have a gentle slope to the lower lands. Drainage conditions are for the most part adequate. The gravel layer favors the absorption of moisture, and generally not much water stands on the surface, even after heavy rains.

The native vegetation consists largely of aspen with a rather thick undergrowth of brush and grasses. In some places, peat, ranging from 1 to 3 inches in thickness, has formed on the surface.

The Pelan soils are not very extensive, and there are no large individual bodies. In general, they occupy narrow elongated areas, mainly adjacent to peat bogs and drainageways. The crops grown on them, where the land has been reclaimed, are the same as on the adjacent soils. Owing to their occurrence in small bodies, no farm consists wholly of Pelan soils, and therefore these soils are not singled out for any special treatment or special crop. Pelan sandy loam, Pelan loam, with an imperfectly drained phase, and Pelan clay loam are mapped. All have similar profile characteristics except for the texture of the topmost layer.

Pelan clay loam.—The surface soil of Pelan clay loam consists of dark grayish-brown somewhat granular clay loam, ranging from 4 to 8 inches in thickness, overlain by a 2-inch layer of very dark brown partly decomposed leaf litter. Beneath the surface soil the material is lighter in color and consists of a 2- to 3-inch layer of rather compact grayish-brown fine sandy loam. This grades into a layer of the characteristic coarse-textured material consisting of fine gravel, sand of various grades, pebbles, and a few small cobblestones. The thickness of this layer varies from place to place and averages about 8 inches. The material is strongly calcareous. Just below this

is the typical glacial till consisting of light grayish-yellow mealy clay loam. Its light-gray color is caused by its high content of carbonates.

Variations in this soil are in the thickness of the surface soil, the thickness of the coarse-textured layer below it, and the intensity of the color of the immediate surface soil. The soil occupies a few small bodies, chiefly in the northwestern part of Grimstad Township.

Pelan sandy loam.—The surface soil of Pelan sandy loam is grayish-brown or dark-gray slightly granular sandy loam ranging from 5 to 10 inches in thickness. Below this is a layer of light grayish-brown rather compact sandy loam, 2 or 3 inches thick, which grades into a layer of gravelly sand, about 6 inches thick. This coarse-textured layer is rather variable in thickness within short distances and in some places is more than 8 inches thick. Below the gravel layer the soil material consists of light grayish-yellow pebbly clay loam, with a high content of carbonates.

Variations in this soil are in the thickness of the dark-colored surface soil and the thickness and lithological composition of the gravel stratum. The soil occurs in a few very small bodies, such as the one in Grimstad Township.

Pelan loam.—The surface soil of Pelan loam is dark grayish-brown granular loam, ranging from 4 to 9 inches in thickness, which is overlain by a layer of forest litter, 1 or 2 inches thick. Underneath the surface layer the soil material becomes somewhat lighter in color, owing to the removal of some of the iron compounds by leaching. This layer is about 2 inches thick and grades abruptly into a 5- to 7-inch layer of sand and gravel, high in carbonates. Below this layer is the typical calcareous light yellowish-gray pebbly clay loam, similar to that underlying Pelan clay loam and Pelan sandy loam.

The principal variations in this soil are in the thickness of both the surface soil and the sand and gravel layer.

Pelan loam, imperfectly drained phase.—This soil is closely related to the better drained Pelan loam, but it has developed under poorer drainage conditions. Some areas are more or less submerged for short periods. A large proportion of the land is still uncultivated, owing to its wet condition and the large number of stones on the surface and through the soil. Peat covers many areas to a depth of 4 to 6 inches. The native vegetation in most places is a stunted growth of aspen, willow, hazel, and other shrubs. During dry years, fires have consumed much of the peat covering, thereby exposing the underlying lighter colored mineral soil with boulders strewn on the surface. Where areas of this soil occupy parts of cultivated fields and the land is not too wet, the soil is handled in much the same manner as the adjacent soil, and the same crops are grown.

FARGO SERIES

The Fargo soils are extremely heavy textured soils developed on lake-laid clays. They are dark-colored to depths ranging from 8 to 16 inches, generally free of stones on and below the surface, and somewhat imperfectly drained. Owing to the fine texture of both the upper and lower parts of the subsoil, water percolates through the soil slowly, and this soil does not warm so quickly in the spring

as do the Kittson or Nereson soils. The Fargo soils occur only in the prairie section of the county, especially along the Roseau River in the northern part. The Fargo soils are represented by two types and one phase, Fargo clay loam, Fargo clay, and Fargo clay, poorly drained phase.

The surface of the Fargo soils is nearly level. Where these soils adjoin streams or drainageways, however, the surface slopes very slightly toward the stream channel. Here, surface drainage is better than elsewhere. These soils have developed from lake-laid clay deposited in the still waters of glacial Lake Agassiz.

Originally a luxuriant growth of grasses covered the land, and the decaying grass roots left the abundance of organic matter that characterizes these soils. In some places, especially along the streams, trees, mostly aspen, constitute the native vegetation, but they have not occupied the land long enough to change markedly the color or the texture of the surface soil.

Some of the land occupied by these soils is under cultivation, especially along the Roseau River, where it is better drained. In other places it is mostly idle, except where it occurs in small bodies and forms part of a cultivated field.

These soils are hard to handle with farm implements, and the moisture conditions must be favorable before the land can be satisfactorily tilled. The soils are well adapted to wheat, oats, barley, and flax, and sweetclover is grown rather extensively, usually being seeded with the small grain. The Fargo soils also are well adapted to the common clovers and alfalfa, and nearly every farmer devotes some of his land to these crops. Corn is grown on a small acreage, but practically none ripens, as it is cut green before or after the first frost in the fall and fed as rough forage. Yields of the small grains are about the same as on the Nereson and Kittson soils, although in the drier years the Fargo soils probably outyield the others because of their water-holding capacity.

Fargo clay.—The surface soil of Fargo clay, to an average depth of 16 inches, is black granular clay. On drying it shrinks greatly, and when disturbed it breaks into small angular fragments, which are held together loosely by numerous fine rootlets. The soil is high in organic matter and is neutral or alkaline in reaction. Below the surface soil is dark olive-gray clay of variable thickness, averaging about 14 inches. As the soil dries, many cracks form, and the dark surface soil either washes or drifts in, forming tongue-like projections in the upper part of the subsoil. Beneath this layer is an 8-inch layer of dull-gray very calcareous compact clay, highly mottled with rust-brown stains. The lower part of this layer and the lower subsoil layer are less compact and tight, and water penetrates more freely. Below this the soil material becomes still more open and consists of silty clay loam, which is grayer because of the larger quantities of lime carbonate it contains.

Variations in this soil are the variable thicknesses of the surface soil and the frequency of occurrence of the dark soil tongues penetrating into the upper subsoil layer. Variations in color, owing largely to organic matter and iron compounds in the lower layers, also are important. The typical dark olive-gray color is mottled in many places with nearly white blotches and concretions of calcareous material.

Fargo clay, poorly drained phase.—The poorly drained phase of Fargo clay occupies flat and slightly depressed areas where water drains from the surface rather slowly. This soil generally is too wet in the spring for cropping, and consequently most of it is not cultivated. Where it is included in farms it is used for wild-hay meadows or for pasture.

The surface soil is black finely granular clay or clay loam, ranging from 4 to 20 inches in thickness, which tends to break into large blocks if the dry soil is disturbed. When it is slightly moist, however, it is more or less friable and breaks into small granular aggregates. No sharp line separates the surface soil from the underlying subsoil, which consists of dark olive-drab granular clay loam about 24 inches thick. This material is very compact, is somewhat bedded, and contains few or practically no stones, except a few concretions of lime (calcium carbonate). The lower part of the subsoil is grayish-blue, mottled with brown, heavy bedded clay. Both surface soil and subsoil are calcareous.

The thickness of the surface soil is extremely variable within short distances. In some places the lake-laid clay is comparatively shallow, in places less than 24 inches thick, and overlies fine-textured stony glacial till. In some places the subsoil is a mixture of heavy till and bedded clay with a few large and small boulders embedded in it.

This soil is associated with the better drained Fargo soils. It occupies slightly depressed areas ranging in size from less than 1 acre to more than 80 acres. It also occupies level flats, most of which lie back from the river or from drainageways. Natural surface drainage is very poor, and internal drainage also is very slow, owing to the extreme fineness of the soil particles.

In a native condition much of the land is covered with willow brush and other shrubs and scattered small trees. Wild grasses are abundant, and some of the wettest areas support a growth of sedges. Plate 2, *C*, illustrates the character of the vegetation on uncleared land.

Fargo clay loam.—Fargo clay loam is developed on heavy-textured lake-laid clays in the central and west-central parts of the county. The surface soil, to a depth of 8 to 12 inches, is black coarsely granular clay loam, which, when dry, becomes rather loose because of the high shrinkage of the soil particles. The coarse granules are more or less angular and subangular and are held together loosely by numerous fine rootlets. The surface soil is neutral or slightly calcareous. No sharp line of demarcation separates the surface soil from the subsoil, as the tongues of black soil projecting downward form a fringelike boundary between them. Beneath this layer is olive-gray finely granular clay loam, which is rather compact and contains some flecks and nodules of lime. This layer ranges in thickness from 8 to 14 inches and with depth passes gradually into rather light olive-gray clay filled with lime concretions. The lacustrine clays of the subsoil are bedded in many places and are remarkably uniform in physical composition. When the dry material is disturbed with a pick or a spade it breaks into large angular compact blocks. Water moves through the clay very slowly, and so much of it is retained that the soil is nearly always wet or moist.

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BEARDEN SERIES

The Bearden soils comprise a large group of soils in the central and northern parts of the county that have developed on silt and very fine sand deposits laid down in glacial Lake Agassiz. These soils are remarkably uniform in their physical composition, they are generally free of stones on and below the surface, and they occur in large bodies north and south of Roseau. The texture of the surface soils shows considerable variation from place to place, ranging from loamy very fine sand to clay loam. The subsoils, however, consisting of fine silty material, in many places mixed with various quantities of very fine sand, are more nearly uniform than the surface soils.

All the Bearden soils have rather wide variations in the soil profile. In Bearden fine sandy loam, some variations in texture occur within short distances. Bearden loam and Bearden clay loam show marked variations in the thickness of the topmost layer, which overlies the coarser textured upper subsoil layer. Many extreme variations in color also occur among all the Bearden soils, but they all, in common, have a mouse-gray subsurface layer, which undoubtedly is richer in lime than the layers immediately above and below it.

Bearden clay loam, the most extensive soil of the series, occurs chiefly in the area north of Roseau; Bearden fine sandy loam, chiefly southwest of Roseau; and Bearden loam, chiefly south of Roseau, toward Wannaska.

In relief, the Bearden soils range from nearly level to undulating. Where these soils lie near or adjoin the streams or drainageways, the land has sufficient slope to provide adequate surface drainage; but where the land is flat or nearly level, surface drainage is, in general, inadequate. Internal drainage is good in most places, owing to the permeable character of the upper and lower subsoil material. In Bearden fine sandy loam and Bearden loam water is absorbed rapidly, but in Bearden clay loam water does not penetrate so easily because of the finer texture of the material.

The parent material from which Bearden fine sandy loam has developed was assorted during the time of deposition in the basin of glacial Lake Agassiz, whereas Bearden loam and Bearden clay loam have developed on finer textured alluvial material overlying the material deposited earlier in the lake bed. These last two soils occur mainly in wide areas on both sides of the Roseau River. This river at one time carried large quantities of fine sediments and deposited them on its flood plains. As a result, rather thick layers of fine-textured alluvial material have accumulated along this stream over the coarser textured silts and very fine sands.

The native vegetation over much of the area of these soils consisted of grasses and scattered trees.

The greater part of the Bearden soils is under cultivation. These soils, with the exception of Bearden clay loam, are easy to till. They are productive soils, rich in organic matter and nitrogen. Owing to their friable character, they are easy to keep in good physical condition and can be handled under a wide range of moisture conditions. All the crops suited to the county are grown on them and yield well. These soils are better adapted to diversified farming than are any other soils in the county. Many of the farmers combine grain farming with dairying, along with the raising of some hogs.

Some of the lighter textured Bearden soils have a tendency to blow when freshly plowed or cultivated. Most fields, however, are more or less protected by either planted or natural groves of trees, and the danger from wind blowing is greatly reduced. All these soils are well adapted to alfalfa and sweetclover, and nearly every farmer has a comparatively large acreage devoted to these crops. Some desirable bodies of these soils are still in a wild state awaiting settlers. The ease with which the soils can be cultivated, their capacity for absorbing and holding water, and their fair to good surface drainage make them desirable for farming.

Bearden clay loam.—The surface soil of Bearden clay loam ranges in thickness from 8 to 16 inches and consists of very dark gray or black granular clay loam. This grades into a 12- to 20-inch layer of dull-gray calcareous clay loam or silty clay loam that is very smooth and contains practically no grit. This material passes rather abruptly into grayish-yellow calcareous very fine sand, which continues to considerable depth. The entire soil mass ranges from neutral to calcareous. Moisture moves slowly through this heavy soil and in many places remains on the surface for some time after heavy rains.

Bearden fine sandy loam.—The surface soil of Bearden fine sandy loam is very dark gray fine sandy loam ranging in thickness from 8 to 14 inches. It is mellow and has little tendency to pack. Below this, the material consists of a 4- to 8-inch layer of yellow mellow fine sandy loam, which rests on a grayish-white very fine sand subsoil. The lower part of the subsoil and the substratum consist of either very fine sand or heavy stony glacial till.

Bearden loam.—The surface soil of Bearden loam consists of dark-gray granular mellow loam, ranging from 10 to 16 inches in thickness. This grades rather abruptly into a layer of yellow silt loam, from 6 to 9 inches thick, which is without definite structure and is slightly compact but very friable. Below this is a layer of olive-gray mellow silty clay loam, with an average thickness of about 10 inches. Beneath this the soil consists of grayish-brown fine sandy loam generally free of fine gravel and pebbles. At a depth ranging from 4 to 8 feet the material is heavy stony glacial till. Both surface soil and subsoil are calcareous.

Included in mapping are a few small areas in which the surface soil consists of dark-gray mellow loamy very fine sand, ranging from 6 to 12 inches in thickness. Below this is a 6- to 10-inch layer of grayish-yellow loose very fine sand. With depth the color becomes lighter gray, owing to the presence of more calcareous material. The very fine sand constituting the lower part of the subsoil continues to an indefinite depth and is grayish white, calcareous, and in places stained rust brown. In some places it is pale yellow mottled with many small dark-brown spots. Underlying the very fine sand layer, at a depth ranging from 4 to 10 feet, is dark olive-gray compact clay of lacustrine origin.

Bearden loam, imperfectly drained phase.—This soil includes soils like those of the Bearden series except that they have poorer drainage and a thicker dark-colored surface soil. As mapped, the texture ranges from clay loam to very fine sandy loam. The 8- to 16-inch surface soil is very dark gray or black loam with a coarse-granular structure. This rests on a 4- to 8-inch layer of somewhat

lighter gray compact silt loam. The subsoil consists of mellow floury silt and very fine sand, the content of sand gradually increasing with depth. The color is pale yellow mottled with reddish-brown stains of iron compounds. The lower part of the subsoil, or the substratum in many places, consists of stony heavy glacial till or a mixture of heavy till and lake-laid clay.

As mapped, the depth and intensity of color of the dark-colored surface soil vary greatly within short distances, and the depth to the heavy stony glacial till varies from place to place. In most places the heavy till lies only 36 inches below the surface, but in some places it lies at a depth of more than 5 feet. In general, this imperfectly drained soil is free of boulders on and below the surface.

Drainage, both surface and internal, is poor. In the areas of the coarser textured soil, moisture is readily absorbed, but if the amount of moisture is excessive the soil becomes saturated because of the prevailingly high water table.

Very little of this imperfectly drained soil is under cultivation, but some is used as pasture land, and wild hay is harvested from some areas that are not too far removed from the farmer's home. The soil occurs only in a few very small areas, such as the one in section 34 of Malung Township.

MALUNG SERIES

The Malung soils are closely related to the Bearden soils in that they have developed from similar parent materials, namely, the silts and very fine sands deposited in the quiet waters of glacial Lake Agassiz. They are distinguished from the Bearden soils by the lighter color of the surface soils. The Bearden soils have developed under grass, whereas the Malung soils have developed under a mixed vegetation of grass and trees. Apparently wild grasses at one time grew luxuriantly in the areas occupied by the Malung soils, but long before settlement commenced, trees had encroached on the grassland and persisted until the land was brought under cultivation. A lighter colored soil was developed under the forest, with a corresponding decrease in the organic-matter content. In some places the tree vegetation has produced marked differences in the surface soils, whereas in other places the modification has been only slight. Where the effect of tree vegetation is more pronounced, the soils are more like the forest soils in the eastern part of the county, and where the effect is less strong, they more closely resemble the soils developed in the grassland areas of the western part. Therefore, rather wide variations are to be expected within short distances on the Malung soils.

The Malung series is represented in this county by three soil types and one phase—Malung loam; Malung loam, imperfectly drained phase; Malung clay loam; and Malung fine sandy loam.

Malung loam.—The 4- to 6-inch surface soil of Malung loam consists of gray mellow loam overlain by a thin coating of brown more or less decomposed forest litter. Beneath the mineral surface soil is a 3- to 6-inch layer of dark-gray finely granular silt loam with a slight brown cast, which is somewhat platy in structure and slightly compact. Below this the soil material becomes almost white,

but in many places it has a distinct yellow color and is a structureless silt loam containing some fine gravel. This layer ranges from 6 to 10 inches in thickness and is slightly acid. The subsoil consists of light straw-yellow flourlike silt loam that is very mellow but slightly compact. As depth increases, the material becomes finer textured and consists of pebbly silt loam or silty clay loam. In many places the material is laminated and interbedded with thin layers of slightly different texture. The reaction of the upper two layers is, in general, slightly acid, and the soil becomes calcareous at a depth of 14 to 18 inches. The soil absorbs and retains moisture well. Very few boulders occur on the surface or in the upper part of the soil.

