

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

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

SOIL SURVEY OF ANOKA COUNTY, MINNESOTA.

BY

WILLIAM G. SMITH, OF THE U. S. DEPARTMENT OF AGRICULTURE,
IN CHARGE, AND GEORGE H. NESOM AND E. G. ROTH,
OF THE UNIVERSITY OF MINNESOTA.

THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1916.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1918.

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LETTER OF TRANSMITTAL.

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

Washington, D. C., February 21, 1918.

SIR: Under the cooperative agreement with the University of Minnesota a soil survey of Anoka County was completed during the field season of 1916.

I have the honor to transmit herewith the manuscript and map covering this work and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1916, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

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

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MAP.

Soil map, Anoka County sheet, Minnesota.

SOIL SURVEY OF ANOKA COUNTY, MINNESOTA.

By **WILLIAM G. SMITH**, of the U. S. Department of Agriculture, In Charge, and **GEORGE H. NESOM** and **E. G. ROTH**, of the University of Minnesota.—Area Inspected by **THOMAS D. RICE**.

DESCRIPTION OF THE AREA.

Anoka County is situated in the southeastern part of Minnesota, a few miles north of Minneapolis and St. Paul. It is bounded on the north by Isanti County, on the east by Chisago and Washington Counties, on the south by Ramsey and Hennepin Counties, and on the west by Sherburne County. The Mississippi River flows between Anoka and Hennepin Counties. The area included is 431 square miles, or 275,840 acres.

The topography of Anoka County in general is that of a modified plain. In the northwestern part there is a relatively small area of rather rough morainic-hill country, and a smaller total area of hilly country occurs in the extreme southern part. The remainder of the county has the appearance of a fairly flat to gently rolling upland plain. In all sections of the county there occur numerous level areas of peat land, lying 2 to 10 feet or more below the general level of the upland. These are much more extensive in the eastern half of the county. With a few exceptions the upland slopes bordering the peat areas are long and gentle. Along the Mississippi and Rum Rivers there is a small development of terrace land lying from 2 to 15 feet above overflow level. There is practically no bottom land subject to overflow in the county.

In the southeast part of Fridley Township and in the northwest corner of the county some small areas reach an elevation of 1,060 feet above sea level, but the greater part of the county comes well within a range of about 850 to 950 feet above sea level, coinciding in a general way with the distribution of deep sandy soil and including in addition considerable areas around Centerville and Nowthen. The greater part of this lower lying land has a slight southwestward slope. Practically all of the county is drained into the Mississippi River by streams having a southerly and southwesterly



FIG. 1.—Sketch map showing location of the Anoka County area, Minn.

course. The most important interior stream is the Rum River, which drains the western half of the county and flows into the Mississippi River at Anoka. The eastern half of the county is largely drained by Coon Creek and Rice Creek, which empty into the Mississippi River a few miles below Anoka. Numerous lakes and ponds throughout the county serve as catchment basins or reservoirs and for the most part connect with natural drainage ways, with usually rather sluggish currents. Part of the northeastern section of the county is drained to the east by Hurley Creek and its tributaries.

Practically all of the county except the peat areas is well drained, but there is an almost entire lack of erosion. Excess rainfall is largely carried to the peat areas through natural drainage depressions. The streams afford fairly adequate drainage for much of the peat area in seasons of normal or subnormal rainfall, but in seasons of unusually heavy precipitation the drainage is insufficient to remove the excess water until late in summer.

The various streams have not cut very deeply below the general upland level. Even the Rum River and the Mississippi River flow only about 5 to 25 feet below the upland. The water in both these streams is comparatively shallow and has a fairly rapid current. The cutting or deepening of the channels that is taking place to some extent along the larger streams is largely offset by the redeposition of transported material, aided somewhat by artificial dams. Except after heavy rains all the streams have comparatively clear water.

Water power is developed on the Rum River at Anoka and St. Francis for grinding flour. At Coon Rapids, on the Mississippi River, a large hydro-electric power plant is operated. Good water for domestic use is abundant throughout the county. In many places it can be obtained in driven wells at 15 to 30 feet below the surface. Bored wells find a supply at about 100 feet. In the vicinity of Centerville there are a few flowing artesian wells, which give excellent drinking water.

That part of the State in which Anoka County is included was organized into counties by the first Territorial legislature in 1849. In 1857 the boundaries of Anoka County were fixed almost as they remain to-day, and Anoka was made the county seat. The population increased from 5,108 in 1880 to 9,884 in 1890, 11,313 in 1900, and 12,493 in 1910. Approximately 77 per cent of the population consists of native-born and 23 per cent of foreign-born whites. The principal foreign nationalities represented are Swedish, German, Norwegian, and Canadian. All the population outside the city of Anoka, or 68.2 per cent of the total, is classed as rural. This gives an average density of 18.6 persons to the square mile. The western half of the county includes the greater part of the population. In a

general way the distribution of the farming population follows quite closely the well-drained upland areas.

Anoka, in the southwestern part of the county, on the Mississippi River, had a population in 1910 of 3,972. Besides being the county seat, it is the business center of the county. Columbia Heights, a suburb of Minneapolis, is the next largest settlement. Smaller towns and villages are scattered throughout the county.

Main lines of the Great Northern and Northern Pacific Railways traverse the county along the Mississippi Valley, passing through Anoka. What is locally known as the Duluth Branch of the Great Northern Railway extends north and south through the central part of the county. The eastern tier of townships is within nearer reach of the Twin City-Duluth Branch of the Northern Pacific Railway, which extends north and south a few miles beyond the east county line. An electric railway connects Minneapolis with Anoka and various other points within the county.

Country roads extend through all parts of the county. The public-road system is somewhat less extensive within the larger peat areas, but in general all the farming communities have ready access to points on railway lines. Owing to the deep, sandy character of much of the upland, the unsurfaced roads are at times very loose and hard to travel. In the peat-land sections it is often necessary to haul road-making material long distances, as the peat material is unsuitable for surfacing. An extensive program of road improvement is planned by the local government, and some of the work is under way. Most of the farms are provided with telephone service, and many farmers own automobiles. Country and town schools are numerous and well located to serve all parts of the county. At Anoka and St. Francis there are well-equipped consolidated schools.