A few small areas are included with Malung loam on the map that have a 3- to 6-inch surface soil of mellow grayish-brown loamy very fine sand underlain by a 6- or 8-inch layer of grayish-brown very fine sand. Beneath this is straw-yellow mellow very fine sand or fine sand, from 12 to 24 inches in thickness. Stony glacial till, finer in texture than the material above, lies at a variable depth but exceeding 30 inches. The reaction is acid to an average depth of 20 inches. No stones are on or near the surface.

Malung loam, imperfectly drained phase.—A 2-inch layer of forest litter and partly decomposed leafmold covers the 4- to 8-inch surface soil of Malung loam, imperfectly drained phase, which is gray or grayish-yellow mellow loam, the upper part being somewhat darker than the lower part. Underlying this layer the soil is grayish-brown structureless slightly compact fine sandy loam, resting on floury light-gray silt loam with a distinct yellow cast. As depth increases, the material becomes yellower and somewhat coarser textured, and at a depth of 4 feet or more the material may be of the same silty character as that above it, or it may be glacial till mixed with fine-textured lacustrine material.

This imperfectly drained soil is associated with the typical Malung soils. It occupies nearly level or flat areas. Developed under slightly wetter conditions than the typical soil, it does not have such well-defined layers as those soils.

Malung clay loam.—The surface soil of Malung clay loam consists of dark-gray slightly granular clay loam ranging from 4 to 8 inches in thickness. Under this is somewhat lighter gray clay loam, with a brown cast, from 4 to 8 inches thick. Below this, the soil material consists of grayish-white rather compact silty clay loam, somewhat bedded, and contains some pebbles and fine gravel. As depth increases, the material becomes flourlike and very smooth, with little or no grit, and consists mostly of silt particles. Glacial till lies at a greater depth. The topmost 10 inches of this soil is slightly acid, but the material becomes calcareous at a depth of 12 to 16 inches. Very few boulders are on or below the surface.

Malung fine sandy loam.—The surface soil of Malung fine sandy loam consists of a 3- to 8-inch layer of grayish-brown mellow fine sandy loam. It is underlain by a 6- to 10-inch layer of light grayish-brown loamy very fine sand. This, in turn, grades into light-yellow or brown mellow very fine sand, which rests on pebbly sandy clay loam at a depth ranging from 30 to 60 inches. The

soil is medium acid to an average depth of 20 inches and below this becomes neutral or calcareous. Boulders are very few on or below the surface.

POORLY DRAINED SOILS

The poorly drained soils of the first group have poor surface drainage, and, owing to the comparatively fine texture of both the surface soil and the subsoil, they have slow internal drainage. Nearly all of them are developed under a rather high water table and, as a consequence, have poorly developed soil layers. They occupy nearly level flats and depressions, and most of them border peat bogs and natural drainageways.

The soils included in this subgroup are members of the Barnett, Maple, and Wildwood series. The Barnett soils are the poorly drained associates of the Kittson soils and have developed on lake-washed glacial till, the same kind of material on which the Kittson soils have developed. They occur in areas associated with the Kittson and Nereson soils and occupy land originally covered by grass. The Maple and Wildwood soils are developed on heavy lake-laid clays.

BARNETT SERIES

The Barnett soils are distributed in the central and western parts of the county in flat, nearly level, or in many places, depressed areas. They have developed on glacial material slightly modified by the wave action of the waters of glacial Lake Agassiz. In some places they have formed on a mixture of glacial till and lake-laid clay, and here the subsoil is very fine textured and compact and water percolates through it very slowly. Natural surface drainage is poor, owing to the flatness of the land. Where these soils occupy slight depressions in the upland, they receive run-off from the surrounding higher land and in wet years are very wet. With their comparatively high water table, these soils are frequently waterlogged during normal seasons, and in wet seasons some of them are actually flooded. In the heavier textured members of the series, water percolates through the soil layers very slowly because of the high content of fine material.

The native vegetation consists of grasses, sedges, rushes, willow bushes, and much scrub aspen. Only a small part of the land is cultivated. Lack of adequate outlets for artificial drainage systems is one of the reasons why so little of the land is adequately drained. In some places where fires have burned off the peat layer, the land is put in crops if it is at all possible to get on it early enough in the spring to work and seed it, but many of these areas remain wet so long that it is impossible to crop them. Where the land is not cropped after fires have destroyed the peat layer, weeds come in and create a menace by infesting the surrounding cultivated better drained soils.

Barnett clay loam.—The surface soil of Barnett clay loam is very dark gray or black granular clay loam from 6 to 12 inches in thickness. It is high in organic matter and is filled with fine roots of the luxuriant wild grasses that formerly grew here. In the wetter and more poorly drained places the surface is covered with a 4- to 6-inch layer of peat. Beneath the surface soil is grayish-black rather com-

pact silty clay loam ranging from 4 to 8 inches in thickness, which is underlain by grayish-yellow silty clay loam or clay loam. Stones, including pebbles and a few large boulders, are throughout the soil mass. Many of the smaller pebbles are of dolomitic origin. Lime occurs at a depth of 10 inches.

The principal variation in this soil is in the color and thickness of the surface soil. Where this soil is associated with the Nereson soils the surface soil is grayer, but where associated with the Kittson soils it is darker. Most of this soil has a mucky or peaty layer overlying the surface soil, but in many places it has been either partly or wholly burned by fires that have repeatedly swept across parts of these areas. Another variation exists in the character of the subsoil. In some places the subsoil is olive-gray very compact and tenacious silty clay loam; in others it is a more mellow and permeable light-gray clay loam.

In some places the number of boulders on the surface and through the soil prevents the land from being farmed. Elsewhere the land is comparatively free of stone, and, where it is cultivated, little or no difficulty is experienced in using farm machinery.

Barnett silt loam.—The surface soil of Barnett silt loam is very dark gray or black silt loam ranging from 6 to 14 inches in thickness. In many places a mucky layer, and commonly a thin layer of peat from 3 to 6 inches thick, overlies it. Beneath this is a 4- to 8-inch layer of dark-gray slightly granular silt loam or loam, which grades into finer textured material—silty clay loam or clay loam. As in Barnett clay loam, this material may be olive-drab or grayish-yellow silty clay loam. Some boulders are present on the surface and through the soil; their number varies greatly from place to place. Pebbles and some cobblestones are distributed throughout the soil mass. The soil is calcareous at a depth ranging from 12 to 18 inches.

Barnett sandy loam.—Barnett sandy loam has a dark-gray or black mellow sandy loam surface soil, ranging from 6 to 10 inches in thickness. In some places it is covered with a 3- to 6-inch layer of peat or muck. Underlying the surface soil is grayish-brown or very dark gray very fine sandy loam or medium sandy loam ranging from 4 to 7 inches in thickness, which gradually merges into grayish-yellow or light-gray silt loam or mellow light clay loam, continuing downward to considerable depth. The surface soil generally is very slightly acid and in some places is neutral or even calcareous. The subsoil, however, everywhere is calcareous, and many of the small pebbles contained in it are limestone. Some boulders are scattered on the surface, and in some places they are very numerous.

Some variation in the texture of the surface soil is noted from place to place, ranging from loamy very fine sand to very fine sandy loam. In most places the subsoil is clay loam, but in some places it is sandy loam.

MAPLE SERIES

Maple clay loam.—The surface soil of Maple clay loam is very dark gray or black clay loam. It has a very high content of organic matter and is very slightly acid or neutral in reaction. It is extremely variable in thickness, ranging from 6 to 20 inches. The subsoil is dark olive-gray waxy compact clay. Both the surface

soil and the subsoil are so compact that water percolates through them very slowly. On drying, the soil material shrinks greatly, forming large cracks. In dry seasons these cracks penetrate the subsoil to a depth of 3 feet or more. Many of the cracks are filled with black surface soil blown in by winds and washed in by rains, producing narrow wedge-shaped tongues, which form a fringelike line between the surface soil and the subsoil. In many places the surface is covered with a 4- to 6-inch layer of peat or muck. Very few boulders are on or in the soil. The subsoil has a high content of lime. Areas of this soil are nearly level, flat, or depressed. The soil is formed from lake-laid clay.

WILDWOOD SERIES

Wildwood silty clay.—The surface soil of Wildwood silty clay in a virgin condition is covered by a 2- to 6-inch layer of either forest debris or peat. In some places this has been burned completely, thereby exposing the underlying mineral soil. The surface soil consists of very dark grayish-brown silty clay ranging from 4 to 8 inches in thickness, which, when dry, breaks into large hard subangular lumps. Beneath this is a 6- to 10-inch layer of dark-gray compact silty clay, which grades into olive-gray silty clay loam or clay loam. This material continues downward without much change in color or texture to an indefinite depth. In many places it is streaked with blotches and concretions of lime, which give a somewhat white color to the material. A few rust-brown, yellow, and orange stains are in the subsurface soil and subsoil. In many places boulders are on the surface, and a few are embedded in the soil. In some areas an abundance of boulders on the surface makes cultivation difficult, although many places are free of them. This soil is slightly acid in the topmost 12 inches, but, as depth increases, it becomes highly calcareous.

Owing to the development of this soil under prevailingly very wet conditions, the thickness of the dark surface soil is extremely variable, even within short distances. The thickness of the peat layer likewise varies from place to place.

Most of this soil is mapped in the central and eastern parts of the county, in association with the Taylor soils. It is developed on lake-laid clays and in this respect is similar to the Fargo soils.

The native forest growth on Wildwood silty clay is rather dense. Aspen, some balsam fir, and spruce are the principal species of trees. The underbrush of willow, alder, and other shrubs is very thick in many places, and the ground floor is well covered with grasses where the tree growth is not too dense.

Not much of this soil is under cultivation. The naturally poor surface drainage, together with the intractable character of the soil, retards its agricultural development.

DARK-COLORED COARSE- AND MEDIUM-TEXTURED SOILS WITH HEAVY SUBSOILS

The soils of the second group—dark-colored coarse- and medium-textured soils with heavy subsoils—occur in the central and western parts of the county, and they are agriculturally important because the greater proportion of them is under cultivation. They have black or dark-gray surface soils, are fairly rich in organic matter, are com-

paratively easy to work, and have a fair to good water-holding capacity. In general, they are free of boulders on and in the soil. All the crops suited to the county are grown with good results on these soils.

Most of this land is nearly level or flat. In some places, adjoining streams or drainageways, the surface slopes gently toward the stream channel. The Grimstad soils have been developed from sediments deposited in glacial Lake Agassiz on top of either lacustrine clay or slightly modified glacial till. In some places the underlying finer textured material comes close to the surface, with the result that the coarser textured overlying layer is comparatively shallow. Extreme variations in the depth of the overlying layer occur within short distances.

The soils of this group are characterized by a layer of more or less assorted sand deposited over a heavier textured subsoil or substratum. The subsoil consists of lake-laid clay, lake-laid silt, or stony pebbly glacial till. The thickness of the overlying sand layer is extremely variable, ranging from 8 to 30 inches, even within short distances. In some places the surface soil is silt loam, but commonly this is not more than 8 inches thick and grades into fine sand, which merges into the finer textured clay loam subsoil at a depth of 30 inches or less. These soils are distributed throughout the county. In the prairie section of the western part, the soils of this group belong to the Grimstad series; in the transitional belt, where the forest and prairie lands intermingle, they belong to the Enstrom series. Like the dark-colored soils with medium- and fine-textured surface soils, these soils may be placed in subgroups of better drained soils (which include imperfectly drained soils) and poorly drained soils.

Natural surface drainage is fair to good, and internal drainage is good in places where the finer textured substratum is not too close to the surface. Where the underlying material consists of lake-laid clay, the soils are inclined to be rather wet late in the spring, because the water moves so slowly through the soil. The native vegetation is mostly grass, although in many places trees occupy the uncleared areas with grasses among them.

BETTER DRAINED SOILS

GRIMSTAD SERIES

The Grimstad soils are fairly extensive in the western part of the county. A large part of them is cultivated, and all the crops suited to this region are grown on them.

Grimstad loamy fine sand.—The surface soil of Grimstad loamy fine sand is dark brownish-black loose loamy fine sand from 3 to 6 inches thick. Beneath this is dark-brown loamy sand mottled with yellowish brown, ranging from 8 to 24 inches in thickness. The material in this layer has a rather loose consistence and contains a few pebbles. This grades rather abruptly into the subsoil, which is grayish-white loam or clay loam. In many places it consists of heavy compact lake-laid clay, free of pebbles and boulders. Generally, however, it consists of stony pebbly glacial till similar to that underlying the Kittson and Nereson soils. Lime is everywhere abundant in the subsoil, and in some places the sandy layer overlying the finer textured substratum contains lime.

Grimstad loamy fine sand, gravelly phase.—Closely related to Grimstad loamy fine sand is Grimstad loamy fine sand, gravelly phase. This soil is very similar to the corresponding typical Grimstad soil just described, except that somewhere within a depth of 24 inches it contains a 1- to 3-inch layer of gravel. In places this layer consists of gravel and sand free of any fine material, although in other places it is mixed with small quantities of silt and clay. This soil is associated with the other Grimstad soils.

Grimstad loam.—The surface soil of Grimstad loam is dark-gray or grayish-brown slightly granular loam or silt loam from 4 to 8 inches thick. This gradually changes into lighter gray loamy very fine sand with a yellow cast, ranging from 6 to 14 inches thick, which grades, without any sharp line of demarcation, into straw-yellow mellow fine sand or very fine sand. Below a depth ranging from 12 to 30 inches the material is finer textured than that above, consisting of either stony pebbly clay loam or stone-free lacustrine clay.

Grimstad loam, imperfectly drained phase.—The surface soil of Grimstad loam, imperfectly drained phase, is very dark gray finely granular loam or silt loam, ranging from 6 to 10 inches in thickness. Below this is an 8- to 12-inch layer of grayish-brown loose loamy fine sand, which grades into dull grayish-white fine sandy loam. This layer is flecked with blotches of white material (chiefly lime) and ranges in thickness from 4 to 8 inches. No sharp line of demarcation separates it from the layer below, which consists of yellowish-gray calcareous silt loam or clay loam containing fine gravel, pebbles, and some larger stones.

This imperfectly drained soil occurs for the most part in areas slightly lower than the typical soil, and it has slower drainage.

Grimstad loam, gravelly phase.—The surface soil of Grimstad loam, gravelly phase, is brownish-black slightly granular loam or very fine sandy loam from 4 to 8 inches thick. It is free of pebbles and stones and is slightly acid in reaction. It grades into a layer of dark coffee-brown rather compact loamy fine sand ranging from 6 to 12 inches in thickness. Rather sharply separated from it is a 2- to 5-inch layer of coarse-textured material consisting of fine gravel and small pebbles mixed with some coarse sand and fine sand. Many of the gravel and sand particles are of limestone and granite, but the former predominates. Below this layer the material consists of grayish-yellow or straw-yellow silt loam or clay loam mixed with some pebbles and a few cobblestones.

The principal variations in Grimstad loam, gravelly phase, are in the thickness of the gravel layer, its mechanical composition, and, to less extent, its lithological composition. The depth at which this layer occurs varies also; nowhere is it in the surface soil; it is either immediately or several inches below it.

ENSTROM SERIES

The Enstrom soils are closely related to the Grimstad soils, having the same kind of parent material. They have developed, however, under a vegetative cover of trees mixed with grass and, accordingly, have different soil features in the surface layer. The surface soils are grayer and thinner than those of the Grimstad soils. In general,

these soils occur in the central part of the county. Most of the uncleared land is covered with trees, largely aspen, and in most places there is a dense undergrowth of brush, chiefly willow, pin cherry, chokecherry, and hazel.

Three soil types and two phases have been mapped—Enstrom loamy fine sand; Enstrom loamy fine sand, gravelly phase; Enstrom very fine sandy loam; Enstrom very fine sandy loam, imperfectly drained phase; and Enstrom silt loam.

Enstrom loamy fine sand.—The surface layer of Enstrom loamy fine sand consists of dark grayish-brown loamy fine sand or loamy very fine sand, ranging from 4 to 10 inches in thickness. It is underlain by a subsurface layer of grayish-brown loose light fine sand from 4 to 12 inches thick. This grades into the subsoil of light-gray compact silty clay loam, which continues to a depth ranging from 6 to 10 feet.

Enstrom loamy fine sand, gravelly phase.—Enstrom loamy fine sand, gravelly phase, differs from typical Enstrom loamy fine sand in that a 2- to 4-inch layer of sand or gravel or a mixture of these lies between the lower part of the surface soil and the heavier textured subsoil. The depth at which the sand or gravel layer occurs and its thickness are extremely variable within short distances.

Enstrom very fine sandy loam.—To a depth ranging from 4 to 8 inches, Enstrom very fine sandy loam is dark-gray or grayish-brown fine sandy loam. Below this layer is dark grayish-brown slightly granular fine sandy loam from 3 to 6 inches thick. This is underlain by a 6- to 10-inch layer of light-gray silt loam containing many small flecks of lime. The lower part of the subsoil consists of light-gray or light grayish-yellow mellow silty loam, which continues to an undetermined depth.

Enstrom very fine sandy loam, imperfectly drained phase.—This soil is closely associated with other Enstrom soils. The surface is slightly smoother and surface drainage is somewhat poorer than in typical Enstrom very fine sandy loam. This soil is very similar to the typical soil, with the exception that the surface soil is somewhat thicker and darker colored. This soil is farmed in the same way and the same kinds of crops are grown as on the typical soil. In seasons of normal rainfall there is very little difference in the time of working and cropping of the two soils. A considerable part of this soil is under cultivation.

Enstrom silt loam.—The 4- to 7-inch surface layer of Enstrom silt loam consists of dark-gray finely granular silt loam. It is underlain by mellow light grayish-brown fine sandy loam. In a few included areas a 2- to 4-inch layer of gravel or coarse sand with pebbles lies from 10 to 18 inches below the surface. The subsoil is light-gray silty clay loam with a high content of carbonates. The pale, almost white, color of the subsoil material is caused by its high lime content.