All the towns and villages in the county serve to some extent as markets and trading points. The surplus products find ready sale in Minneapolis and St. Paul, which are reached by steam or electric railway, wagons, and autotrucks.

CLIMATE.

The records of the Weather Bureau station at Minneapolis are considered representative of the climatic conditions in Anoka County. The mean annual precipitation as shown by these records is 29.31 inches, of which nearly 74 per cent falls during the crop-growing season, from April to September inclusive. The average monthly precipitation during this period is rather uniform, ranging from about 2½ to 4 inches. Most of the precipitation comes as gentle rains, with sufficient frequency to insure normal growth of farm crops. Occasionally, however, continued cold rains in the spring delay spring or early summer seeding, and occasional heavy rain-

storms, sometimes almost cloudbursts, as well as rather long dry spells, may occur during the growing season. The precipitation in the driest year on record (1910) was 11.59 inches, and in the wettest year (1868), 41.64 inches. The average annual snowfall amounts to 41.8 inches. Snow often covers the ground for long periods.

The mean annual temperature is 44.7° F. The mean temperature for the summer is 69.6° F., and for the winter 16.5° F. The lowest temperature on record is -33° F., reached in both January and February, and the highest temperature recorded is 102° F., in July.

The average date of the last killing frost in the spring is April 28, and that of the first in the fall October 8. The average growing season is thus 163 days in length, and is sufficient for maturing all the common crops. The latest killing frost recorded in the spring occurred on May 20, and the earliest in the fall on September 13. Corn, the crop most subject to injury, is almost invariably matured even in years with abnormally short growing seasons.

Fall and spring winds sometimes do considerable injury on the sandy soils of the county, even after the young growth of grain or other crops is fairly well started. Small fruits such as strawberries, raspberries, and grapes are subject to injury from the alternate freezing and thawing that takes place throughout the winter, unless protected by a snow cover. A good depth of snow can not be relied upon, and the plants are usually protected by a covering of straw or soil applied in the fall. Exposed grass and clover fields may occasionally be winter-killed.

The following table, compiled from the records of the Weather Bureau station at Minneapolis, shows in detail certain climatic data applicable to Anoka County:

Normal monthly, seasonal, and annual temperature and precipitation at Minneapolis, Hennepin County.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1868).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	20.4	56	-27	0.95	0.31	0.55	6.4
January.....	13.7	52	-33	.69	1.08	1.96	8.3
February.....	15.3	64	-33	.73	.51	1.75	8.6
Winter.....	16.5	64	-33	2.37	1.90	4.26	23.3
March.....	29.5	83	-17	1.65	.09	9.00	9.5
April.....	46.7	86	12	2.44	.64	2.01	4.0
May.....	57.4	93	22	3.92	1.39	4.37	0.2
Spring.....	44.5	93	-17	8.01	2.12	15.38	13.7

Normal monthly, seasonal, and annual temperature and precipitation at Minneapolis, Hennepin County—Continued.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1868).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
June.....	67.4	98	36	4.01	1.24	4.23	0
July.....	71.8	102	44	3.81	.74	3.09	0
August.....	69.5	99	42	3.69	1.56	2.81	0
Summer.....	69.6	102	36	11.51	3.54	10.13	0
September.....	62.1	97	29	3.66	2.58	2.82	T.
October.....	49.8	86	16	2.58	.86	4.92	0.3
November.....	33.0	73	-13	1.18	.59	4.13	4.5
Fall.....	48.3	97	-13	7.42	4.03	11.87	4.8
Year.....	44.7	102	-33	29.31	11.59	41.64	41.8

AGRICULTURE.

The first settlers in this county found much of the upland fairly well timbered, with oak as the dominant growth. There was some merchantable pine in the north-central part of the county, and much of the peat land supported a large growth of tamarack, the remainder being largely open marsh. A narrow strip of upland bordering the Mississippi River was open prairie, the last coinciding in a general way with the distribution of the Merrimac loamy sand. The first white settlers are said to have come into the county as early as 1844. By 1860 several farms were established, small grains, corn, and potatoes being produced in conjunction with the raising of live stock. The early settlers cut most of the merchantable pine for lumber and the red oak and tamarack for railway crossties and cordwood. There is still considerable forest growth in the county, but this is in the form of farm woodlots rather than a source of merchantable forest products.

Corn and potatoes apparently were first grown in 1848. In 1859 the products of the county included 34,734 bushels of potatoes, 40,411 bushels of corn, 8,762 bushels of wheat, 9,917 bushels of oats, and 315 bushels of rye. The Colorado potato beetle made its appearance in 1866, and by 1869 the production of potatoes had been reduced to less than one-half that of 1859. The production of wheat had trebled during this decade, and all other crops had increased in acreage and production. By 1879 the use of paris green to control the potato bug had become common, and potatoes have since remained

one of the most important products of the county. In 1864 the first railroad line was built through the county, and the improvement in transportation facilities greatly stimulated agriculture.

In 1879 about 9 per cent of the area of the county was in crops. About 42 per cent of the cropped land was in hay, 28 per cent in wheat, 16 per cent in corn, and 7 per cent in oats. The 1890 census showed an increase of 59 per cent in crop acreage. About 50 per cent of the cropped area was occupied by hay, 20 per cent by corn, 15 per cent by oats, 7 per cent by potatoes, and 4 per cent by rye. In 1899 about 66,000 acres, or over 22 per cent of the area of the county, was in crops. About 29 per cent of the farmed area was in wild hay, 17 per cent in corn, 13 per cent in rye, 12 per cent in oats, 11 per cent in tame hay, 10 per cent in potatoes, and 7 per cent in wheat. The value of dairy products sold in 1899 amounted to \$118,687, of animals sold or slaughtered to \$103,101, and of poultry and eggs produced to \$25,639. The 1910 census reports 71,661 acres, or almost one-fourth the area of the county, as being cultivated or used for hay production. About 26 per cent of the cropped land was occupied by wild hay, 17 per cent by corn, 15 per cent by tame grasses, 15 per cent by potatoes, 13 per cent by oats, 8 per cent by rye, and 2 per cent by wheat.