POORLY DRAINED SOILS

TANBERG SERIES

The poorly drained soils of the second group belong to the Tanberg series. They occur only in the marshes and swamps, where the vege-

tation consists of willow brush and other shrub vegetation. They are associated mostly with the Grimstad and Enstrom soils throughout the western and central parts of the county. Included in the series are four soil types—Tanberg silt loam, Tanberg loam, Tanberg clay loam, and Tanberg loamy fine sand.

Tanberg silt loam.—The surface soil of Tanberg silt loam is black silt loam, from 6 to 20 inches thick. The upper part in most places is mucky and rich in organic matter, although in many places a 3- to 8-inch layer of peat covers the surface. The boundary between the surface soil and the subsoil generally is more or less irregular. The subsoil consists of yellow loose sand underlain at a varying depth by heavy lake-laid clay or unmodified glacial till. The sand layer ranges in thickness from less than 8 to more than 24 inches and in color from the various shades of yellow to dull olive gray or dove gray, in many places mottled with rust brown. Most of the Tanberg soil is rich in lime, even near the surface, and in a few places a 2- to 4-inch layer of marl occurs in some part of the subsoil.

Areas of this soil are flat or depressed, and many of them occupy the lower lying land between the better drained Grimstad and Enstrom soils.

Practically none of Tanberg silt loam is under cultivation. Some of it is used either as wild-hay meadows or as pasture, but much of it is left idle, because it stays wet the year round.

The native vegetation consists of grasses, with reeds and sedges in the wettest places, willow and other shrubs, and some trees, mostly aspen. Some areas, locally called sloughs, are saturated with water the year round and are suitable as game sanctuaries.

Tanberg loam.—Tanberg loam is like Tanberg silt loam, except that the surface soil is dark-gray loam or very fine sandy loam. In many places it is covered with a 3- to 6-inch layer of muck or peat. The surface soil is variable in thickness, and the subsoil is either fine or coarse sand to a depth ranging from 3 to 6 feet, or heavy lake-laid clay or glacial till at a depth ranging from 14 to 30 inches. Tanberg loam is associated with the Grimstad and Enstrom soils.

Practically none of this soil is under cultivation. The native vegetation is similar to that on Tanberg silt loam.

A variation of Tanberg loam occupies nearly level flats or depressions within areas of the typical soil. Practically none of this soil is under cultivation except as small parts of cultivated fields where adequate surface drainage has been provided. Most of this soil in a virgin condition supports a luxuriant growth of wild grasses, and, in some places, willow and other brush are abundant.

Tanberg clay loam.—Tanberg clay loam is similar to Tanberg loam, with the exception that the surface soil of the former is very dark gray or black compact clay loam ranging from 5 to 12 inches in thickness. Most of it is covered with a layer of peat, which in many places has been burned. The upper and lower parts of the subsoil are similar to those layers of Tanberg loam. The surface soil is neutral or calcareous. Areas of this soil are nearly level or depressed, and practically none of them is cultivated.

Tanberg loamy fine sand.—Tanberg loamy fine sand has a surface soil of dark-gray or black loamy fine sand or fine sandy loam ranging from 6 to 14 inches in thickness. Most of it has a 3- to 6-inch

layer of brown or dark-brown poorly decomposed peat covering the mineral soil. Beneath the surface soil is an irregular layer of gray fine sand or fine sandy loam, which is loose and frequently moist. It is highly stained with rust-brown iron compounds and is neutral or slightly alkaline in reaction. This material grades into olive-gray silty clay loam or clay loam containing some fine gravel and pebbles and much lime. In general, this soil is free of boulders on and below the surface.

Tanberg loamy fine sand is extremely variable in the texture of the surface soil. Where the peat or muck layer is absent, the surface soil is either loamy fine sand or loamy very fine sand; but where it is present, the surface soil tends to become heavier in texture—fine sandy loam or very fine sandy loam. Below this is a 6- to 12-inch layer of gray loamy fine sand or fine sandy loam highly stained with rust brown, which grades into pebbly clay loam or silty clay loam.

Tanberg loamy fine sand is not an extensive soil. It is scattered in both large and small bodies in the western and central parts of the county and is closely associated with the Grimstad and Enstrom soils. Owing to its wet condition and lack of adequate drainage, very little of it is under cultivation. Some of the drier areas that comprise parts of farms are used as wild-hay meadows and as pasture land.

DARK-COLORED SILTY AND SANDY SOILS WITH SANDY SUBSOILS

The dark-colored silty and sandy soils with sandy subsoils, which compose the third group, are developed on loose sandy material that had been well assorted by wave action at the time of deposition and probably was partly reworked afterward by the wind. Underlying the sand layer, at a depth of 30 inches or more, is the heavier unmodified till or lake-laid clay deposited at an earlier period. The thickness of the sand layer is extremely variable within short distances, but in all the soils of this group the sand layer is at least 30 inches thick, whereas it is less than 30 inches thick in the soils included in group 2. The difference between the soils of group 2 and 3, therefore, is one of thickness of the overlying sand layer.

Included with this group are the soils developed on the gravel and sand ridges that represent the shore lines of ancient glacial Lake Agassiz.

Four soil series are included in the group. The Ulen series comprises the soils developed under a native vegetation of grass and occur mostly in the western part; the soils of the Poppleton series are developed where groves of trees and grassland intermingle, chiefly within the transitional belt in the central part; the soils of the Sioux series occupy the sandy and gravelly ridges, under both grass and forest vegetation; and the Arveson series includes the poorly drained soils associatied with the Ulen and Poppleton soils.

BETTER DRAINED SOILS

ULEN SERIES

All the Ulen soils have somewhere in the substratum finer textured material underlying the sandy layers. In some places this is reached at a depth of as much as 6 feet, but nowhere at a depth of less

than 30 inches. Owing to the marked variation in the depth of the sand within short distances, however, some areas shown as Ulen soils on the map include areas of Grimstad soils, in which the fine-textured layer lies within a depth of 30 inches.

The Ulen series includes the following types and phases: Ulen loamy fine sand; Ulen loamy fine sand, undulating phase; Ulen loamy fine sand, gravelly phase; Ulen very fine sandy loam; Ulen very fine sandy loam, gravelly phase; and Ulen very fine sandy loam, imperfectly drained phase.

Ulen loamy fine sand.—The surface soil of Ulen loamy fine sand is dark grayish-brown loose loamy fine sand, ranging from 4 to 10 inches in thickness. This grades rather gradually into mouse-gray or light grayish-brown loose loamy fine sand, from 4 to 9 inches thick. Below this, the material consists of grayish-brown slightly compact loamy fine sand, from 6 to 8 inches thick. The subsoil is grayish-yellow or straw-yellow slightly compact uniform loamy sand in many places stained with rust brown. This layer is from 12 to more than 36 inches thick, and it rests on clay loam or silty clay loam.

The sands that make up the upper soil layers are assorted, and only a small quantity of fine gravel or pebbles is mixed with them. Ulen loamy fine sand is generally free of boulders on and below the surface.

Ulen loamy fine sand is rather high in organic matter, and the depth of the dark-colored layer depends to a large extent on the character of the original ground cover and the permeability of the soil. In general, the topmost 20 inches of soil is slightly acid, but with depth the soil becomes neutral, and the underlying finer textured material is alkaline.

Most of Ulen loamy fine sand occurs in the western one-half of the county, where it is associated with the Grimstad soils. The largest area is west of the town of Roseau. This land is nearly level, with a slight slope toward streams or natural drainageways. Owing to its sandy character, the internal drainage is good, and water very seldom stands on the surface. In some places where the heavier textured substratum is close to the surface, the upper soil layers may be somewhat wet; and where the land is cultivated this condition may retard early working and seeding of the land. Most of this soil is under cultivation.

Ulen loamy fine sand, undulating phase.—Ulen loamy fine sand, undulating phase, has the same soil profile characteristics as the typical soil. The only difference is that soil of the phase has a gently undulating surface. Much of it is associated with the soils developed on the gravel ridges, where the Ulen soil occupies the lower slopes. In some places the texture of the upper and lower parts of the subsoil is coarser, the material consisting of medium and coarse sand mixed with some fine gravel. In most places the finer textured substratum lies 5 feet or more below the surface. No stones are present. Soil of this phase occurs in very small bodies, such as the one in section 17 of Barnett Township.

Ulen loamy fine sand, gravelly phase.—Ulen loamy fine sand, gravelly phase, occurs in the same parts of the county as the other Ulen soils. This soil has the same general profile characteristics as the gravel-free Ulen loamy fine sand, with the exception that somewhere in the upper 24 inches of the soil there is a layer of gravel

ranging in thickness from less than 1 to 4 inches. In typical Ulen loamy fine sand the soil material consists of well-assorted sands free from any gravel or pebbles, but in the gravelly phase the outstanding characteristic is the presence of this coarse-textured stratum. In most places the soil has very little if any fine material, such as silt and clay, mixed with the gravel.

The surface soil of Ulen loamy fine sand, gravelly phase, is grayish-brown loose loamy fine sand ranging from 4 to 10 inches in thickness. This is underlain by a 3- to 6-inch layer of light grayish-brown loose loamy fine sand, which grades into a layer of light-yellow rather compact fine sand, from 4 to 8 inches thick. This, in turn, rests on a 2- to 4-inch layer of fine gravel mixed with coarse sand and small pebbles, which overlies grayish-yellow mellow assorted fine sand. This sand may continue downward for several feet before the finer textured material is reached, although in places, as in the typical Ulen soil, it is present at a depth of 30 inches below the surface.

Ulen very fine sandy loam.—The 4- to 8-inch surface layer of Ulen very fine sandy loam is dark grayish-brown slightly granular very fine sandy loam or silt loam. It is underlain by dull-gray, in places with a brown cast, loamy very fine sand, ranging from 3 to 8 inches in thickness, which, in turn, grades into a layer of grayish-yellow or straw-yellow rather compact loamy fine sand from 12 to 30 inches thick. The substratum, which consists of pebbly clay loam, lies 30 inches or more below the surface. As in Ulen loamy fine sand, the upper 20 inches is slightly acid, but with increasing depth the soil material becomes calcareous.

This soil occurs in the same sections as Ulen loamy fine sand and occupies only a comparatively small area.

The surface is nearly level, and there is practically no surface run-off, as all the water is rapidly absorbed by the soil. Internal drainage is generally good, except where the finer textured material of the substratum, which impedes the downward movement of water, lies at a depth of 36 inches or less.

Ulen very fine sandy loam, gravelly phase.—Ulen very fine sandy loam, gravelly phase, is similar to the typical soil, but somewhere within a depth of 24 inches a 2- to 4-inch coarse-textured or gravelly stratum occurs. Underlying the gravel layer is yellowish-brown assorted fine sand, which in places is as much as 4 feet thick but more commonly is not more than 2 feet thick. Beneath this layer is the finer textured substratum.

The principal variations in this gravelly soil are the thickness of the gravel stratum and the depth to it, both features being extremely variable within short distances. Another important variation is in the thickness of the sandy layer overlying the finer textured pebbly clay loam substratum. No surface features indicate at what depth this fine-textured material may be reached, and its thickness cannot be determined until the land is explored with a spade or a soil auger.

Ulen very fine sandy loam, gravelly phase, is inextensive and is distributed over those parts of the county occupied by the Ulen soils. The areas are nearly level. Owing to the porous character of the soil, water percolates through it freely, and it is seldom if ever in

a waterlogged condition for any great length of time. Practically all areas of this gravelly soil are cultivated, and the crops grown are similar to those grown on the other dark-colored soils in the county.

Ulen very fine sandy loam, imperfectly drained phase.—Closely associated with the Ulen soils are imperfectly drained areas of similar soils indicated as Ulen very fine sandy loam, imperfectly drained phase. Most of these areas are nearly level or flat, in places slightly depressed. Elsewhere they appear to have the same relief as the normal soils, but in years of excessive precipitation they do not drain so well.

The surface soil of Ulen very fine sandy loam, imperfectly drained phase, consists of a 6- to 12-inch layer of slightly granular very dark gray or black very fine sandy loam, high in organic matter. This is underlain by a 4- to 6-inch layer of rather loose grayish-brown loamy fine sand, and this, in turn, grades into light-gray loose fine sand, which becomes grayer with depth and is mottled with orange-colored and rust-brown stains. Fine-textured glacial till lies at a depth of 30 inches or more. The upper part of the soil is very slightly acid or neutral, and with increasing depth the soil material becomes calcareous.

A considerable part of this imperfectly drained land is under cultivation and is farmed in the same way as the typical Ulen soils. The crops grown are much the same.

POPPLETON SERIES

The Poppleton soils are related to the Ulen soils in that they have developed from the same kind of material. The native cover was mixed forest and grass; accordingly, the surface soils are lighter colored, are shallower, have less organic matter, and are more acid in the upper layers.

All the Poppleton soils have very few or no stones on or below the surface. Where the underlying heavier textured material lies from 30 to 36 inches below the surface, a few boulders may be scattered about. In some places, particularly in the soils of the imperfectly drained phases, the soil contains some gravel in the form of thin strata, lenses, or pockets.

The areas of the Poppleton soils are nearly level or very gently undulating. Where they occur near the gravel ridges, they have a gentle slope to the adjacent lower land. Most of these soils have fair to good surface drainage, except on some of the nearly level areas. Internal drainage is good, owing to the coarser textured material of the upper part of the soil. On the more nearly level areas, where the substratum is not more than 30 inches below the surface, the soils in wet years are rather wet, as this finer textured material retards the downward movement of water.

The native vegetation consists largely of aspen, with wild grasses growing among the trees. A large part of the Poppleton soils is under cultivation, and the crops grown on them are similar to those grown on the other soils in the county. On the lighter textured members of the series, more winter rye is grown, and some of the land is devoted to corn. Ordinarily, corn is not allowed to ripen but is cut green and used for feed. Wheat and barley are grown to a small

extent. Alfalfa is well adapted to this soil, and a considerable acreage is devoted to it.

The Poppleton soils are extensive. Large areas occur in the central part of the county, associated with the finer textured soils. There are a few areas in some of the eastern townships, but in general these areas are small. Three types and four phases of the Poppleton soils are mapped—Poppleton loamy fine sand; Poppleton very fine sandy loam; Poppleton silt loam; Poppleton loamy fine sand, gravelly phase; Poppleton very fine sandy loam, gravelly phase; Poppleton very fine sandy loam, imperfectly drained phase; and Poppleton loamy fine sand, undulating phase.

Poppleton loamy fine sand.—The surface soil of Poppleton loamy fine sand is dull-gray loose loamy fine sand, ranging from 6 to 12 inches in thickness. This is underlain by a 6- to 20-inch layer of grayish-brown or light-gray slightly compact loamy very fine sand, which, in turn, gradually merges into light grayish-yellow or straw-yellow very fine sand or fine sand. This continues to a depth of several feet or, in places, is not more than 30 inches thick. Underlying the sand subsoil is a finer textured material, either lake-laid clay, silt, or glacial till. The depth at which this material occurs ranges from 30 inches to more than 5 feet but averages about 4 feet. This heavier material is strongly calcareous. In some places the sandy layer above it contains carbonates, but, as a rule, the upper 20 to 30 inches of the soil is slighty acid, although in a few places it is neutral.

Poppleton loamy fine sand, undulating phase.—In profile characteristics, the undulating phase of Poppleton loamy fine sand is similar to typical Poppleton loamy fine sand, except that it has a gently undulating surface. It occurs near the gravel ridges, where it borders the coarser textured Sioux soils that occupy the crests of the ridges. In places areas of the Poppleton soil parallel the ridges on both sides for considerable distances.

Poppleton loamy fine sand, gravelly phase.—Poppleton loamy fine sand, gravelly phase, is formed from the same kind of material as the other Poppleton soils but differs from them in that somewhere within a depth of 30 inches the soil contains a thin layer of gravel, 1 to 3 inches thick, mixed with various grades of sand. The surface layer consists of gray loose loamy fine sand, from 3 to 6 inches thick. This is underlain by a 3- to 6-inch layer of rather compact light-gray fine sand, which grades into more compact light grayish-yellow fine sand, and this, in turn, passes into a 4- to 10-inch layer of coarse gravel with some admixture of sand. The gravel layer is sharply separated from the underlying layer of loose straw-yellow fine sand or very fine sand. As in the typical Poppleton soils, the finer textured substratum lies at a depth ranging from 30 inches to more than 5 feet. This soil is closely associated with the gravel-free Poppleton soils and occurs in both large and small bodies.

Poppleton very fine sandy loam.—Poppleton very fine sandy loam has a 5- to 10-inch surface layer of gray or dark-gray very fine sandy loam, which is moderately acid. Beneath this is light grayish-brown or light grayish-yellow loose very fine sandy loam, ranging from 6 to 24 inches in thickness, which in many places is calcareous.

Underlying this is rather light gray, in places with a yellow cast, very fine sand mixed with small white concretions of lime. In places this layer has a distinct straw-yellow color and consists of well-assorted sand. The underlying material is calcareous and consists of either fine-textured lacustrine silt, clay, or glacial till. It is reached at a depth ranging from 30 inches to more than 5 feet.

Poppleton very fine sandy loam, gravelly phase.—Poppleton very fine sandy loam, gravelly phase, is similar to Poppleton loamy fine sand, gravelly phase, except that the surface soil is dark-gray very fine sandy loam or silt loam, and the layer immediately below it is fine sandy loam. Other profile characteristics of the upper and lower parts of the subsoil are similar. As in Poppleton loamy fine sand, gravelly phase, the gravel stratum occurs within a depth of 30 inches.

Poppleton very fine sandy loam, imperfectly drained phase.—The 2- to 4-inch surface layer of this imperfectly drained soil is grayish-brown loose very fine sandy loam or loamy fine sand. The upper part of the layer is darker, owing to the higher content of organic matter, and it is slightly acid in reaction. Below this is a 4- to 8-inch layer of light grayish-brown loose loamy very fine sand, which grades into a layer of grayish-brown slightly compact loamy very fine sand, about 8 inches thick. This, in turn, passes into somewhat compact light grayish-brown fine sand with a yellow cast, which continues to a depth of 30 inches or more. It is commonly streaked with rust-brown stains and is calcareous. The substratum consists of material that is finer textured than the material above.