The value of all crops produced in 1909 is reported by the census as \$1,118,212. On the basis of value of production the most important class of crops is vegetables, chiefly potatoes. Potatoes were grown on 10,756 acres in 1909 and produced 1,255,880 bushels, or an average of 116.7 bushels per acre. Miscellaneous vegetables were grown on 482 acres. The value of all vegetables produced amounted to \$406,395. The area in potatoes increased by 58 per cent from 1899 to 1909. The crop is grown principally as a source of revenue, and is shipped largely to St. Paul and Minneapolis.

The value of all cereal and seed crops produced in 1909 amounted to \$402,818. Corn occupied 12,075 acres and produced 375,378 bushels, averaging 31.1 bushels per acre. Oats occupied 9,668 acres and produced 278,498 bushels, or 28.8 bushels per acre. Rye, which was grown on 5,500 acres, produced 77,062 bushels, the yield averaging 14 bushels per acre. Wheat occupied 1,523 acres, producing 28,487 bushels, an average of 18.7 bushels per acre. Barley was grown on 613 acres, beans on 294 acres, emmer and spelt on 154 acres, and buckwheat on 49 acres. Cereal and grain crops are grown mainly for use on the farm. Much of the corn crop is put in silos and used to feed stock, principally dairy cows.

Hay and forage were produced in 1909 to the value of \$236,258. Wild hay, cut mainly from peat land, occupied 18,503 acres and produced 22,814 tons, an average of 1.23 tons per acre. Tame or cultivated hay crops, consisting almost entirely of timothy and

clover, collectively occupied 11,001 acres and produced 16,542 tons, or 1.5 tons per acre. Owing to the high prices often paid in St. Paul and Minneapolis for hay, part of the crop is sold. The second cutting of clover grown alone is used for seed, which is also sold. The seed yields about 2 to 3 bushels per acre, and sells for \$7 to \$10 a bushel. The census reports a valuation of \$60,144 under the heading of "all other crops." This probably consists largely of revenue derived from the sale of wire grass cut from wet peat land, or what is commonly termed marsh, the product being used in the manufacture of grass matting. The area cut over for wire grass is probably about 4,000 acres.

The 1910 census reports 2,992 apple trees and 2,784 plum trees in the county. Small fruits occupied 81 acres. Sixty-seven acres were in strawberries, which produced 106,523 quarts in 1909, and 10 acres in raspberries, which produced 7,360 quarts. The value of all fruits produced amounted to \$12,597.

The census reports the value of live stock and live-stock products produced in 1909 as \$566,137. Dairy products, excluding that portion used in the home, amounted in value to \$285,363; animals were sold or slaughtered to the value of \$171,829; poultry and eggs produced amounted in value to \$107,966; and \$979 worth of wool was clipped. The 1910 census reports 8,649 milch cows in the county, 6,949 other cattle, 4,756 horses, 4,396 hogs, and 1,318 sheep. Hogs are raised in connection with dairying, and sold on the near-by city markets. Practically every farmer keeps some milch cows. The product is sold mainly in the form of either whole milk or cream. Some of it is sold to local creameries. A considerable proportion goes direct to the Twin City markets, being collected by motor trucks or wagons which follow specified routes. A powdered-milk factory at Anoka uses a large proportion of the whole milk produced in a wide surrounding territory. Several creameries in various sections of the county have been discontinued.

Crop production in Anoka County is practically restricted to the upland. The use of the peat and marsh areas is in general limited to the cutting of wild hay, the cutting of wire grass to be used in grass-matting manufacture, and pasturage. Any extensive cultivation of the peat land is necessarily dependent upon artificial drainage, which has already been done to some extent. At present there is no particular recognition of the adaptation of the various soils to certain crops. The soils with clay subsoils are known to be more durable than those of deep sandy character, but the same crops are grown on both kinds of land.

Practically all the annual crops are spring sown except rye, which is usually seeded in September. On the heavier soils, which are not so subject to wind erosion or drifting, early fall plowing may

be advantageous, as the severe freezing and thawing process which takes place until early spring improves the physical condition of the soils, especially the clayey types. For the most part preparation of the sandy soils for spring or early summer seeding is deferred until spring. Small grain is seeded usually in April, potatoes in May or June, and corn in June. The small grains sown in the spring mature in late July and early August. Rye is harvested three or four weeks earlier. About the last of August corn can be cut for ensilage, and the first weeks in September usually find most of it ripened. Potatoes are dug in August and September, or later.

Improved machinery is largely used in seeding and harvesting crops. Single walking plows and riding gang plows of standard makes are used, drawn by 2 to 6 horse teams. Drills are invariably used in seeding small grain, and in many instances machines are used in planting potatoes. Potato-digging machines requiring 5 or 6 horse draft are in use on many farms. Small grains and corn are harvested with binders. Windmills and gas engines are in common use for pumping water, and small gas engines are sometimes employed in grinding feed. Large traction engines, both of steam and gasoline power, are kept by some farmers who have grain and clover separators and ensilage cutters. Large draft types of horses are commonly used in plowing and in tillage operations, as traction engines of the ordinary wheel types are not well suited to use on the sandy lands. Caterpillar tractors might prove serviceable on sandy soils as well as on peat lands, but there are only one or two in the county.

Most of the intertillage of row crops, such as potatoes and corn, is done in late June, July, and early August. For the most part much attention is given to this work, horse-drawn riding cultivators being used to good advantage. Most of the soils seem to have an abundance of weed seeds, which sprout and produce a luxuriant growth if given but slight opportunity. Summer fallowing is almost impracticable except on the heavier soils, the sandy types being too much subject to drifting by the wind. Smothering by grass sod and thorough cultivation seem to be the most promising methods of keeping row crops clean.

Practically all the farmers practice some form of crop rotation in which clover is included. The rotation in most common use may be outlined as follows: A small grain is drilled in in the spring, with clover or mixed clover and timothy sown either by means of an attachment on the grain drill or put in later with a wheel-harrow seeder or broadcasted by hand. Under normal conditions the grass comes up well in the stubble after late-summer cutting of the small grain. The following season hay is usually cut, and the grass sod

may be retained for two years or more. The sod may be fall plowed on the heavier soils, but on the light sandy soils spring plowing is better. The land is disked and harrowed in preparation for late May and early June planting of corn. Where potatoes follow corn part of the land under rotation is available for some other crop, and it is usually put in a small grain. Where potatoes follow the tame grasses the unused land is planted in corn. Some farmers are very positive that potatoes do better following clover or clover and timothy mixed than when made to follow a cultivated crop, such as corn, but good results seem to follow with either practice, and in any case at least four years usually intervenes before potatoes are again planted in the same field.

Commercial fertilizers are used to a very small extent in Anoka County. In 1910 only 19 farms reported their use, with an average expenditure of \$42 each. At present the principal method of keeping up the productiveness of the upland soils is the growing of clover in crop rotation and the use of all the available barnyard manure.

Farm labor is rather difficult to obtain at certain times of the year. Much of the work is done by the farmer and his family. The expenditure for labor in 1909 amounted to \$148,892. There were 689 farms using hired labor, with an average expenditure of \$215 each. Where engaged by the month, farm laborers are paid \$25 to \$35 or more, in addition to board. Day laborers receive about \$1.50 to \$2.50 a day, with board.

In 1910 there were 1,445 farms in the county, occupying 69.1 per cent of its area. The average size of the farms was 140.6 acres, of which 70.3 acres were improved. There are a few farms ranging in size from 300 to 1,000 acres or more.

The 1910 census reports 86.3 per cent of the farms operated by owners, 12.7 per cent by tenants, and 1 per cent by managers. Most of the tenanted farms are rented on a share basis, the landowner receiving one-third of all the crops. A cash rental of about \$2 to \$2.50 an acre is paid for tillable upland, while peat land for pasture is rented for about \$1 an acre.

The 1910 census reports an average valuation per farm of \$6,560, of which 63.7 per cent is represented by the land, 21.2 per cent by buildings, 11.1 per cent by domestic animals, and 4 per cent by implements. Land values in Anoka County range from about \$10 to \$100 an acre. Land with clayey subsoils, such as is included in the Miami and Gloucester series, ranges in selling value from about \$60 to \$100 an acre. Areas of deep sandy soils, included largely in the Merrimac series, sell for \$40 to \$70 an acre, and the peat lands bring about \$10 to \$30 an acre.

SOILS.

According to available geological data,¹ Anoka County lies within an area of surface exposures of what are termed young gray glacial drift, red glacial drift, deep wind-laid sand, and glacial-river terrace material washed from both of the glacial-drift sheets, but mainly from the young gray drift. The entire county is apparently underlain by a relatively thick sheet of red glacial drift, which is overlain more or less completely by a relatively thin sheet of young gray glacial till. Overlying this is the extensive outwash-plain and dune-sand mantle. Within the areas of glacial-drift exposure as well as in the sand-plain area there occur many depressions of various sizes and depths. These are largely filled with peaty accumulations.

Approximately 4.8 per cent of the county is covered by the well-defined gray drift. This is exposed only in the southeastern part of the county, where it occupies the southeastern parts of Columbus, Centerville, and Fridley Townships. It occurs mostly as a low, rather level till plain, which becomes hilly in a few places. The soils derived from this material are characterized by more or less calcareous,² clay subsoils, and are classed in the Miami series.

The red glacial drift is exposed in the northwestern part of the county, covering most of Burns Township and part of western St. Francis Township. It occupies approximately 9.1 per cent of the county. The greater part of the area covered by this material has a nearly level to gently rolling surface and the soils are classed in the Gloucester series. In the extreme northwestern corner of the county a rather hilly, morainic topography is developed. The soils here are classed in the Hinckley series. Both the Gloucester and Hinckley series have subsoils of varying clay content, and are non-calcareous, although in many places the drift is underlain, apparently at depths varying from 4 to 8 feet, by calcareous material.

The remaining uplands or about 52 per cent of the area of the county is occupied by sandy soils consisting of glacial river-terrace materials washed mainly from the gray drift and sands derived from the same material and deposited by the wind over terraces and outwash plains. This water-laid deposit is of considerable thickness in most places. It is noncalcareous, at least in the upper 3 to 10 feet, and is of sandy texture throughout. The surface varies from quite level to gently rolling, and in places has the character of sand dunes. This deep sandy area is occupied largely by the Merrimac soils. Relatively small areas are classed in the Buckner and Hinckley series.

¹ See Minneapolis-St. Paul Folio, Minn.; also Leverette sketch map of soil material for Minnesota.

² This term is used when the material contains enough lime carbonate to cause distinct effervescence in hydrochloric acid. It has no reference to the occurrence of lime in compounds other than carbonates.

The peat or marsh lands occur throughout the various upland soil divisions. They are most extensive in the eastern half of the county, within the deep sandy areas. The size of the individual areas ranges from a few acres to several thousand acres. In the aggregate they cover about 34 per cent of the area of the county.

The Miami series is characterized by gray to light-brown surface soils underlain by pale-brown to gray subsoils which are quite uniformly clayey and almost invariably calcareous. Normally there are more or less small gravel, cobblestones, and medium-sized boulders on the surface and throughout the 3-foot section. In the lower subsoil and substratum some of the stones are limestone, but in the upper soil section they are of noncalcareous material, the limestone boulders probably having been dissolved. The subsoils are rather compact, being hard when dry and plastic when wet, and the moisture movement is somewhat retarded. In general the surface is rather level or gently rolling, but in places it is hilly and rolling, showing some evidence of morainic accumulation. In the lower areas the till plain seems to have been modified to a greater or less degree by a thin deposit of sediment from the adjacent out-wash-plain section of the county.