Poppleton silt loam.—The surface soil of Poppleton silt loam is dark-gray granular silt loam ranging from 4 to 8 inches in thickness, and it is neutral or alkaline in reaction. It is underlain by a 6- to 24-inch layer of light grayish-brown rather compact fine sandy loam, which, in turn, rests on light grayish-yellow loose very fine sand. This passes into fine-textured lake-laid clay or glacial till at a depth ranging from 30 inches to 5 feet.

SIOUX SERIES

The Sioux soils occupy long smoothly rounded narrow ridges, which mark the ancient shore lines of glacial Lake Agassiz. They lie from 10 to 15 feet higher than the surrounding land and therefore have good natural drainage. The most prominent ridge is in the western part of the county. It enters Roseau County near Pelan and extends northeastward to a point about 4 miles west of Roseau village, passing through the towns of Greenbush and Badger. The Great Northern Railway and a State highway traverse it. The Sioux series is represented in this county by one soil type and one phase—Sioux loamy sand and Sioux loamy sand, smooth phase.

Sioux loamy sand.—The 4- to 8-inch surface layer of Sioux loamy sand consists of dark-brown loose loamy sand containing small quantities of coarse gravel and small pebbles. This grades into a layer of dark-brown slightly compact gravelly sand, which ranges in thickness from 3 to 8 inches. Underlying this layer is a 6-inch layer of gray loose gravelly sand, which grades into beds of stratified coarse sand and gravel, containing some small and large pebbles and a few cobble-

stones. The most characteristic features of the Sioux soils are the beds of stratified sand and gravel in the subsoil and substratum. The surface soil, when wet, is almost black, and on drying it has a tendency to bake into a rather solid mass, the particles being loosely held together. Cracks soon develop, and the material breaks into large irregular lumps. In some places in the central part of the county the surface soil is shallower than elsewhere and the color is more grayish brown than black. In many places the layer immediately underlying the surface soil is reddish-brown sandy loam, which, when dry, becomes very hard and somewhat indurated and is rather difficult to break with a pick or a soil auger. The thickness of the underlying gravel layer ranges from 4 to more than 10 feet, more commonly the latter, and in many places the gravel is interbedded by more or less thick strata of well-assorted sand. The surface soil is, in general, slightly acid, but the gravel in nearly all places is calcareous. Probably more than half the pebbles in the gravel are limestone.

Sioux loamy sand occupies long narrow ridges ranging in width from about 4 rods to more than one-half mile. The relief is very gently rolling. Natural surface drainage is good, and internal drainage is excessive. Owing to its coarse texture, the soil holds very little water. In general, this soil is free of large stones on and below the surface.

The characteristic native forest growth consists of scrub oak and aspen, the former predominating. Few of the trees attain a height greater than 20 feet. In some places, especially in the central part of the county, this soil supports a dense growth of underbrush, most of which is chokecherry, pin cherry, and hazel.

Owing to the comparatively high position of the ridges above the adjacent more level areas, they serve as desirable situations for building sites, and many farm buildings are located on them. In many places the gravel is excavated for use in construction of roads and buildings.

A comparatively large acreage of Sioux loamy sand is under cultivation. Of the small grains, winter rye is most extensively grown, followed by oats. Some corn is grown, and in favorable seasons it matures, although most of it is cut green, shocked, and used for feed. This soil is very droughty, and crops often suffer from lack of moisture during the short dry periods common in July and August.

Sioux loamy sand, smooth phase.—This soil is similar to the typical soil, except that the land is nearly level. In most places it adjoins the typical soil, or, in places where streams have broken through the ridges and washed the gravel away from the ridge, it is spread over comparatively smooth areas. In profile characteristics it is similar to the typical soil. Only a very small area is mapped, most of which is not under cultivation.

POORLY DRAINED SOILS

ARVESON SERIES

The poorly drained members of the third group of soils belong to the Arveson series. They include the soils developed under wet conditions and occupy marshes, sloughs, and depressions scattered through the areas occupied by the Ulen, Poppleton, and Grimstad

soils. Most of the areas of these soils remain in their native condition and support a cover of wild grasses, willow and other shrubs, and, in some places, trees accompanied by a rather dense growth of underbrush. In many places drainage has been so poor that a layer of peat, composed of partly decayed grasses and sedges and other water-tolerant plants, has formed. The peat ranges in thickness from 2 to 6 inches and in most places is poorly decomposed. The Arveson series is represented in this county by three soil types—Arveson loamy fine sand, Arveson very fine sandy loam, and Arveson silt loam.

Arveson loamy fine sand.—The surface soil of Arveson loamy fine sand consists of very dark gray loamy fine sand ranging from 4 to 20 inches in thickness, the upper part of which in many places is mucky or peaty. This is underlain by dull-gray rather compact sand of variable thickness, which merges into grayish-yellow or deep straw-yellow fine sand. The material in this layer is highly stained with rust-brown streaks and in many places contains white seams of calcareous material. This sand layer varies in thickness within short distances and in some places is less than 6 inches thick, in others more than 3 feet thick. Underlying the sand is fine-textured lacustrine silt, clay, or unmodified glacial till consisting of pebbly clay loam.

Arveson loamy fine sand also has marked variations in the color and thickness of the surface soil. In some places the peat layer, which originally covered the surface, has been burned by fires over large areas, thereby exposing the underlying mineral soil. In some of these places the dark-colored surface soil is very thin, less than 4 inches thick, and in places it is as much as 2 feet thick. In most places the surface soil is very dark gray or grayish brown, and in many places scattered white flecks of lime give it a somewhat white appearance. The lower part of the subsoil, to a depth of 30 inches, is commonly rust-brown fine sand, in places mottled with different shades of gray. In many places it contains strata of nearly pure marl. Below the sand is the heavy-textured material, which may be reached at a depth ranging from 30 inches to 5 feet.

In general, this soil is free of stones on the surface, although a few bodies are rather stony, mainly those adjacent to areas of the Kittson and Nereson soils.

The native vegetation consists of grasses, shrubs, and trees. Practically none of this soil is under cultivation, although some of it is used as wild-hay meadows or as pasture.

Arveson very fine sandy loam.—The surface soil of Arveson very fine sandy loam is very dark gray finely granular very fine sandy loam ranging from 6 to 14 inches in thickness. This is underlain by a 3- to 10-inch layer of dull-gray fine sandy loam, which grades into loose highly stained reddish-brown or yellow fine sand. This sandy layer includes material of various colors, in some places being uniformly gray and in others bright orange or lemon colored, and it contains rust-brown stains. Heavy lake-laid silt, clay, or pebbly clay loam underlies the sand at a depth ranging from 30 inches to 5 feet. In general, this soil is free of stones on and below the surface, although some gravel and small pebbles commonly occur within the topmost 2 feet.

This soil is not so extensive as Arveson loamy fine sand. Very little of it is under cultivation, but some is used for wild hay and pasture.

Arveson silt loam.—Arveson silt loam has a surface soil of dark-gray finely granular silt loam ranging from 4 to 9 inches in thickness. In most places a 3- to 6-inch layer of peat covers the surface, but in many uncleared areas this has been burned. Below the mineral surface soil the material consists of dark grayish-yellow or dark grayish-brown fine sandy loam of variable thickness but averaging about 8 inches. This, in turn, gradually merges into a layer of fine sand or very fine sand, which is mellow and in many places highly colored with yellow, orange, and rust-brown stains. This layer ranges from a few inches to several feet in thickness. It merges below into fine-textured lake-laid clay, silt, or glacial till, the latter being either clay loam or sandy clay. In most places both the surface soil and the subsoil are well supplied with lime, and the surface soil is acid in very few places. This soil occupies large and small areas in association with the other Arveson soils. Practically none of it is under cultivation, as the soil is too wet and very little of it has been adequately drained.

LIGHT-COLORED FINE-TEXTURED SOILS WITH HEAVY SUBSOILS

Light-colored soils that have fine-textured surface soils and heavy-textured subsoils make up the fourth group. They occur chiefly in the forested districts in the eastern part of the county. The better drained soils of the group have light-colored surface soils because they have developed under a cover of trees, which has prevented the growth of grass, and consequently only a small amount of dark-colored organic matter has accumulated in the surface soil. Leaching has been more active than in the soils developed under grass. Many of these soils are under cultivation, and they have been made more productive by growing legumes. In general, the upland soils of this group have better natural drainage than the soils occupying the prairie. They are gently undulating, and water seldom stands on the surface for any great length of time after heavy rains. A somewhat different type of agriculture is practiced on these soils, as practically no wheat is grown and flax is a minor crop. Oats, barley, and some winter rye, on the lighter soils, are the principal small grains grown. A large acreage is devoted to legumes—alfalfa and the common clovers, chiefly alsike clover. Some corn, particularly the earlier maturing varieties, is grown, but the growing season seldom is long enough to mature the grain. Corn is commonly cut green after the first light frost and used as forage for winter feeding.

The soils of this group have developed on heavy-textured material of lake-laid clay and silts and pebbly glacial till. The land is undulating and not so flat as in other sections of the county.

BETTER DRAINED SOILS

The better drained soils of this group are included in the Chilgren, Taylor, and Baudette series. The Chilgren soils are developed from heavy glacial till or on till mixed with lacustrine clay; the Taylor soils are developed on somewhat lighter textured glacial till; and the

Baudette soils are developed from lake-deposited silts and very fine sands.

TAYLOR SERIES

Taylor very fine sandy loam.—The surface soil of Taylor very fine sandy loam is light-gray mellow fine sandy loam from 3 to 6 inches thick. The upper part of this layer is slightly darkened by the incorporation of organic matter from the overlying leafmold, but the darkened part is not more than one-half inch thick. Overlying the surface soil is a 2-inch layer of forest litter and leafmold. Beneath the surface soil is a 4- to 10-inch layer of dark yellowish-brown granular silty clay loam, which, when dry, breaks into cube-like fragments with sharp edges and from one-eighth to one-fourth inch in diameter. Along many of the joint seams is a dark coating of organic matter, which gives the soil material a rather dark appearance; but the interior of the fragments, as is revealed when they are crushed, is light brown. Beneath this layer is gray calcareous silty clay loam, the parent material, which in many places has a yellow cast and contains small white concretions of lime that impart a speckled appearance to the material. The large quantity of finely divided lime makes the soil mellow, and it shows little if any compactness. Water percolates through it freely, affording good internal drainage. On many areas of this soil boulders are on the surface, and some are embedded in the soil. To a depth of 16 inches the soil in most places is acid in reaction, but the upper and lower parts of the subsoil are nearly everywhere full of carbonates.

Some variations occur in the upper part of the soil. Commonly, the ash-gray surface layer reaches a thickness of 8 or 10 inches, with a corresponding increase in thickness of the finer textured layer immediately below it. In some places the underlying soil material consists of fine-textured, compact, leatherlike, lacustrine clay, and in other places it is a mixture of lacustrine clay and glacial till, which, when dry, breaks into large angular chunks when disturbed.

This soil occupies rather well drained areas, many being adjacent to streams or drainageways. A considerable area occurs in the east-central part of the county.

On the virgin soil, the vegetation consists of mixed hardwoods, together with a few scattered white pine, balsam fir, and white spruce. Aspen, birch, ash, and balm-of-Gilead poplar are the dominant trees. Much of the merchantable timber has been removed by settlers living nearby, and the lumber produced has been an additional source of income to them.

BAUDETTE SERIES

The Baudette soils are developed on the same kind of material as are the Bearden and Malung soils, largely deposits of fine silty material or extremely fine sand laid down in the quiet waters of glacial Lake Agassiz.

Baudette very fine sandy loam.—The surface layer of Baudette very fine sandy loam is dark-gray mellow very fine sandy loam, from 3 to 6 inches thick. This is underlain by a 4- to 8-inch layer of light grayish-brown very fine sandy loam that is more compact than the material in the layer above. Below this layer is light grayish-yellow

or light-gray calcareous mellow silt loam, slightly laminated and in places showing soil lenses of slightly different texture. This layer reaches to a depth ranging from 3 to 5 feet, where a more variably textured material is reached, in many places consisting of pebbly clay loam or sandy clay. The upper soil layers, in general, are acid, but as depth increases, the soil becomes neutral and finally calcareous. There are no boulders on or below the surface. In some places this soil is similar to Malung very fine sandy loam, but, ordinarily the surface soil of Baudette very fine sandy loam is much lighter colored than the corresponding layer of that soil.

Areas of this soil range from nearly level to undulating, with a more pronounced slope near the streams and drainageways. Surface drainage is fair to good, and internal drainage generally is good.

The forest growth on this soil is similar to that on Taylor very fine sandy loam, that is, it consists mostly of mixed hardwoods with scattered white pine. Some small tracts are under cultivation, but most of the land is in a virgin state.

CHILGREN SERIES

Chilgren clay loam.—Chilgren clay loam is developed on glacial deposits of heavy material and is similar to Taylor very fine sandy loam, with the exception that its upper layers are composed of more compact, finer textured material. Chilgren clay loam also has somewhat poorer surface and internal drainage than the Taylor soil. It occurs in nearly level areas, where run-off is less than on that soil. This soil is slow to warm in the spring and is rather difficult to work with farm machinery. Stones on and below the surface are rather numerous, and these, together with the rather dense stand of trees, make it difficult to clear and prepare the land for crops.

Overlying the surface soil is a 1- or 2-inch layer of forest litter and leafmold. The surface soil is dark grayish-brown compact clay loam from 4 to 6 inches thick. Below this is gray more compact tight silty clay loam, from 8 to 12 inches thick. On drying, this material breaks into more or less cubical fragments about the size of walnuts. This, in turn, grades into dark-gray or dark olive-gray silty clay loam or silty clay containing small concretions of lime and limestone and granite pebbles. This layer is more mellow than the layer immediately above and is rather permeable to percolating water. In general, the surface layer is acid, but the material below it is either neutral or calcareous. Boulders on and below the surface are about as abundant as in Taylor very fine sandy loam.

The areas of Chilgren clay loam range from nearly level to gently undulating. As a whole, the land is somewhat imperfectly drained, especially where it occupies low positions. In its native state it is heavily wooded with hardwood trees and scattered white pine, balm-of-Gilead poplar, and aspen. Nearly everywhere the growth of underbrush is dense.

Very little of the land has been cleared for farming, because of its rather intractable character and the expense necessary to clear it of vegetation and stones. In some places where fires have repeatedly swept over it, the expense of reclamation has been greatly lessened.

POORLY DRAINED SOILS

SPOONER SERIES

The Spooner soils are developed on various kinds of fine-textured material and are the poorly drained associates of the Baudette soils.

Spooner very fine sandy loam.—The surface soil of Spooner very fine sandy loam, beneath a 2- to 4-inch layer of forest litter and leaf-mold, consists of gray rather compact very fine sandy loam or silt loam, mottled with light gray and rust brown, ranging from 4 to 9 inches in thickness. Below this is light-gray silt loam or silty clay loam, highly stained with yellow and rust brown. This layer has a large content of silt and has a smooth floury feel when rubbed between the fingers. The topmost 12 inches of this soil is either slightly acid or neutral, and below that it is strongly calcareous.

This soil occupies flat or slightly depressed areas. In many places a thin layer of peat covers the surface, but fires have burned over much of the land in the drier years. Much of the peat has been destroyed, thereby exposing the underlying mineral soil. Natural drainage is poor. The permeable character of the upper soil layers allows good movement of water through the soil, but the finer textured material of the substratum and a naturally high water table keeps the upper part waterlogged most of the time. This soil has practically no stones on or below the surface. It is associated with the better drained Baudette very fine sandy loam.

The forest growth on Spooner very fine sandy loam consists chiefly of hardwoods, such as aspen, balm-of-Gilead poplar, and ash, accompanied by a rather dense growth of underbrush. Owing to its permanently wet condition, practically none of this soil is under cultivation, but some areas are used as wild-hay meadows and pastures.

LIGHT-COLORED SANDY SOILS WITH HEAVY SUBSOILS

The fifth group includes soils with light-colored sandy surface soils and heavy-textured subsoils. They are developed under a forest cover, have light-gray or light grayish-brown surface soils, and are low in organic matter. They occur mostly in the eastern part of the county, where the native vegetation is largely mixed hardwoods and conifers. These soils are developed on sandy material, which overlies finer textured lacustrine clay, silt, or ice-laid till. Much of the materials on which the soils have developed have undergone some change since deposition, principally reworking and assorting by the waters of glacial Lake Agassiz. In some places the materials show considerable reworking and are definitely of lacustrine origin, whereas in other places the materials show little evidence of any change but are practically the same as when the ice deposited them. Soils of three series comprise this group—the McDougald, Gudrid, and Salol.

The McDougald soils have the best natural drainage and the Salol soils the poorest. The McDougald soils are developed on sandy material overlying ice-laid till, which has been but slightly modified, if at all, by wave action. The sand layer is not more than 30 inches thick. The McDougald soils are generally free of gravel in the

upper layers. The Gudrid soils are developed on a sandy layer underlain, at a depth of 30 inches or less, by lacustrine clay. The Salol soils are the imperfectly drained associates of the McDougald soils.

M'DOUGALD SERIES

McDougald loamy fine sand.—The surface layer of McDougald loamy fine sand is light grayish-brown or light yellowish-brown loamy fine sand, ranging from 6 to 12 inches in thickness, the upper part of which is somewhat darker, owing to the infiltration of organic matter from the overlying leafmold, which, together with the forest litter, is from 2 to 4 inches thick. The lower part of the surface layer is generally more yellow than the upper part and in many places is mottled with gray and dark yellow. Below this is a 4- to 6-inch layer of finer textured material, consisting of yellowish-brown sandy clay loam, mottled with gray and rust brown. This layer has a pronounced blocky structure, which stands out prominently when the undisturbed soil is allowed to dry. The blocky soil aggregates range from one-fourth to one-half inch in diameter and are angular to subangular. Below this layer is the unweathered ice-laid material of mellow light-gray calcareous till, either sandy clay or clay loam, containing some fine and coarse gravel together with pebbles and a few boulders. Boulders are scattered over the surface and embedded in the soil, but ordinarily they are not numerous enough to prevent the land from being farmed, except in a few places. Where the sand layer is thick, the number of boulders is smaller. The upper part of the soil, to a depth of 12 to 16 inches, is acid in many places, but below that depth it is rich in carbonates.