The surface soils of the Gloucester series vary from dark gray to grayish brown, and the subsoil from buff to light brown. The lighter colors are more prominent in the lower subsoil and substratum. The subsoils are noncalcareous, and range in texture from a rather heavy clay to an open sandy clay. In most places there occur on the surface and throughout the subsoil and substratum small gravel, cobblestones, and medium-sized boulders, of crystalline and other noncalcareous rocks. In some places calcareous material occurs at a depth of several feet below the surface. The subsoil is everywhere fairly retentive of moisture and moderately open to moisture movement. The surface of the Gloucester soils is mainly that of a rather level to gently rolling glacial-till plain, but it becomes hilly in places.

The Hinckley series is characterized by gray to brown surface soils underlain by buff-brown to light-brown, noncalcareous subsoils. The subsoil and substratum show a wide variation in texture. The substratum remains noncalcareous to considerable depths. In most places small gravel, cobblestones, and medium-sized boulders of noncalcareous rocks occur on the surface and throughout the 3-foot section. The surface is rather rough and hilly, a feature characteristic of morainic material.

The surface soils of the Merrimac series range in color from brown to dark brown and black. The subsoil in places is slightly dark brown, but for the most part it is brown to light brown. The entire 3-foot section and the substratum to great depths are of a sandy

nature, without any marked accumulation of clay, but the subsoil is fairly compact and moderately retentive of moisture. The material apparently is uniformly noncalcareous to great depth, though in some places calcareous gravel and sand mixtures occur at depths of 8 to 15 feet below the surface. The surface of the Merrimac soils varies from level to gently rolling.

The Buckner soils occupy a comparatively narrow strip of disconnected terraces adjacent to the Mississippi River. The series consists of dark-brown to black surface soils underlain by a subsoil ranging in color from rather deep orange brown to somewhat lighter brown. The subsoil and substratum vary from a rather coarse loamy sand to a medium loamy sand, and contain stratified gravel and coarse sand. The material to depths of at least 3 to 10 feet is noncalcareous. It contains enough fine material to be fairly retentive of moisture. The Buckner soils consist of alluvial sediments washed from drift-covered uplands and deposited by the Mississippi River when it flowed at a higher level than at present. They are younger than the Merrimac soils. The surface ranges from rather level to gently undulating.

The soil type classed as Peat consists of a brown and black, spongy, more or less resistant mass of undecomposed roots, moss, and vegetable fiber intermixed with more finely divided material, and underlain by more uniformly black and more finely divided and decayed fibrous matter. Peat owes its origin to the decay of a luxuriant growth of sedges and other aquatic plants in old ponds and lakes. The surface is nearly flat, with a slight slope in the direction of stream flow in places. Areas in which the organic accumulation averages less than 3 feet in depth are not considered typical. Where the underlying soil is a sand the Peat is mapped as a sandy-subsoil phase, and where it is a clay as a heavy-subsoil phase.

In the following pages of this report the various soils mapped in Anoka County are described in detail and discussed in their relation to agriculture. The table below shows the name and the actual and relative extent of each type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Peat.....	91,520	37.6	Miami loam.....	5,632	2.0
Sandy-subsoil phase.....	10,048		Miami fine sandy loam.....	2,880	1.0
Heavy-subsoil phase.....	1,920		Hinckley gravelly sandy loam.....	2,496	.9
Merrimac loamy fine sand....	88,060	32.3	Buckner loamy fine sand.....	2,304	.8
Merrimac loamy sand.....	42,688	15.5	Gloucester loam.....	2,048	.7
Gloucester fine sandy loam...	15,872	5.8			
Hinckley fine sand.....	9,472	3.4	Total.....	275,840

MIAMI FINE SANDY LOAM.

The Miami fine sandy loam consists of a gray to dark-gray fine sandy loam, 8 to 18 inches deep, underlain to a depth of 3 feet or more by a pale-brown to gray clay subsoil which becomes more gray in the lower part and in the substratum. In most places small gravel, cobblestones, and medium-sized bowlders are more or less abundant on the surface and throughout the soil, subsoil, and substratum. Within the 3-foot section they are practically all of crystalline-rock origin, those of limestone origin probably having been dissolved. In a few places the lower subsoil contains calcareous clay, gravel, and bowlders, and the substratum invariably shows an abundance of calcareous material.

The Miami fine sandy loam is developed in the southeastern part of Columbus, Centerville, and Fridley Townships. It has a level to gently rolling surface. In places it occupies low, elongated ridges. The surface drainage and underdrainage are on the whole very favorable for crop growth. The surface material is readily absorptive of rainfall, and the clay subsoil is retentive. The soil is easy to till, and warms up early in the spring.

This is one of the most important soils in the county. About 90 per cent of it is in cultivation, the remainder supporting a growth of large oaks included in woodlots and wooded pasture. Corn, oats, tame grasses, and potatoes are the most important crops on this type. Corn is grown to a considerable extent for silage to feed dairy cows, and dairy products are a source of income throughout the year. Hogs are usually raised in connection with dairying, spring-farrowed pigs being marketed in the fall and winter. Oats and hay are grown principally for use on the farm, only the surplus being sold. Potatoes are usually the last field crop gathered, but only a small proportion of the potato crop is kept for winter storage. Rye, wheat, other grains, garden stuffs, and strawberries are grown to some extent for home and local use. Corn yields from 20 to 40 bushels per acre, oats 25 to 50 bushels, rye 15 to 30 bushels, and wheat 12 to 25 bushels. Potatoes yield from 50 to 125 bushels per acre. Tame hay, consisting largely of clover and timothy, ranges in yield from 1 to 2 tons per acre.

Land values on this type range from about \$60 to over \$100 an acre, depending largely upon the state of improvement. Most of the type is very well situated with reference to railway lines and markets.

The surface soil of the Miami fine sandy loam is sufficiently sandy to be blown into drifts where bare of vegetation. This tendency is largely met by deferring seed-bed preparation until immediately before putting in crops. Grass sod, grain stubble, and potato vines

left in fields retard drifting to some extent. In other parts of the United States, under similar conditions, it has been found advisable to lay off fields in narrow strips, bounded by grass sod. The turning under of manure, straw, and other vegetable matter would lessen injury from drifting, and the growing of green cover crops to be turned under would also be of benefit in maintaining the productivity of the soil. Rape or millet could well be sown in corn fields at the last cultivation, as such seeding would add to the corn-stubble pasturage following corn harvest, in addition to lessening the exposure of the soil to wind erosion.