Most of McDougald loamy fine sand has fair to good surface drainage. Areas of this soil range from nearly level to gently undulating, and some are slightly rolling. The soil shows a wide range of characteristics. In some places the loamy fine sand reaches to a depth of 30 inches and resembles Hiwood loamy fine sand. Some difference occurs also in the texture of the surface soil, as it ranges from loamy sand to very fine sandy loam. Where the sand layer is comparatively shallow—from 10 to 16 inches thick—the surface soil tends to be finer textured. In places where the heavier textured layer is not reached within a depth of 30 inches, the sand layer shows but little difference in texture.

In a native condition, McDougald loamy fine sand supports mixed hardwoods and scattered white pine, balsam fir, and white spruce. In places where the sand layer is deep, jack pine and some red pine make up the larger proportion of the tree growth. Most of this soil, except where it is covered with jack pine, supports a dense stand of underbrush. A considerable part of McDougald loamy fine sand is under cultivation, as its general accessibility to good roads and towns has encouraged its development.

GUDRID SERIES

Gudrid fine sandy loam.—The surface soil of Gudrid fine sandy loam is light-gray or pale grayish-yellow fine sandy loam, ranging from 8 to 14 inches in thickness. The upper part is darkened with

stains of organic matter from the overlying leafmold. Below this is a 4- to 8-inch layer of grayish-yellow or gray loamy fine sand with rust-brown stains. This material, in turn, lies on laminated or platy yellowish-brown silt loam or silty clay loam, interbedded with layers of lake-laid clay, which reaches to considerable depth. Above a depth of 16 inches the soil is slightly acid or neutral, but below that depth it is very calcareous. This soil, in general, is free of boulders on and below the surface. The soil is similar to McDougald loamy fine sand, with the exception that it has a substratum of lacustrine clay, whereas McDougald loamy fine sand has a substratum of ice-laid till.

Gudrid fine sandy loam occurs mostly in Warroad Township and to a smaller extent in the adjoining townships. Areas of this soil range from nearly level to gently undulating. Some bodies occur in the well-drained uplands adjacent to some of the shallow stream valleys where the relief is more pronounced.

Most of this land is covered with mixed hardwoods, mainly aspen, balm-of-Gilead poplar, and birch, with small numbers of elm, oak, and balsam fir. The growth of underbrush is dense. A small part of the land is under cultivation, but most of it remains in a virgin condition.

A few small areas are included with Gudrid fine sandy loam in mapping, which differ from it chiefly in having a 2- to 4-inch coarse-textured layer of gravel and coarse sand at a depth ranging from 6 to 14 inches. In most places this layer sharply separates the layers above and below it, but in some places considerable fine material mixed with the coarser material obscures the line of demarcation. Below the gravel layer is gray ice-laid till, which is similar to the lower part of the subsoil underlying McDougald loamy fine sand. Boulders are present on and below the surface. Like the typical soil, this inclusion is not generally cultivated. A mixed hardwood forest and a rather thick stand of underbrush cover the land.

SALOL SERIES

Salol loamy fine sand.—Salol loamy fine sand has a 2- or 3-inch surface covering of forest litter and leafmold over a layer of gray or light grayish-yellow loose fine sand, about 10 inches thick. The upper part is somewhat darker, owing to the admixture of some organic mater from the leafmold. Below this layer is a layer of yellowish-gray rather compact fine sand or very fine sand mottled with rust brown and orange, through which are distributed thin lenses and layers or pockets of finer textured material consisting of silt or a mixture of silt and clay. This layer ranges from 6 to 20 inches in thickness. At a depth of 30 inches or less, the material is silty clay loam or clay loam, containing pebbles of limestone and granite. The upper part of the soil, where it has developed from sandy material, is acid, but the finer textured material underlying it generally is strongly calcareous. This soil is stony both on the surface and throughout the soil mass, and much of it is too stony to be cleared and plowed.

This soil is closely associated with McDougald loamy fine sand. It has developed on the same kind of material as that soil, but differs chiefly in its poorer drainage. The surface is nearly level or slightly

depressed. The land is somewhat poorly drained internally and occasionally is waterlogged for a long time.

The forest that covers this soil varies with drainage conditions. On some of the drier areas the growth is principally jack pine, but in the wetter places alder, aspen, and willow thrive. Most of the land supports a dense stand of underbrush. Practically none of it is under cultivation, although some is used for pasture.

LIGHT-COLORED SANDY SOILS WITH SANDY SUBSOILS

The sixth group includes light droughty sandy soils developed under a cover of mixed hardwoods and conifers, largely in the eastern part of the county. They have light-colored surface soils and are comparatively low in organic matter and nitrogen. Exception is made, however, of the poorly drained member of this group. In this soil a dark-colored surface soil has resulted from a more luxuriant growth of water-tolerant plants, whose roots, on decaying, have contributed considerable organic material and a darker color to the surface layer. The better drained soils of the group belong to the Hiwood, Faunce, and Mahnomen series and the poorly drained soils to the Potamo series. The soils of this group have developed on thick deposits of sand alone or mixed sand and gravel. The Hiwood soils are developed on well-assorted sands, the Faunce soils on poorly assorted sands, the Mahnomen soils on mixed sand and gravel of the ridges, and the Potamo soils on various grades of sand in poorly drained situations.

BETTER DRAINED SOILS

HIWOOD SERIES

Hiwood loamy fine sand.—Overlying the surface soil of Hiwood loamy fine sand is a 1-inch layer of pine needles and leaf litter. The surface layer of mineral soil is light-gray or nearly white loose loamy fine sand from 2 to 4 inches thick. The upper part of this layer is stained dark with organic matter derived from the overlying organic material. Below this is a 4- to 8-inch layer of brown or yellowish-brown loose loamy fine sand with a slight red cast. This grades into light yellowish-brown slightly coherent fine sand, which continues to a depth of 4 or more feet. Much of the material comprising all the soil layers consists of rounded and subangular translucent quartz grains and a few minerals, probably of the ferromagnesian group. Underlying the sand, at a depth ranging from 5 to 15 feet, the finer textured glacial till of calcareous origin is reached. To a depth of 24 inches the soil is acid, but the lower part of the subsoil is, in general, neutral. As depth increases, the material becomes calcareous. Hiwood loamy fine sand has formed on assorted fine sand considerably modified during the time of deposition by water and probably later by wind.

The principal variation in Hiwood loamy fine sand is in the thickness of the underlying sand layer. It is nowhere less than 30 inches thick; commonly it is at least 6 feet and in some places it is more than 15 feet thick. The ash-gray layer near the surface is not everywhere present, and, in places where it is lacking, the color of the surface soil is grayish yellow or light grayish brown. In the more level

areas the entire soil mass has a mottled appearance, with different shades of red and brown on a base color of gray.

This soil occurs in association with McDougald loamy fine sand throughout the eastern part of the county and aggregates a large total area. It occurs in well-drained areas adjacent to streams and on higher situations away from them, either on ridges or islands in peat bogs. The land ranges from nearly level to undulating. Natural surface drainage in most areas is thorough, and internal drainage is excessive, owing to the porous character of the soil. During dry periods crops are severely affected by drought, the more damaging effects being in the areas of deeper sand that lie in the highest places.

The chief tree growth is jack pine, with scattered red pine and a few white pine. On the areas of shallower sand the native vegetation is mixed hardwoods and jack pine, with a rather dense growth of underbrush.

A considerable area of Hiwood loamy fine sand has been cleared and is under cultivation. Many of the fields are small and well protected on all sides by groves of trees or thickets of brush, which prevent the loose fine sand from drifting. This soil contains practically no stones.

Hiwood loamy fine sand, imperfectly drained phase.—This imperfectly drained soil has a surface soil and subsoil essentially the same as the typical soil, except that the surface soil of the phase has a higher content of organic matter, which masks the characteristic light-gray color so pronounced in the typical soil. The subsoil is more highly stained with rust-brown and gray mottlings than that of the typical soil.

A mixed vegetation of hardwoods and brush is the native ground cover. The soil occurs in nearly level areas or slight depressions, ranging in size from 1 to 80 acres. Practically none of the land is under cultivation.

Hiwood loamy fine sand, gravelly phase.—This soil is similar to typical Hiwood loamy fine sand, except that somewhere in the upper 30 inches of it is a gravelly layer, from 2 to 4 inches thick. In general, this layer consists of mixed sand and gravel with very little silt and clay in it. This soil is associated with typical Hiwood loamy fine sand and to some extent with Faunce sand and Mahnomen loamy sand. The relief ranges from undulating to gently rolling. Practically none of the land is under cultivation, except within fields occupied by typical Hiwood loamy fine sand.

FAUNCE SERIES

Faunce sand.—Faunce sand has a ½- to 1½-inch surface covering of forest litter and leafmold. Below this is a 4- to 6-inch layer of grayish-brown loose medium or coarse sand, the topmost one-half inch of which is dark grayish brown, owing to the incorporation of some organic matter in the mineral soil from the overlying leafmold. Beneath the surface layer, the soil material is grayish-yellow or light grayish-yellow loose coarse or medium sand. As depth increases the sand becomes brown in color and is mottled with gray and rust-brown stains. The sands comprising this soil are not so well assorted

as they are in Hiwood loamy fine sand, but the material consists largely of medium sand with some fine sand, very fine sand, coarse sand, and fine gravel, and, in places, small pebbles. Most of the sand grains are quartz, but a great number consist of feldspars and ferromagnesian minerals. Most of the sand grains are rounded or subangular.

Faunce sand differs from Hiwood loamy fine sand in that the light-gray layer is less prominent in Faunce sand and the soil materials consist of coarser, less well assorted sands and may even be gravelly in some places. The sands underlying Faunce sand have a larger or more evident proportion of silicate minerals than those underlying the Hiwood soils.

This soil is, in general, medium acid to a depth of 3 feet, and below that depth it is either neutral or mildly alkaline. In general, no boulders are on the surface or in the soil. Large areas of this soil occupy well-drained sandy plains and ridges in the eastern part of the county. Run-off is very scant as the porous character of the soil allows the rain to be absorbed rapidly. The relief ranges from undulating to very gently rolling.

The forest growth on Faunce sand is chiefly coniferous trees, jack pine being dominant. In some places where moisture is more plentiful, aspen and birch are scattered among the pines. Very little of this land is under cultivation.

Faunce sand, imperfectly drained phase.—This imperfectly drained soil occupies nearly level tracts or slight depressions and is closely associated with typical Faunce sand. Its profile characteristics are similar to those of the typical soil, with the exception that the subsoil is more mottled with gray and has many rust-brown stains. The native vegetation consists of mixed jack pines and aspen, with a rather thick growth of underbrush. A few stones occur on and below the surface. Very little of the land is under cultivation.

Faunce sand, stony phase.—Faunce sand, stony phase, is similar in both the surface soil and the subsoil to the typical soil, with the exception that boulders occur on and below the surface. It occupies small bodies, ranging in size from less than 5 to more than 160 acres, in the same districts as areas of both Hiwood loamy fine sand and Faunce sand. In relief it is similar to the typical soil. Practically none of the land is under cultivation.

Faunce gravelly sand.—Faunce gravelly sand is an inextensive soil closely associated with Faunce sand. It has in general the same profile characteristics as that soil, except that the various soil layers contain considerable coarse gravel mixed with the finer grades of sand. Some boulders occur on and below the surface. In some places many cobblestones are scattered on the surface, but these occur mostly in the surface soil. Practically none of this soil is under cultivation. It occupies well-drained uplands and slight ridges. The native vegetation is similar to that on Faunce sand.

MAHNOMEN SERIES

Mahnomen loamy sand.—The surface soil of Mahnomen loamy sand is covered with a ½- to 1-inch layer of forest litter consisting of pine needles and leaves from hardwood trees. Beneath this is

an 8-inch layer of light grayish-yellow loose loamy sand. This grades into a 3- to 6-inch layer of reddish-brown rather compact gravelly loamy sand. This material is coherent when moist and hard and somewhat indurated when dry, owing to its clay content. Beneath this is loose coarse sand and gravel. Many of the pebbles and a large part of the particles of gravel and sand grains are limestone, and many of the granite and other pebbles are lime-coated, which gives a white or light-gray color to the soil mass. Much of the material below the reddish-brown layer is stratified gravel, in many places interbedded with layers of fine sand, coarse sand, and medium sand, or a mixture of these. In some places the soil to a depth of 3 feet consists of more or less assorted sand with very little gravel and pebbles present, whereas in other places coarse gravel constitutes the entire soil mass from the surface downward.

Mahnomen loamy sand occupies the ridges that represent the old shore lines of glacial Lake Agassiz and rise from 5 to 20 feet above the adjacent more level land. In general, this soil is practically free of boulders. This soil occurs in the south-central and eastern parts of the county. The principal native forest growth is jack pine, with some aspen and birch, and the land supports a rather dense growth of underbrush in places where the stand of jack pine is not too dense.

The upper 8 inches of this soil is moderately acid, but below that depth it becomes neutral and, finally, strongly calcareous. Some of the land is under cultivation, although in general the crops grown on it are disappointing, owing to its droughtiness. There is practically no run-off as all the water is readily absorbed by the loose sand and gravel. The soil is naturally low in organic matter and nitrogen, and these deficiencies limit its adaptability to crops. Winter rye, with some oats and corn, are the principal crops.

Mahnomen loamy sand, smooth phase.—The smooth phase of Mahnomen loamy sand is similar in all respects to the typical soil, except for its smooth surface. This soil occupies the flatter and the slightly sloping lands away from the crests of the ridges covered by typical Mahnomen loamy sand. On these smoother areas the profile characteristics are not so well developed as in the typical soil. In many places the reddish-brown subsurface layer is absent and the soil material contains less coarse gravel and small pebbles; in such places the soil resembles Faunce sand. This is not an important agricultural soil, as the areas are isolated and small.

POORLY DRAINED SOILS

POTAMO SERIES

Many areas of the Potamo soil are so wet that a layer of peat of variable thickness covers the surface. In many places the peat layer has been burned by forest fires during dry seasons, thereby exposing the underlying mineral soil. The soil is light-textured, both in the surface soil and in the subsoil, and a few boulders occur on and below the surface.

Potamo loamy sand.—Overlying the surface soil of virgin areas of Potamo loamy sand is a layer of leaf litter and leafmold and in the wetter places a layer of peat ranging from 1 to 6 inches in thick-

ness. Beneath this is a 6- to 12-inch layer of light grayish-yellow loose sand, which grades into loose grayish-brown loamy sand. With increasing depth the color of this material changes from a mixture of brown, orange, and yellow to grayish blue. In many places the soil is highly stained with rust brown. With depth the soil in places becomes somewhat coarser in texture, and in some places gravel and small pebbles are present. The sand continues to a depth ranging from 30 inches to more than 5 feet. In some places thin clayey sand layers or pockets are numerous. The surface soil and upper part of the subsoil are pervious, but because of a high water table the subsoil is usually moist or waterlogged below a depth of 30 inches. To a depth ranging from 3 to 4 feet the soil is moderately acid, and below this depth the material is neutral or slightly alkaline. In general, this soil is free of boulders, although in some small areas they occur on and below the surface.

Small areas of this soil occur within areas of Hiwood, Faunce, or Mahnomen soils in the eastern part of the county. The soil occupies nearly level areas, depressions, or, in many places, the flat land bordering peat bogs. The native forest on this soil varies with drainage conditions. In the drier places, aspen and jack pine grow, but in more or less permanently wet places, willows, alders, and other water-tolerant plants are dominant. Practically none of this soil is under cultivation, but some is used for pasture.

ORGANIC AND ALLUVIAL SOILS

The soils of the seventh group include the peat soils, both shallow and deep, and the mixed alluvial soils that occupy the bottom lands along the streams and drainageways and are subject to periodic flooding. In addition to the areas of peat, the group includes peat that has been partly burned, leaving the land marked by small and large hummocks of unburned peat. The texture of the underlying mineral soil, whether sand or clay, was determined, and this important feature is shown on the soil map.

Peat.—A large part of Roseau County is covered with peat, some occurring in every township. In the central and eastern parts of the county nearly every section of land has some peat on it. The peat ranges in thickness from less than 6 inches to more than 8 feet. In many places, particularly in the great marsh in the northwestern part, which covers most of several townships, the average depth of the peat is about 3 feet; and in the eastern and southern parts its thickness averages about 4 feet. In making the soil map the peat deposits less than 36 inches thick are mapped as peat, shallow phase. In many places the peat layer has been entirely burned, thereby exposing the underlying mineral soil, commonly with many boulders scattered over the surface (pl. 3, *A*). The soils of these burned-over areas are included with the mineral soils that have similar characteristics. In some places where only a part of the peat has been burned, large and small hummocks of partly burned peat remain, making the land unfit for any use (pl. 3, *B*). Since the soil map was made, many other areas of peat have been burned over, the peat being completely or partly destroyed.

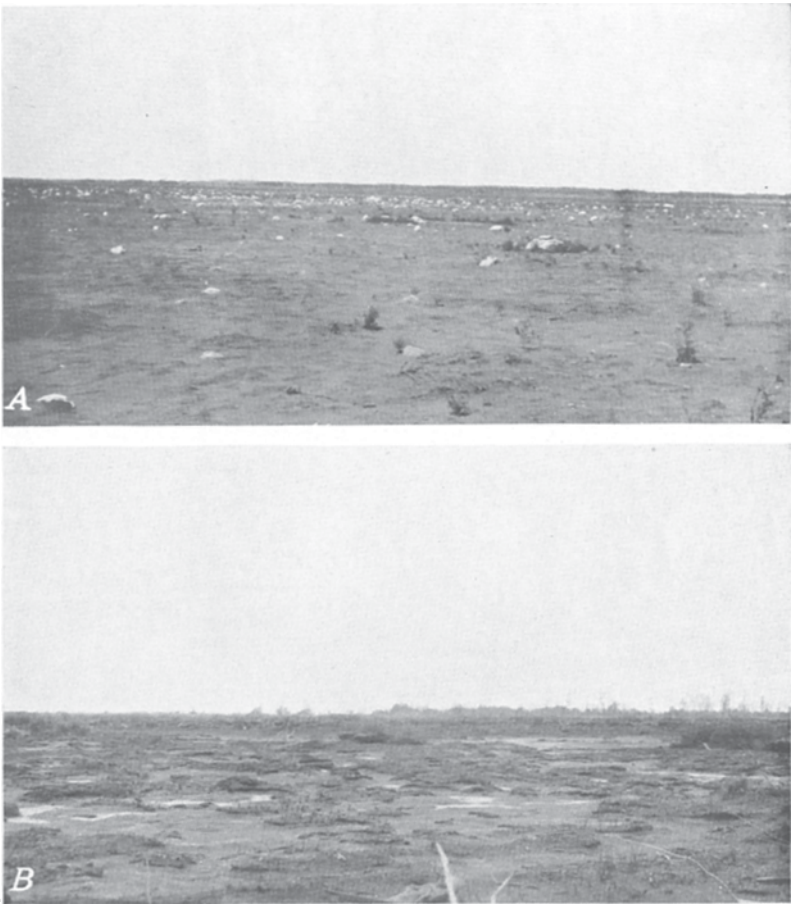
Peat was formed in places that were wet practically the year round, and it consists almost entirely of the more or less decomposed remains of plants. It ranges from brown coarse fibrous material to finely divided material, depending to some extent for its characteristics on the species of plants from which it was formed and on the degree of disintegration and decomposition that has taken place. In the great northwestern marsh the peat has been formed largely from sedges and grasses and at present supports little or no tree growth but is covered with native grasses. In the great northeastern swamp and in some smaller areas much of the peat is a mixture of woody fragments together with material from sphagnum moss. These areas at present are largely covered with black spruce, tamarack, and some white cedar.

Compared with mineral soils, peat soils suffer from serious handicaps. Most peat soils are naturally poorly drained, and in some areas it is difficult to provide satisfactory drainage. Many bogs, even after the installation of drainage sufficient for ordinary seasons, are susceptible to occasional flooding after abnormally heavy rains, and crops are drowned out when water stands on or above the surface of the soil for even a short time. A serious handicap in the use of peat soils for sensitive crops, like potatoes and corn, lies in their susceptibility to late and early frosts, which may occur at any time, even in the summer. Grasses and clovers are practically immune to injury from such frosts and are the safest crops on peat soils. Plate 4, *A*, shows a field of barley on peat land from which some of the peat has been burned.

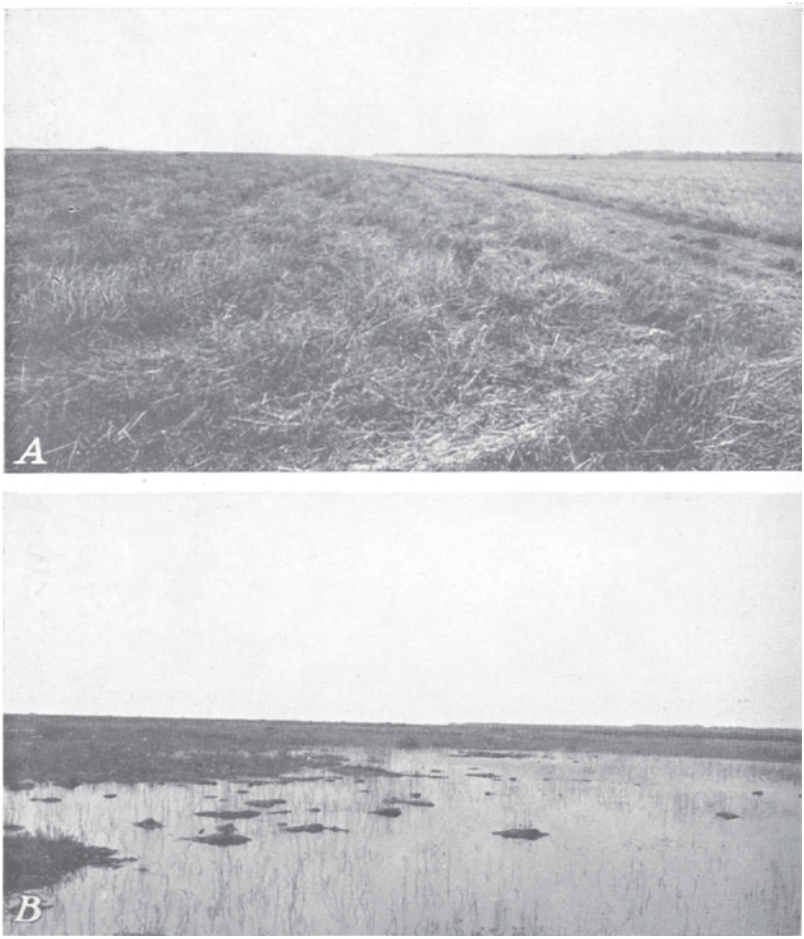
With but few exceptions, peat soils require annual applications of commercial fertilizer, either phosphate alone, potash alone, or, more commonly, both phosphate and potash. Stable manure may be used to supply part of the phosphate and potash, but seldom is it available in sufficient quantity, and further, it can be used more profitably on mineral soils.

Peat, shallow phase, over sand.—Peat that is less than 3 feet thick and overlies sand is mapped as peat, shallow phase, over sand. A comparatively large area of this kind of peat has been mapped. It occurs as large and small bogs and as bodies surrounded by areas of deep peat.

In its general characteristics the shallow peat itself is similar to the deeper peat. In some places the thickness of the original peat deposit has been reduced by fires, and in other places by shrinkage resulting from drainage with the subsequent drying out of the peat deposit. Generally, the lower part of the peat and the underlying sandy mineral soil are moist except in seasons of low rainfall, when the entire mass may be dry. Where the peat ranges from 6 to 10 inches in thickness, some of the underlying mineral soil is turned up in plowing, and the resulting peaty soil may not need special treatment and selected crops so much as areas where none of the underlying soil is brought to the surface. It is a common practice in this county where the peat is shallow to burn off the whole peat layer—an easy task in dry years. This allows a wider crop adaptation, and the land can be farmed in the same way as the mineral soils. Extensive areas that once were covered with a shallow layer



A, Boulders exposed after layer of peat has been burned; *B*, partly burned peat with hummocks of unburned peat.



A, Heavy growth of barley on burned peat land, showing lodging of the grain; *B*, shallow ponds resulting from peat fires.

of peat are now farmed like the surrounding mineral soils, and it is impossible to distinguish between them.

Peat, shallow phase, over clay.—Peat that is less than 3 feet thick and overlies clay is mapped as peat, shallow phase, over clay. Like the shallow peat over sand, it is widely distributed and occupies areas where the surrounding mineral soil is fine textured. This kind of peat is more extensive than that underlain by sand, and more of it has been reclaimed because of the more favorable moisture conditions for plant growth. Where clay underlies the peat, the peat does not dry out so easily and therefore is a better soil for crops. Where the entire peat layer has been burned, as in reclamation projects, exposing the underlying heavier textured soil, good yields are generally obtained and the soil eventually becomes nearly as productive as the surrounding better drained land, provided drainage conditions are satisfactory. Where the peat layer is 2 feet or more thick and all is burned, the lowered surface may so impair drainage conditions that the land will be unsuitable for crops. In seasons of more than normal precipitation such land is often too wet to plow early enough in the spring to prepare and seed the land. As a result, many uncropped areas become covered with noxious weeds, which spread to the surrounding cropped land. As the vegetation dies in the fall the accumulation of combustible material often creates a serious fire hazard.

Burned peat over sand.—Many areas in the county that were originally covered with peat have been subjected to fires in the last few years, with the result that the peat layer has been burned, either entirely, leaving only the ash, or partly, leaving hummocks or patches of partly burned peat with the ash from the burned peat among them. These areas are shown on the soil map separately from the areas of other peat. Where the underlying or exposed mineral material is sand, the areas are designated as burned peat over sand. These areas in their present condition are unfit for cultivation because of the pitted condition of the land. Burning the peat in many areas has so lowered the surface that many of these areas, after heavy rains, become ponds and small lakes with the hummocks of unburned peat occurring as islands. Weeds have gained a foothold in the drier tracts and annually reinfest the surrounding farms. Plate 4, *B*, shows a pond created by incomplete burning of peat.

Areas of burned peat occur in all parts of the county, but most of them are in the south-central and eastern parts, where many of the bogs were covered with trees, and the fires have burned the peat away from the roots, killing and overthrowing the trees and creating a fire hazard. Most of the burned peat over sand is associated with sandy mineral soils.

Burned peat over clay.—Burned peat over clay is similar to burned peat over sand, differing in the heavier, more clayey character of the underlying or exposed mineral substratum. If this land is put into agricultural use, the areas with the clay substratum will be similar in use and value to such soils as the Wildwood and Chilgren.

Alluvial soils, undifferentiated.—Alluvial soils, undifferentiated, include the narrow strips of first-bottom land along the streams and some of the drainageways. The soils are extremely variable and mixed. Some consist of a thick or shallow deposit of peat, others of a thin deposit of muck. In places considerable sand is mixed with the peat or muck, forming a soil high in organic matter. In still other places, mineral soils constitute the bulk of the deposits, and in texture they range from heavy clay to loamy sand. In many places the material to a depth of several feet is interbedded with materials of different textures. Practically all of the material was carried onto the flood plain by streams and deposited during times of high water.

Nearly every stream in the county has some of this soil on both sides of its main channel, the strips ranging in width from a few hundred feet to more than one-half mile. Much of this bottom land in the central and eastern parts of the county is badly dissected by old stream channels, depressions filled with water part of the time, and small stony areas where ice has pushed the stones from the stream bed. All are poorly drained except in very dry years, when small patches of dry soil may be found. Many areas of alluvial soils are covered with trees, some attaining great height, and in many places there is a dense growth of willow and alder among them. Along the Roseau River in the northern part of the county this soil is mostly grass-covered and consists of both peat and fine-textured mineral soil. Practically none of this land is used for crops, but in many places it affords good grazing.

PRODUCTIVITY RATINGS

In table 9 the soils of Roseau County are rated according to their capacities to produce the more important crops of the region and are listed in the approximate order of their general productivity under current farming practices.

TABLE 9.—*Productivity ratings of the soils of Roseau County, Minn.*

Soil [1]	Crop productivity index [2] for—												General productivity grade [3]
	Corn (grain)	Corn (silage and fodder)	Wheat	Oats	Barley	Rye	Flax	Clover and timothy hay	Alfalfa	Sweet-clover	Potatoes	Pasture	
Bearden loam [4]	30	70	100	100	100	.....	100	100	100	100	100	80	1
Bearden clay loam	30	70	100	100	100	.....	100	100	80	100	90	90	
Malung clay loam	30	70	100	100	100	.....	100	100	80	100	90	90	
Malung loam [4]	30	70	90	100	100	.....	100	90	80	100	100	80	
Fargo clay loam	20	50	100	100	100	.....	100	100	80	100	70	80	
Fargo clay	20	50	100	100	100	.....	100	100	80	100	70	80	
Kittson silt loam	20	50	80	90	90	.....	90	90	70	100	70	90	2
Kittson clay loam	20	50	80	90	90	.....	90	90	70	100	70	90	
Bearden loam, imperfectly drained phase [5]	20	60	90	90	90	.....	90	90	50	70	70	80	
Nereson silt loam	20	50	80	80	80	.....	80	90	70	90	70	80	
Nereson clay loam	20	50	80	80	80	.....	80	90	70	90	70	80	
Bearden fine sandy loam	30	70	80	80	80	.....	80	80	90	80	90	70	
Malung fine sandy loam	30	70	70	80	70	.....	70	80	90	80	80	70	3
Malung loam, imperfectly drained phase [5]	20	60	80	80	80	.....	80	90	50	70	70	90	
Kittson clay loam, imperfectly drained phase [5]	10	40	70	80	80	.....	80	80	50	80	60	90	
Kittson gravelly silt loam	20	40	70	80	80	.....	80	80	60	80	60	80	
Kittson gravelly clay loam	20	40	70	80	80	.....	80	80	60	80	60	80	
Nereson gravelly clay loam	20	40	70	80	80	.....	80	80	60	80	60	80	
Nereson sandy loam	20	50	60	70	70	.....	70	80	70	80	70	70	
Nereson clay loam, imperfectly drained phase [5]	10	40	60	70	70	.....	70	80	50	80	60	80	
Baudette very fine sandy loam	20	40	50	70	70	.....	60	80	80	70	80	80	
Taylor very fine sandy loam	10	40	50	70	70	.....	60	80	80	70	80	80	
Grimstad loam	30	60	70	70	70	70	70	70	70	80	80	70	
Grimstad loam, gravelly phase	30	60	70	70	70	60	70	70	50	70	80	70	4
Kittson sandy loam	20	50	60	70	70	.....	70	70	70	80	80	70	
Nereson sandy loam, imperfectly drained phase [5]	30	50	60	70	70	.....	70	80	40	70	60	70	
Ulen very fine sandy loam	40	50	60	70	70	60	70	60	80	80	80	70	
Kittson sandy loam, imperfectly drained phase [5]	10	40	60	70	70	.....	70	70	40	70	80	80	
Grimstad loam, imperfectly drained phase [5]	20	50	60	60	60	50	60	60	30	80	80	70	
Grimstad loamy fine sand, gravelly phase	30	60	60	60	60	50	60	50	50	70	80	60	
Chilgren clay loam	20	40	50	60	60	.....	50	70	50	60	70	70	
Enstrom silt loam	30	60	50	50	50	70	50	60	80	80	80	70	
Enstrom very fine sandy loam	30	60	50	50	50	70	50	60	80	80	80	60	
Grimstad loamy fine sand	30	60	50	50	50	60	50	50	80	80	80	60	

See footnotes at end of table.

TABLE 9.—*Productivity ratings of the soils of Roseau County, Minn.*—Continued

Soil	Crop productivity index for—												General productivity grade
	Corn (grain)	Corn (silage and fodder)	Wheat	Oats	Barley	Rye	Flax	Clover and timothy hay	Alfalfa	Sweet-clover	Potatoes	Pasture	
Nereson gravelly sandy loam	20	40	50	60	60	------	60	60	50	60	50	60	5
Kittson gravelly sandy loam	20	40	50	60	60	------	60	60	40	60	60	60	
Ulen very fine sandy loam, gravelly phase	30	40	50	60	60	50	50	50	50	50	60	50	
Pelan clay loam	20	40	50	60	60	------	50	40	30	50	50	50	
Gudrid fine sandy loam	20	30	40	60	60	------	50	60	70	60	70	70	
Foxhome loam	20	40	40	60	60	------	50	40	30	50	50	50	
Foxhome clay loam	20	40	40	60	60	------	50	40	30	50	50	50	
McDougald loamy fine sand	20	40	40	50	50	50	40	60	70	60	60	70	
Enstrom very fine sandy loam, imperfectly drained phase [5]	20	50	40	40	40	60	40	60	50	80	80	70	
Enstrom loamy fine sand	30	50	40	40	40	60	40	50	70	70	80	50	
Foxhome loam, imperfectly drained phase [5]	10	30	50	50	50	------	40	30	20	30	50	60	6
Pelan loam, imperfectly drained phase [5]	20	30	40	50	50	------	50	50	20	30	50	70	
Pelan loam	20	30	40	50	50	------	40	40	30	40	50	50	
Foxhome sandy loam	20	40	40	50	50	------	40	30	20	40	50	40	
Ulen very fine sandy loam, imperfectly drained phase [5]	30	40	30	40	40	50	40	50	30	60	70	70	
Ulen loamy fine sand	30	50	30	40	40	50	40	30	60	70	70	60	
Ulen loamy fine sand, undulating phase	30	50	30	40	40	50	40	30	60	70	70	60	
Ulen loamy fine sand, gravelly phase	20	40	40	40	40	40	40	40	30	50	60	50	
Enstrom loamy fine sand, gravelly phase	20	50	40	40	40	50	40	30	50	70	70	50	
Pelan sandy loam	20	30	40	40	40	------	40	30	20	40	50	40	
Poppleton silt loam	30	40	20	30	30	50	30	40	70	70	50	40	
Wildwood silty clay [5]	------	20	30	40	40	------	40	90	30	40	------	80	
Burned peat over clay [5 6]	------	20	30	40	40	------	------	90	------	40	------	80	
Poppleton very fine sandy loam	30	40	20	30	30	40	30	30	70	70	50	30	7
Poppleton very fine sandy loam, gravelly phase	30	30	20	30	30	40	30	30	40	50	50	50	
Poppleton loamy fine sand	20	40	20	30	30	30	30	20	60	50	50	30	
Poppleton loamy fine sand, undulating phase	20	40	20	30	30	30	30	20	60	50	50	30	
Poppleton very fine sandy loam, imperfectly drained phase [6]	30	30	20	30	30	40	30	30	40	40	40	40	
Peat, shallow phase, over clay [5 6]	------	------	------	40	40	------	------	60	------	40	40	60	

See footnotes at end of table.