MIAMI LOAM.

The Miami loam consists of a gray to dark-gray very fine sandy loam to loam, 6 to 10 inches deep, underlain by a brownish-drab to gray clay with brown and greenish mottling. On the surface and throughout the soil to a depth of several feet there are usually present more or less small gravel, coarse gravel, and boulders. To a depth of about 3 feet this coarse material is almost entirely of crystalline-rock origin, those of limestone origin that may have been present in earlier geologic time probably having been disintegrated and the lime leached away. In some places, however, the clay, gravel, and larger rounded stones in the lower subsoil are calcareous. The substratum is invariably strongly calcareous.

In the lower lying situations contiguous to the Miami fine sandy loam there has been some modification by overwash from the outwash plain area, and fine sand and very fine sand have been mixed with the soil to such a degree that it is hard to distinguish the type in places from the fine sandy loam.

The Miami loam occurs in close association with the Miami fine sandy loam, fairly well removed from the outwash-plain area. It is developed in the southeastern parts of Columbus, Centerville, and Fridley Townships. In general it has a plainlike, level to gently rolling surface. In the southern part of Centerville Township and over most of the type in Fridley Township the surface is more hilly and knolly. With very few exceptions, the type has good surface drainage and underdrainage, and is retentive of moisture.

The Miami loam is an important type agriculturally. It is naturally strong and productive. Ninety per cent or more of its area is in cultivation, the remainder consisting of woodlots. Corn, oats, clover, other tame grasses, and potatoes are the most important crops on this type. It is one of the best soils in the county for dairying, and a large part of the grain and hay grown is fed to dairy cattle. Part of the corn is used for silage, which helps to keep the milk production uniform throughout the year. Hogs are largely

raised in connection with dairying. Cattle are raised in considerable numbers. Corn yields 25 to 50 bushels per acre, oats 25 to 50 bushels, rye 10 to 30 bushels, and wheat 15 to 30 bushels. Potatoes yield 75 to 200 bushels per acre. Tame hay, consisting of clover and timothy mixed as well as each grown alone, ranges in yield from 1 to 2 tons per acre. Strawberries yield from 1,000 to 2,000 quarts per acre.

Owing to its heavier texture this type does not drift readily, and plowing can be done at any season of the year. Fall plowing is desirable, as it lessens the amount of work to be done in the spring, allows the soil to be mellowed by alternate freezing and thawing, and hastens the decay of weeds and other trash. As a consequence, much fall plowing is done on this soil, harrowing and other operations as may be necessary to prepare a proper seed bed being deferred until spring.

Land values on this type range from \$70 to over \$100 an acre. It is favorably situated with reference to railway lines and other means of transportation.

GLoucester FINE SANDY LOAM.

The Gloucester fine sandy loam consists of a dark-gray, gray, or grayish-brown fine sandy loam, 10 to 24 inches deep, underlain by an orange-brown to light-brown clay loam or clay. Occasionally the subsoil may be quite clayey and compact to considerable depths, but in many places the lower subsoil and the substratum have a varying admixture of fine sand and small gravel mixed with clay and are more or less open, though not to the extent of being leachy. The type differs from the Miami fine sandy loam in being less uniformly clayey throughout the subsoil and substratum, and in having an entire absence of calcareous material within the upper 3 or 4 feet. Small crystalline gravel, cobblestones, and medium-sized bowlders occur more or less abundantly on the surface and throughout the soil mass. In places calcareous clay and limestone gravel, cobbles, and bowlders occur at depths of 4 to 8 feet. In the older fields very few bowlders remain on the surface, having been removed from time to time since the land has been under cultivation.

The Gloucester fine sandy loam is developed in the northwestern part of the county. Its principal area lies in Burns Township and in the western part of St. Francis Township, with a small extension into Ramsey Township. The surface is for the most part level to rolling. A small total area is hilly. The type is well drained, but the texture and structure of the soil and subsoil are favorable to the conservation of moisture for crop use.

The Gloucester fine sandy loam ranks high agriculturally. It is easy to cultivate, warms up early in the spring, and responds well to

good cultural methods. About 70 per cent of the type is in cultivation. Most of the remainder supports a growth of large oaks, with some maple and birch and an undergrowth of brush and native grasses. This forested land is used part of the year as live-stock range. Much of it is in farm woodlots, but there are some fairly large tracts remote from cultivated fields.

Corn, oats, hay, and potatoes are the most important crops on this type. It is extensively used for dairying, but it is not as well adapted to this industry as are the heavier soils of the county. Hogs are raised in connection with dairying, and beef cattle are a source of income on many farms. Much of the corn crop goes into silos. Part of the crop is sold, as is also the surplus of the oats and hay produced. Potatoes are an important sale crop. Rye, wheat, other grains, beans, garden crops, and strawberries are grown mainly for home and local use.

Corn yields range from 20 to 40 bushels, oats 20 to 50 bushels, rye 15 to 25 bushels, and wheat 12 to 20 bushels per acre. Potato yields range from 50 to 150 bushels per acre. Tame hay, consisting largely of clover and timothy, yields from 1 to 2 tons per acre.

The surface soil of this type is blown into drifts if allowed to remain bare of vegetation, and for this reason the type is seldom plowed in the fall except where winter rye is to be sown.

Land values on this type range from \$50 to \$70 an acre, depending largely on the state of improvement and the location with reference to transportation points and markets.

GLOUCESTER LOAM.