Spooner very fine sandy loam		10	10	40	30		20	50				50	
Salol loamy fine sand		10	10	30	30		10	30				50	
Hiwood loamy fine sand	10	20	10	30	30	20	10	20	40	40	40	20	
Faunce sand	10	20	20	30	30	20	10	20	30	30	40	10	
Faunce sand, stony phase	10	20	20	30	30	20	10	20	30	30	40	10	
Faunce sand, imperfectly drained phase [5]	10	20	20	30	30	20	10	20	20	20	40	20	
Hiwood loamy fine sand, imperfectly drained phase [5]	10	20	10	30	30	20	10	20	10	10	30	40	
Poppleton loamy fine sand, gravelly phase	20	30	20	20	20	20	20	30	30	30	50	30	
Sioux loamy sand, smooth phase	30	40	20	20	20	20	10	10	20	40	40	10	8
Sioux loamy sand	30	40	20	20	20	20	10	10	20	40	40	10	
Maple clay loam [5]												70	
Fargo clay, poorly drained phase [5]												70	
Peat, shallow phase, over sand [5 6]				20	20			40		30	30	50	
Burned peat over sand [5]												10	
Barnett sandy loam												70	
Barnett silt loam												70	
Barnett clay loam												70	
Hiwood loamy fine sand, gravelly phase	10	20	10	30	30	20	10	20	10	10	30	20	
Mahnomen loamy sand, smooth phase	10	30	20	20	20	20	10	10	20	20	40	10	
Mahnomen loamy sand	10	30	20	20	20	20	10	10	20	20	40	10	
Faunce gravelly sand	10	20	20	20	20	20	10	20	10	10	30	10	
Arveson silt loam		10						10				60	
Arveson very fine sandy loam		10						10				60	9
Arveson loamy fine sand		10						10				40	
Potamo loamy sand								30				30	
Tanberg loam	10	20	10	10	10		10	10		10		20	
Tanberg silt loam	10	20	10	10	10		10	10		10		20	
Tanberg clay loam	10	20	10		10		10	10		10		20	
Tanberg loamy fine sand	10	10	10	10	10		10	10		10		20	
Peat (deep)													10
Alluvial soils (undifferentiated)													

[1] The soils are listed in the approximate order of their general productivity under the average current practices, the most productive first.

[2] The soils are given indexes that indicate the approximate average production of each crop in percentage of the standard of reference.

[3] This classification indicates the comparative general productivity of the soils under dominant current practices. See text, p. 70, for further explanation.

[4] These soil types as mapped include small areas of sandier soils that are less productive.

[5] The imperfectly and poorly drained soils have been given ratings that represent production under the more favorable conditions, such as in comparatively dry years or where artificial drainage has been provided. Yields under less favorable circumstances are lower, and the range of crops is limited often to pasture and to clover and timothy or sweet-clover for hay.

[6] Yields of crops on these areas of peat are extremely variable, and crops fail completly in some years. Ratings are included only for the information they suggest as to relative productivity for the average of the better years.

The rating compares the productivity of each soil for each crop to a standard of 100. This standard index represents the approximate average acre yield obtained without the use of amendments on the better and more extensive soils in the region where the crop is principally grown. A crop-productivity index of 50, for example, indicates that the soil is about half as productive for the specified crop as are soils with the standard index. Soils given amendments such as lime and fertilizers or small areas of unusually productive soils may have ratings of more than 100 for some crops.

The following tabulation sets forth some of the acre yields that have been set up as standards of 100. They represent long-time average yields of crops of satisfactory quality on the better soils without the use of amendments.

Crop:		
Corn (grain)	bushels	50
Wheat	do	25
Oats	do	50
Barley	do	40
Rye	do	25
Flax	do	15
Potatoes	do	200
Clover and timothy hay	tons	2
Alfalfa hay	do	4
Sweetclover hay	do	2
Corn silage	do	12
Pasture	cow-acre-days[1]	100

[1] Cow-acre-days is a term used to express the carrying capacity of pasture land. As used here it is the product of the number of animal units carried per acre multiplied by the number of days the animals are grazed without injury to the pasture. For example, the soil type able to support 1 animal unit per acre for 360 days of the year rates 360, whereas another soil able to support 1 animal unit on 2 acres for 180 days of the year rates 90. Again, if 4 acres of pasture support 1 animal unit for 100 days the rating is 25.

The principal factors determining the productivity of the land are climate, soil, slope, drainage, and management. All these factors must be taken into account and an attempt made to evaluate their combined influence on crop yields in setting up productivity ratings for particular soil types. Crop yields themselves over a long period offer the best summation of the combined effects of these factors, and reported yields are used as guides in establishing ratings wherever they are available. Because of a lack of sufficient definite information regarding yields from specific soil types, however, the ratings are based partly on inductive estimates as well as on reported crop yields. In spite of the unavoidable limitations of crop-productivity indexes, it is thought that the ratings provide a reasonably accurate picture of the relative productivities of the different soils of the county.

Imperfectly drained soils are used largely for pasture and hay—principally clover and timothy, and sweetclover. Some other crops, however, are grown under the more favorable conditions, such as in the drier years or where artificial drainage has been provided. The crop indexes given in the table for these crops are for the more favorable conditions.

The soils are listed in the order of their general productivity under dominant current practices in the column headed "General productivity grade." The general productivity grade is based on a weighted average of the indexes for the various crops, using the approximate proportional acreage and value of the crop grown on each group of soils as a basis. If the weighted average falls between 90 and 100,

the soil type is assigned a grade of 1; if it falls between 80 and 90, it is assigned a grade of 2, and so on. Since it is difficult to measure mathematically either the exact significance of a crop to local agriculture or the importance and suitability of certain crops for individual soil types, the weightings set up were used only as guides in assigning soils to productivity grade classes. Certain deviations from the classes indicated by the weighted average have been permitted in the general rating of the soils.[7]

[7] The weights in percentage given each crop index to arrive at the general productivity grade, and the soil series in the different groups, are as follows:

CROP INDEX WEIGHTS

Crop	Better drained soils					
	Dark-colored			Light-colored		
	Medium fine textured soils with heavy subsoils	Coarse and medium-textured soils with heavy subsoils	Silty and sandy soils with sandy subsoils	Fine-textured soils with heavy subsoils	Sandy soils with heavy subsoils	Sandy soils with sandy subsoils
Corn (all)	5	5	5	5	5	5
Wheat	15	5	5			
Oats	20	20	20	25	35	40
Barley	10	10	10	5	5	
Flax	20	10	5	5	5	
Rye		5	10		5	20
Clover and timothy	5	5	15	20	20	5
Alfalfa	5	10	10	10	5	10
Sweetclover	10	10	5	5		
Potatoes		5	5	5		5
Pasture	10	15	10	20	20	15

SOIL SERIES IN DIFFERENT GROUPS

	Kittson. Nereson. Foxhome. Pelan. Fargo. Bearden. Malung.	Grimstad. Enstrom.	Ulen. Poppleton. Sioux.	Taylor. Baudette. Chilgren.	McDougald. Gudrid.	Hiwood. Faunce. Mahnomen.

CROP INDEX WEIGHTS

Crop	Poorly drained soils						
	Dark-colored				Light-colored		
	Medium- and fine-textured soils with heavy subsoils	Coarse and medium-textured soils with heavy subsoils	Silty and sandy soils with sandy subsoils	Organic soils	Fine-textured soils with heavy subsoils	Sandy soils with heavy subsoils	Sandy soils with sandy subsoils
Clover and timothy	10	5	10	10	5	5	10
Sweetclover	5	5	5				
Pasture	30	30	30	30	30	30	30

SOIL SERIES IN DIFFERENT GROUPS

	Barnett. Maple. Wildwood.	Tanberg.	Arveson.	Peat.	Spooner.	Salol.	Potamo.

Productivity rating tables do not present the relative roles that soil types play in the agriculture of a county; the tables indicate rather the productive capacity of each individual type. Total agricultural production from any soil will depend on its areal extent as well as on its productive capacity, and the use of soils will depend on their pattern of distribution as much as on their productivity.

Economic considerations have played no part in determining the productivity indexes, and the indexes cannot, therefore, be interpreted into land values except in a very general way. The value of land depends on distance from market, the relative prices of farm products, and a number of other factors, in addition to the productivity of the soil.

LAND USES AND AGRICULTURAL METHODS

According to the Federal census of 1935, Roseau County had a total of 534,169 acres in farms. In 1934, crops were harvested from 232,237 acres. Of this acreage about 43 percent was in hay crops, 17 percent in flax, 14 percent in oats, 4 percent in barley, 3 percent in wheat, and the rest in corn, rye, potatoes, and other minor crops. Most of the unimproved land included in farms is either tree-covered upland or swampland, or both. Much of the forested upland is used as grazing land, whereas most of the swampland is left idle. On many farms some new land is cleared and brought under cultivation each year, the amount ranging from 1 to 20 acres a farm. The land originally covered with a shallow layer of peat that has been burned is worked up and seeded to spring grains, provided it is not too wet. In unusually wet years it is allowed to remain idle and is not cropped until a drier year, when it is again sown to grain. A comparatively large acreage of this kind of land is included in the farms in Roseau County, and, accordingly, the amount of cropland varies from year to year, depending on the prevailing moisture conditions.

The agriculture of this county is mainly the production of dairy products, livestock, and small grains. More small grains are grown in the western and central parts than in the eastern part, because the soils are richer in nitrogen and hence more adapted to grain crops. The finer textured soils are preferred for small grains (pl. 2, *B*). The moisture conditions over the entire county in general are productive of good pastures and meadows, and these, together with other feeds that can be grown, cause dairying to be more important than in the regions farther west where grain growing is more extensive.

Rather significant changes took place in the agriculture between the years 1899 and 1929. For the first two decades wheat was the dominant crop, but since then the agriculture has become more stabilized, and now more emphasis is placed on feed crops and livestock. The acreage devoted to small grains other than wheat, such as oats, barley, and corn, has increased. The acreage seeded to flax, a strictly cash crop, has shown marked variations, but in general it has steadily increased. The acreage devoted to tame hay also has shown a marked increase. With the shift to feed crops, a change in the number of livestock has taken place. The increase in the number of dairy cows has been rapid; the number of swine has remained

about stationary, with some fluctuations from year to year; the number of horses increased up to 1920, but since then it has decreased somewhat; and the number of sheep has increased greatly, so that by 1935 Roseau County ranked third among the counties of the State in the number of sheep on the farms.

One problem of outstanding importance in the management of the soils is the eradication of weeds, in order to keep the land clean. Sowthistle, Canada thistle, and quackgrass are the most widespread and most destructive weeds. On many farms the extent of the total annual damage caused by weeds is great. In some places the infestation is so heavy as to cause crops to be entirely abandoned. Wild oats are prevalent in many grainfields, and they spread rapidly under continuous cropping. On badly infested land the first step in eradication or control of weeds is a season of summer fallow. Control is then maintained by following this with a crop rotation in which a cultivated crop is included. A good stand of alfalfa left on the land for 2 or 3 years will eradicate sowthistle and Canada thistle, but it is ineffective in the control of quackgrass.

Continuous cropping to small grains has gradually lowered the yields, owing in part to the effect of weeds and diseases, and on some farms the productivity may have been markedly lowered by cropping. The use of farm manure is effective, especially on the lighter colored soils of the eastern part of the county. A deficiency of phosphate is a problem in some districts, particularly on some of the heavy black soils of the central and western parts, and profitable returns may often be obtained by the use of superphosphate on alfalfa and small grains. On the deep peat soils that have not been burned, an application of either phosphate alone or a combination of phosphate and potash is necessary for all crops.

Satisfactory drainage is still a pressing problem in many parts of Roseau County. Owing to the flatness of the land, difficulty is experienced in removing the surface water that stands on many of the fields in the spring. In the slight depressions where water collects, in many seasons the land cannot be seeded, or, if seeded, the crops may drown out when the rainfall is more than normal. Better drainage may be obtained through more surface drains and more attention to the maintenance of the larger ditches, which are well distributed over the county. Many ditches have insufficient outlets.

As wheat is generally the first crop seeded in the spring, most of the land devoted to it is fall-plowed, and in the spring it may be disked, smoothed with a spring-tooth harrow, or dragged with an ordinary spike-tooth harrow before seeding. Wheat, as well as other small grains, is drilled. After seeding, some of the fields are harrowed. In general, the grain is harvested, shocked, and threshed from the shock. Some farmers stack their grain and thresh it later in the fall. On some of the larger farms the combined harvester-thresher is used.

As with wheat, land to be sown to oats is fall-plowed, harrowed in the spring, seeded with a drill, and then commonly harrowed to smooth the land. In growing barley, more of the land is spring-plowed than for either oats or wheat. It is then disked and harrowed, and the seed is sown with a drill. With flax better yields

usually result from early seeding. The land is generally fall-plowed, disked and harrowed in the spring, and occasionally compacted by rolling. Land that is not under cultivation for several years is plowed in the spring, rolled, and flax drilled on the sod without further preparation.

Practically all of the land for corn is plowed, about one-half in the fall and one-half in the spring. It is then disked thoroughly, harrowed, and a clean smooth seedbed prepared. After planting, it is cultivated from three to six times. Where corn is to be used for silage or fodder it is drilled in rows, but from many fields checkrowed corn is cut and used for fodder. Owing to the small acreage grown, no expensive special machinery is used in the production of corn. Commonly, the early frosts injure it, and then it is all cut green and fed to livestock.

The acreage devoted to alfalfa is increasing annually. Alfalfa is commonly seeded with one of the small grains, principally barley, early in the spring. A good seedbed free of weeds is prepared. Liming is not necessary in any part of the county except, perhaps, on the light-colored sandy soils in the eastern part. Two cuttings of hay are commonly made, and occasionally a third cutting is made, but this practice is not recommended, owing to the likelihood of winterkilling. Sweetclover, which is gaining more and more in popularity, is always seeded with a small grain, mostly oats. On some farms the sweetclover is either pastured or cut for hay or for seed. On many farms the production of sweetclover seed is the principal source of income. On many farms the sweetclover is plowed under early in the second summer and the land fallowed the rest of the season. Wild hay is harvested from land generally not suited to other crops, because the land is too wet to be worked in the spring. Only one cutting of wild hay is made, except in some of the wetter sloughs, where a second cutting is made late in the fall.

The great superiority of sweetclover as a pasture crop is rapidly becoming more and more appreciated by the farmers, as it can be grown successfully on nearly all the soils. When sown in the spring with small grain it usually furnishes pasture the same year from about mid-August until freezing weather. The second-year crop lasts from June 1 to September 1. A growing practice is to seed all spring grain to sweetclover, allowing the livestock to graze after the grain crop is removed. The following year a sufficient acreage is set aside to provide the necessary pasture required to carry the livestock through the grazing period. Some sweetclover is cut for hay. It has a feeding value about equal to that of alfalfa. It must be cut early in the bud stage, otherwise a woody coarse-stemmed hay is obtained, which is not relished by livestock.

Both sweetclover and wild hay are used in connection with the feeding of alfalfa and other rough forage. Mixed with other forage it is suitable for feeding to cattle and sheep. The corn, except the little that matures, is cut and a part put in silos, where available, and the rest shocked and fed as fodder. Oat straw generally is available, and, when hay is scarce, the straw is fed to livestock. The concentrates fed to the dairy cattle and for fattening livestock are bar-

ley and oats, both of which are grown extensively. Barley is nearly equal to corn in feeding value and is substituted for it. Oats, which provide excellent feed for horses, colts, ewes, and calves, are valuable also in concentrate mixtures for dairy cows.

Sheep raising is expanding at a more rapid rate than any other livestock enterprise. Many of the farms are surrounded by large acreages of uncleared land where the sheep are allowed to browse at will with little or no attention given them. They use sweetclover pasture to good advantage, require less shelter than either dairy cattle or hogs, and, to a certain extent, they can be used to control weeds.

MORPHOLOGY AND GENESIS OF SOILS

As shown by Marbut on his map of the great soil groups of the United States,[8] Roseau County lies in two extensive geographic soil belts. The western part lies in the northern Chernozem zone and the eastern part in the Podzol zone. Between the two is a transitional zone in which the soils have the combined morphological features of both the Chernozem and the Podzol profiles. The Chernozems are extensively developed in the extreme western part of Minnesota and extend into eastern parts of the Dakotas. In northwestern Minnesota the eastern line of the belt projects into Roseau County about 15 miles. The Chernozems are characterized by black or very dark gray surface soils, high in organic matter and nitrogen, and, somewhere in the soil profile, generally within the upper 2 feet, an enriched zone of calcium carbonate. These soils have formed under a grass vegetation, with long cold winters, short hot summers, and a precipitation confined chiefly to the growing season. In Roseau County the typical Chernozem profile is not so well developed as it is farther west, owing to the fact that the climatic conditions are more favorable to the development of the podzolic type of soil. The surface soils, however, are dark-colored and have a pronounced granular structure, common characteristics of the Chernozems, but the zone of lime accumulation is not everywhere present.

These black soils, as well as all the other soils in the county, have developed from calcareous material of the late Wisconsin glaciation, practically all of which was more or less modified by the waters of glacial Lake Agassiz, which once covered all of Roseau and the adjoining counties. In some places the soils have developed on lacustrine clays, in others on lake-laid silts and sands of various sizes, and also on till that has been more or less slightly reworked. Nowhere have the soils formed from the finer textured material been leached of carbonates, but in some of those formed on deep sand, which have better internal drainage, the carbonates, if ever present, have been removed from both the A and B horizons and in many places from the upper part of the parent material.

The light-colored soils are east of the transitional belt, where they have developed under a cover of both coniferous and deciduous trees.

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[8] MARBUT, C. F. SOILS OF THE UNITED STATES. U. S. Dept. Agr. Atlas of American Agriculture, pt. 3 (Advance sheets No. 8), 98 pp., illus. 1935.

They are similar in general profile characteristics to the soils throughout northeastern Minnesota.

Owing to the nearly level terrain of most of Roseau County, the soils are naturally poorly or imperfectly drained, with the result that most of them have poorly developed profiles. Near some of the streams, more particularly in the eastern part of the county, where the land has a more undulating surface, development of the soil profile is better, but these areas are confined to districts where the podzolic soil-forming process is active. Generally, the poorly developed profiles occur where the soils have dark-colored surface soils.

Owing to the submergence of all the land of this section by the waters of glacial Lake Agassiz, during the closing stages of the last ice age, the till, as originally deposited by the ice, was considerably modified and a large proportion of the particles composing it were sorted. The fine clays, silts, and sands were separated and redeposited in areas in nearly pure forms, and from these materials the soils have developed.

Descriptions of representative profiles of some of the soils developed on the most extensive parent materials, under both grass and forest vegetation, are given in detail in the following paragraphs.

Kittson clay loam is formed on ice-laid till that was only slightly modified by the waters of glacial Lake Agassiz. It has developed under a cover of grass and is a typical Chernozem. The following description of a profile of Kittson clay loam is representative of the soil as developed in this county:

0 to 6 inches, very dark gray or black finely granular clay loam, slightly acid or neutral in reaction. It is rather high in organic matter and is filled with many fine grass roots.

6 to 9 inches, a grayish-brown transitional layer of silty clay loam containing some pebbles of limestone and crystalline rocks. The material is somewhat granular. This layer contains tonguelike projections of the overlying surface soil, consisting of black fine-granular material, which extend through it. The reaction is neutral.

9 to 18 inches, dark to light grayish-yellow compact silty clay loam. The aggregates are angular, but they pulverize easily when crushed. The lower part of this layer is somewhat lighter colored and contains limestone and granite pebbles. It is the zone of lime accumulation.

18 to 36 inches, light grayish-yellow mellow calcareous till consisting of permeable silty clay loam that effervesces freely with hydrochloric acid.

Ulen loamy fine sand is formed on fine sand under a grass vegetation. Most of the material undoubtedly was deposited by water, but since deposition it probably was shifted back and forth by the wind. Underlying it is finer textured material of ice-laid origin. Following is a description of a profile of this soil as observed in Roseau County.

0 to 7 inches, dark coffee-brown loamy fine sand that is loose and incoherent but has a faint finely granular structure. A large part of the sand consists of fine quartz grains, which can be detected readily in the soil mass. The material is very slightly acid in reaction.

7 to 15 inches, mouse-gray loamy fine sand streaked with very dark gray, slightly compact, and without structure. The mass crumbles readily when the moist material is pressed in the hand. The gray color is due to the higher content of carbonates in this layer. It is the zone of lime accumulation.

15 to 24 inches, light grayish-brown loamy fine sand that has no structure but is slightly compact. It is calcareous.

24 to 38 inches, straw-yellow loamy sand that becomes somewhat coarser with increasing depth. It is rather compact but when handled is easily reduced to a loose incoherent mass.
38 to 40 inches, grayish-yellow stony clay loam containing some pebbles and coarse gravel. This is the glacial till high in carbonates.

Taylor very fine sandy loam is developed on ice-laid till similar to the material from which the Kittson soils are formed, but it differs markedly from those soils in its profile development. The Taylor soils are podzolic, having developed under a cover of trees. Following is a description of a representative profile of Taylor very fine sandy loam:

0 to 2 inches, fibrous dark-brown or black forest litter and leafmold.
2 to 5 inches, strongly acid very light gray loose very fine sandy loam. The upper part of this layer is darkened for one-half inch by some admixture of leafmold from the overlying layer.
5 to 10 inches, dark yellowish-brown rather compact silty clay loam with a pronounced blocky or nutlike structure. The lower part of this layer is somewhat lighter in color, but it is as fine textured and has the same structure as the layer above. It is neutral in reaction.
10 to 36 inches, light grayish-yellow mealy silty clay loam, with some small pebbles of both granite and limestone distributed through the soil mass. It is strongly calcareous.

Hiwood loamy fine sand is developed on deep sand in the forested part of the county and is podzolic. It is covered largely by jack pine and little or practically no underbrush. Following is a description of a profile of Hiwood loamy fine sand:

0 to ½ inch, forest litter, mostly pine needles.
½ to 3 inches, very light gray loose loamy fine sand, strongly acid in reaction.
3 to 8 inches, grayish-brown loose loamy fine sand. In some places it is rather compact and contains a few crystalline pebbles. It is moderately acid.
8 to 36 inches, light yellowish-brown fine sand becoming slightly coarser with depth. It is slightly acid or neutral in reaction.

McDougald loamy fine sand is developed on shallow sand overlying unmodified ice-laid till. In no place is the sand layer more than 30 inches thick, but commonly it is 14 inches or less. Deciduous trees, with a dense growth of underbrush, constitute the native ground cover. McDougald loamy fine sand shows the following profile characteristics:

0 to 2 inches, black or dark-brown forest litter and leafmold.
2 to 3 inches, very dark gray loamy very fine sand high in organic matter.
3 to 6 inches, light-gray loose fine sandy loam with a few light reddish-brown iron stains. It is strongly acid.
6 to 12 inches, gray loose fine sandy loam, slightly darker than the material in the layer immediately above. It has more iron stains, which are of a darker shade. It is strongly acid.
12 to 17 inches, yellow-brown or rust-brown gritty sandy loam, rather compact and slightly cemented when dry. It is moderately acid.
17 to 36 inches, mellow calcareous light grayish-yellow silty clay loam with pebbles of both calcareous and igneous rocks. It is without structure but has a mellow and mealy consistence and is very permeable. It effervesces freely with dilute hydrochloric acid.

Moisture equivalents for the horizons of certain soils are shown in table 10.

TABLE 10.—*Moisture equivalents of the horizons of certain soils in Roseau County, Minn.*

Soil type	Horizon	Thickness	Moisture equivalent	Soil type	Horizon	Thickness	Moisture equivalent
		Inches	*Percent*			*Inches*	*Percent*
Kittson silt loam	A	0–10	18.6	Malung loam	A	0–6	23.1
	B	10–24	18.9		B	6–11	19.2
	C	24–48	17.0		C	11–35	18.5
Do	A	0–11	28.1	Malung loam, imperfectly drained phase	A	0–5	16.4
	B	11–18	20.3		B	5–10	15.5
	C	18–42	13.8		C	10–34	10.7
Kittson clay loam	A	0–5	24.4	Wildwood silty clay	A	0–8	28.9
	B	5–12	15.8		B	8–22	36.8
	C	12–36	15.5		C	22–46	38.1
Do	A	0–6	28.4	Grimstad loamy fine sand	A	0–4	12.4
	B	6–19	19.9		B	4–17	7.3
	C	19–43	18.4		C	17–41	11.4
Kittson sandy loam	A	0–7	14.6	Tanberg loamy fine sand	A	0–7	12.6
	B	7–15	11.2		B	7–12	18.3
	C	15–39	14.9		C	12–36	26.5
Kittson gravelly sandy loam.	A	0–6	20.1	Ulen very fine sandy loam, imperfectly drained phase	A	0–14	10.4
	B	6–10	7.8		B	14–25	9.5
	C	10–34	14.9		C	25–49	17.1
Nereson clay loam, imperfectly drained phase.	A	0–4	26.5	Poppleton loamy fine sand	A	0–7	12.5
	B	4–8	23.4		B	7–15	3.7
	C	8–32	21.6		C	15–39	2.6
Foxhome loam	A	0–4	23.4	Do	A	0–8	10.4
	B	4–15	4.9		B	8–12	7.0
	C	15–39	14.6		C	12–36	8.6
Foxhome loam, imperfectly drained phase.	A	0–5	20.5	Do	A	0–6	8.9
	B	5–15	16.0		B	6–28	8.8
	C	15–21	6.8		C	28–52	8.0
Fargo clay	A	0–16	44.2	Poppleton very fine sandy loam	A	0–6	15.0
	B	16–27	35.4		B	6–26	10.5
	C	27–51	36.0		C	26–50	35.5
Do	A	0–12	40.1	Do	A	0–9	14.9
	B	12–24	42.6		B	9–19	5.0
	C	24–48	22.5		C	19–43	9.7
Do	A	0–16	45.6	Poppleton very fine sandy loam, imperfectly drained phase	A	0–8	10.7
	B	16–32	40.1		B	8–22	8.0
	C	32–56	31.6		C	22–46	8.4
Fargo clay, poorly drained phase.	A	0–4	41.3	Sioux loamy sand	A	0–6	11.6
	B	4–29	42.0		B	6–15	4.7
	C	29–53	36.1		C	15–39	1.7
Fargo clay loam	A	0–10	34.7	Taylor very fine sandy loam	A	0–12	12.7
	B	10–24	39.7		B	12–30	29.1
	C	24–28	34.0		C	30–54	19.0
Bearden clay loam	A	0–11	30.9	McDougald loamy fine sand	A	0–7	5.2
	B	11–23	26.1		B	7–20	3.4
	C	23–47	8.5		C	20–44	16.6
Bearden loam	A	0–14	20.1	Do	A	0–7	5.2
	B	14–24	14.4		B	7–13	18.5
	C	24–28	14.8		C	13–37	11.3
Do	A	0–12	22.7	Hiwood loamy fine sand	A	0–3	4.4
	B	12–30	16.8		B	3–8	4.6
	C	30–54	11.8		C	8–32	2.6
Do	A	0–6	23.1	Do	A	0–4	4.4
	B	6–14	18.7		B	4–10	3.0
	C	14–38	14.8		C	10–34	2.3
Do	A	0–8	18.5	Faunce sand	A	0–3	5.4
	B	8–15	14.4		B	3–9	4.8
	C	15–39	10.4		C	9–33	1.9
Do	A	0–8	21.6	Do	A	0–5	7.0
	B	8–16	15.6		B	5–29	2.8
	C	16–40	11.9		C	29–53	2.8
Malung loam	A	0–7	21.6				
	B	7–14	15.8				
	C	14–38	18.8				

Moisture equivalents are determined by subjecting the saturated soil to a force of 1,000 times gravity in a centrifuge. These equivalents are expressed in percentages of moisture calculated on the basis of oven-dry soil. They serve as an indication of the moisture-holding capacity of the soil.

SUMMARY

Roseau County is in the northwestern part of Minnesota, bordering on Canada and Lake of the Woods. It comprises an area of 1,670

square miles, or 1,068,800 acres. Roseau, the principal town and county seat, is about 300 miles by air line northwest of Minneapolis and St. Paul.

The county is a nearly level plain, which is crossed by a series of low northwest-southwest ridges ranging from 6 to 20 feet in height. These are the beach ridges marking the position of successive shore lines of glacial Lake Agassiz. The county is a part of a vast region covered by the last great ice sheet. As the ice front retreated northward, waters from the melting ice were ponded in the Red River Valley, forming a large lake known as glacial Lake Agassiz. The lake extended westward into North Dakota and northward into Manitoba, Canada. Subsequent drainage of the old lake exposed its former bottom as a nearly level plain from 1,000 to 1,200 feet above sea level. The streams in the county, of which the Roseau River is the largest, have not had time enough to cut adequate drainage channels, and much of the land is poorly drained. Numerous drainage ditches have been constructed, but a large proportion of the land still lacks sufficient drainage.

The climate is characterized by short, warm summers, with an abundance of sunshine, and long, cold winters. The average frost-free period is 104 days, too short for the production of corn for grain, but long enough for maturing small grains. The mean annual precipitation at Roseau is 20.34 inches, of which about two-thirds falls during the growing season. It is favorable to the production of small grains and hay crops.

The first settlers came to the county about 1885, and the county was organized in 1894. The population in 1930 was 12,621, of whom 10,079 were of native birth. Warroad, the largest village, in 1930 had a population of 1,184, and Roseau had 1,028. Smaller towns are Greenbush, Badger, and Roosevelt. The Great Northern and Canadian National Railways serve the county. Water transportation on Lake of the Woods offers facilities to the Northwest Angle and to island points. Farm products are shipped by truck and rail to Fargo, N. Dak., and St. Paul and Minneapolis.

Only about 50 percent of the total area of the county is in farms, and of this less than half is in cropland. Nearly one-half of the cropland is devoted to hay crops, the rest to grain and minor crops. A large part of the uncleared land is tree-covered or open swampland, much of the latter being of little value in its present condition. Satisfactory drainage is still a pressing problem in many parts of the county. Lack of adequate drainage outlets and an insufficient number of ditches are responsible for this condition. The average size of the farms is 233.6 acres. About three-fourths of the farms are operated by owners; those occupied by tenants, in general, are farmed under some form of a share system of rental.

The agriculture of the county consists of dairy farming, grain farming, and mixed dairy and grain farming. Some income is derived from the production of sweetclover, alfalfa, and timothy seed. Of the 1,922 farms in 1930, 675 were classed as dairy farms and 700 as general farms. On many of the latter, dairying was the largest source of income.

The soils have developed on sediments of clay, silt, and various grades of sand, deposited in the basin of glacial Lake Agassiz, and on the gravelly ridges of the ancient shore lines of the lake. A large part

of the lake bottom was covered with shallow water, and little or no deposition of assorted material, such as clay, silt, or very fine sand, resulted. The soils in these areas, therefore, have formed directly from the unchanged ice-laid material, and, aside from their nearly level surface, they are somewhat similar to the soils outside of the lake basin on the rolling uplands. The soils developed on the lake-laid clays are some of the heaviest in the State and are well adapted to growing small grains; those formed on the silt deposits are easier to work, very productive, and adapted to a wider range of crops; and the soils developed on the sand deposits show a wide range in productivity. In many places the sand cover is comparatively shallow, averaging about 18 inches in thickness, whereas in other places the sand reaches to a depth of 4 feet or more. Where the sand cover is shallow, the yields are more certain, owing to more favorable moisture conditions.

The native vegetation has had a marked influence on the characteristics of the soils. The western part of the county originally was a grass-covered plain, whereas the eastern part always supported trees. The soils of the western part have dark-colored surface soils that are rich in organic matter and nitrogen; those under forest vegetation have light-colored surface soils and are low in these constituents. The dark-colored soils are better adapted to grain growing than the light-colored soils, owing to their more abundant content of nitrogen. Although many of the farms are devoted to dairying and a comparatively large acreage is used to grow feed crops sufficient to provide for the needs of the livestock, sufficient grain is generally produced to meet the feed requirements and still provide a surplus for sale. When small grains are sown, sweetclover is commonly seeded with them, and the following year some is allowed to mature and a crop of seed harvested. On the light-colored forested soils the farms are comparatively small and more land is devoted to pasture and hay crops. The small grains are limited to oats and rye. Practically none is sold, with the exception of a little rye.

Peat, together with poorly drained mineral soils, constitutes a large proportion of the land. Most of the peat bogs in the western part of the county are grass-covered, whereas those in the central and eastern parts support spruce and tamarack trees. A large acreage that is now cropland was originally covered with a layer of peat ranging from 6 to 24 inches in thickness, but much of the peat has been burned, either accidentally by grass and forest fires, or intentionally by the settlers. The destruction of the peat in many places has improved the productivity of the soil, and, where the peat was not too thick, drainage has not been seriously impaired.

The principal soils in the prairie part of the county belong to the Kittson and Nereson series. They have developed on ice-laid till only slightly modified by wave action. The Fargo soils have developed on lake-laid clay, and the Bearden and Malung soils on the silty deposits. On the sandy deposits, the Ulen soils occur where the sand is 30 or more inches thick, and the Grimstad soils in places where the sand layer is less than 30 inches thick. The Sioux soils have developed on the gravelly ridges. In the forested section, the Taylor soils occur on the glacial till, the Baudette soils on the silty material, the Hiwood and Faunce soils on the deep sandy deposits, and the McDougald soils on glacial till overlain with a layer of sand.

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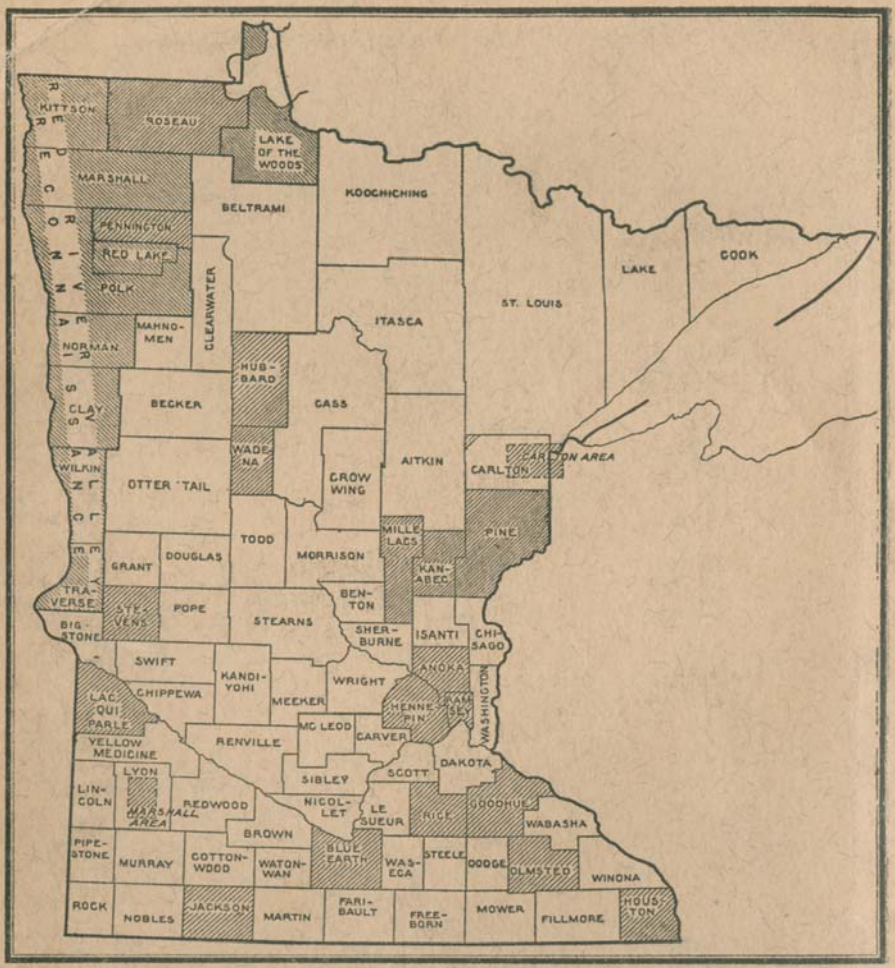

Areas surveyed in Minnesota, shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching.

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