The surface soil of the Gloucester loam is a gray, dark-gray or grayish-brown very fine sandy loam to loam, 8 to 12 inches deep. The subsoil is an orange-brown to light-brown clay loam or clay. In some places it is compact to a considerable depth, while in others the lower subsoil and the substratum show various admixtures of fine sand and small gravel, forming a mass which is more or less open structured but not so porous as to be leachy. In most places small gravel, cobblestones, and medium-sized bowlders are more or less abundant on the surface and throughout the lower depths. The gravel and stones are entirely of crystalline-rock origin within the upper 3, or 4 feet. In some places gray calcareous clays, limestone gravels, cobbles, and bowlders are encountered at depths of 4 to 8 feet.

The Gloucester loam occurs in a few small areas closely associated with the fine sandy loam, in Burns and Ramsey Townships. Its surface is level to gently rolling, becoming hilly in a few places. The type has thorough drainage, but the soil and subsoil are retentive of moisture.

The Gloucester loam ranks high agriculturally. Owing to its loamy texture it is easily cultivated, and it warms up fairly early in the spring. Over 50 per cent of the type is under cultivation, the remainder largely supporting a growth of oak, with some maple and birch and an undergrowth of brush and native grasses. This soil is used for the same crops and is handled in about the same way as the Gloucester fine sandy loam. Its heavier texture allows somewhat wider latitude in plowing and cultivation, the type not being so subjected to injury from wind erosion.

Land values on this type range from \$50 to \$70 an acre.

HINCKLEY GRAVELLY SANDY LOAM.

The surface soil of the Hinckley gravelly sandy loam consists of a rather light brown to dark-brown, gravelly sandy loam, 10 to 18 inches deep. In the lower part the material is invariably of lighter color than in the surface 5 or 6 inches. Gravel and bowlders are rather abundant in some places, but occasionally they are almost lacking. The subsoil varies in color from orange brown to light brown, and in texture from a rather light clay to a rather open, sandy to sandy and gravelly clay. In some areas it consists largely of sand and gravel with variously sized cobbles and bowlders. In general it contains clay enough to make it retentive of moisture. The gravel, cobbles, and bowlders in this soil are invariably of crystalline rocks, no calcareous material being encountered at any depth. This type differs from the Gloucester in containing more gravel and coarser sand and in having a wider variation in composition, but as mapped it includes some small areas of typical Gloucester soil.

The Hinckley gravelly sandy loam occurs in the extreme northwestern corner of the county. Its surface is rather rough and hilly, being characterized by large and small knolls, hills, and ridges with intervening kettlehole depressions and large Peat marshes. The topography is typical of a rather well developed moraine. The type has thorough natural drainage, but is not markedly droughty, although yields are often reduced to some extent by prolonged dry weather.

The Hinckley gravelly sandy loam ranks lower in agricultural value than the Gloucester soils. Owing to its hilly surface it can in most places be cultivated only in small, irregular fields, and large horse-drawn implements can be used on only a few farms. Apparently 10 to 15 per cent of the type is in cultivation, the remainder being forested mainly with large oak, with some scrub oak and a scattered growth of maple, birch, hazel, and other brush. Wild vetch and grasses afford good grazing during the summer. Considerable merchantable timber remains, and several portable sawmills are in operation in the forested areas.

Corn, oats, and potatoes are the most important crops on this type. Beans and garden crops are grown to a small extent. Yields in general are lower than on the Gloucester soils.

Land values on this soil are rather variable, prices quoted by farmers ranging from \$15 to \$65 an acre. The roads are hilly and in need of improvement in grades and otherwise before heavy produce can be economically transported.

HINCKLEY FINE SAND.

The Hinckley fine sand consists of a rather light brown to dark-brown fine sand, 6 to 10 inches deep, underlain by a subsoil and substratum of light-brown fine sand. In exposed situations the soil is subject to wind erosion and drifting. Deep holes or "blowouts" occur in places. The type is locally known as "Bunker Prairie."

The Hinckley fine sand occurs mainly in the south-central part of the county, in a few fairly large areas in Grow, Anoka, Blaine, and Fridley Townships, and in Bethel Township in the north-central part. In general the surface varies from gently rolling to rather sharply rolling. Some small areas are broken and hilly, as a result of the drifting of the sand, and over these the surface is broken by "blowouts." The type is almost everywhere thoroughly drained, and much of it is droughty. In the lower lying areas but little elevated above the Peat land the water table is normally near the surface, and the moisture conditions are more favorable for crop growth.

Only a small proportion of the Hinckley fine sand is in cultivation. The remainder supports a forest growth consisting largely of scrub oak, with an undergrowth of sand cherry, chokecherry, and coarse sand grasses. Corn, oats, clover, and potatoes are grown on the better areas of the type. Crop yields are rather uncertain, but in some years fairly good yields are obtained.

Land values on this type range from less than \$10 to more than \$40 an acre. The roads on this soil are usually loose and difficult to travel.

Owing to its light, sandy texture, this soil can not be extensively farmed without the incorporation of manure, straw, Peat soil, or green cover crops to serve as a binder. Under present conditions the cleared areas should be kept in tame grasses as much as possible and used as pastures in order to fill the soil with grass roots and prevent drifting.

MERRIMAC LOAMY SAND.

The Merrimac loamy sand consists of a brown to very dark brown loamy sand, 10 to 18 inches deep, underlain by a brown loamy sand subsoil and substratum. The surface material in places appears almost

black. In some areas the surface soil contains pebbles and small gravel, and these are more uniformly present in the subsoil, sometimes in stratified layers. The substratum often contains alternating stratified layers of clean sand, heavy-textured material, and gravel beds of varying thickness. The soil to depths of 3 to 8 feet or more is not highly calcareous. In excavations west of St. Francis and near Anoka the material at depths of 8 to 15 feet, consisting of gravel and sand, is to a fairly large extent calcareous, and calcareous material probably exists in the lower substratum throughout much of the type.

The Merrimac loamy sand occurs quite extensively in the western part of the sand-plain division of the county. It is also developed in narrow strips on the terraces along the Mississippi River. The type is characterized by a rather level to gently rolling surface. It occurs mainly in large areas which contain depressions of various depths often filled with peaty accumulations. The type lies usually several feet above normal stream levels. Along the streams and around depressions some rather steep slopes occur.

The type is naturally well drained, but fairly retentive of moisture. As a whole the type is somewhat more susceptible to drought than the Merrimac loamy fine sand, but in seasons of normal rainfall there is no apparent difference between the two types so far as the supply of moisture for crops is concerned. The higher average level of the Merrimac loamy sand above streams and peat-land depressions may be in part responsible for its greater susceptibility to drought.

The Merrimac loamy sand covers 15 per cent of the area of the county or about one-half the area occupied by the Merrimac loamy fine sand. It is slightly inferior to the latter soil in productiveness, but is nevertheless under the climatic conditions of this region a reasonably good agricultural soil. About 80 per cent of its area is in cultivation. Little if any of the type in the southwestern part of the county has ever been forested; its original vegetation consisted of brush and various grasses and legumes. This part of the type is still locally known as prairie. In the north-central part of the county the type supported a heavy forest of oak and other trees similar to those on the Merrimac loamy fine sand. The remnants of this forest are now confined largely to woodlots.

Corn, oats, hay, and potatoes are the most important crops on this soil. A large part of the farm products is fed to dairy, beef or work animals. Potatoes are the principal money crop. A small surplus of corn, oats, and hay is sold. Hogs, calves, and steers are raised in connection with dairying. Rye, wheat, other small grains, vegetables, and strawberries are grown for home and local use. The average yield of corn ranges in different years from 20 to 50 bushels

per acre. Oats yield 20 to 40 bushels per acre, rye 10 to 25 bushels, and wheat 10 to 20 bushels. Potatoes yield from 75 to 150 bushels per acre.

Land values on this type range from \$40 to over \$100 an acre. Good transportation and market facilities and nearness to towns account for the higher values. Some of the roads within the areas of this type are in good condition, but many are deep with sand, and hard to travel.

The Merrimac loamy sand is not so durable as the types with clay subsoils, but with good farming methods, including the growing of clover, good average yields can be maintained. Where the soil has a tendency to drift preparation of the seed-bed should be postponed until just before seeding. Coarse vegetable matter should be plowed under. The sowing of catch crops such as rape or millet in corn fields at the last cultivation would add to the pasturage value of the corn stubble and lessen exposure of the soil to wind erosion during the winter.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Merrimac loamy sand:

Mechanical analyses of Merrimac loamy sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
320809.....	Soil.....	3.9	21.0	16.6	40.9	3.7	8.1	5.7
320910.....	Subsoil.....	3.7	23.6	18.6	39.2	2.4	7.5	5.0

MERRIMAC LOAMY FINE SAND.

The Merrimac loamy fine sand consists of a brown to dark-brown loamy fine sand, 8 to 10 inches deep, underlain by a light-brown to brown loamy fine sand which in many places continues into the substratum. In some places the type is characterized by layers of clean, loose fine sand alternating with quite heavy textured material, the vertical section here being suggestive of stratification. The material to depths of at least several feet is noncalcareous. Judging from other outwash plain types it is probable that calcareous material occurs at lower depths.

The Merrimac loamy fine sand occurs extensively through the sand-plain division of the county. It is developed to some extent in practically every township, and the upland in the central and eastern townships consists mainly of this type. The surface varies from gently undulating to fairly rolling. None of the type is too rough for easy cultivation. It occurs in large bodies containing peat-filled depressions and ponds, as well as on low knolls and ridges within

large bodies of peat land. The type has good natural surface drainage. In some of the higher lying areas where the subsoil is somewhat open and leachy the type is droughty, but in general the type is fairly retentive of moisture. Areas lying but little above the level of peat land have a relatively high water table, and the supply of moisture for crop use in such places is invariably good.

The Merrimac loamy fine sand next to Peat is the most extensive soil in the county. It covers at least one-third of the total area. Owing to its resistance to drought it is somewhat more productive than the loamy sand. About 65 per cent of the type is in cultivation. The remainder supports a forest consisting mainly of large oak, with a scattering growth of scrub oak and poplar. Sand cherry, choke cherry, and wild plum are found in places, and there is generally an undergrowth of brush and grasses in the forested areas. The forested land is not only of considerable value as a source of firewood, but also affords some pasturage.

Corn, oats, potatoes, and tame grasses, principally clover, are the most important crops on this soil. Dairying is an important industry, although the soils of heavier texture make more ideal dairy farms. Hogs and some beef cattle are raised. Poultry products are a source of considerable income. The yield of corn in good years is as high as on the Gloucester and Miami soils. In extremely dry years it is somewhat lower. The average is about 35 bushels per acre, but with normal rainfall a yield of more than 50 bushels is often obtained. Potatoes yield from 75 to 150 bushels per acre. There is a somewhat wider variation in yields than on types having clay subsoils.

Land values on this type range from \$40 to more than \$70 an acre, depending on the state of improvement, the transportation and market facilities, and the location. The roads over most of the type are in poor condition, many of them being of loose sand.

The Merrimac loamy fine sand is somewhat subject to drifting, which can be prevented to some extent by keeping the land in grass sod or in some catch crop, such as rape or millet, as much of the time as possible.

BUCKNER LOAMY FINE SAND.

The Buckner loamy fine sand consists of a rather dark brown to black, loamy fine sand, 12 to 18 inches deep, underlain by a subsoil of brown loamy fine sand. The change from surface soil to subsoil is very gradual. In several included areas the texture ranges to a very fine sandy loam or loam. In some places the soil and subsoil contain gravel. Apparently there is no calcareous material within the 3-foot section, but the substratum is probably more or less calcareous.

The Buckner loamy fine sand is developed on narrow, disconnected terraces along the Rum and Mississippi Rivers. These terraces are frequently spoken of as bottom lands, and lie only 2 to 10 feet above the stream, but they are almost entirely above the reach of overflows.

The surface varies from level to gently undulating, and in most places drainage is good. On the whole this type seems to be less susceptible to drought than the Merrimac loamy sand, probably because of its lower position and higher ground-water level.

The native vegetation on this soil consisted of large oak, soft maple, and box elder, with some willow and poplar and an undergrowth of briars, vines, and wild grass. A very large proportion of the type is in cultivation, principally to corn, oats, potatoes, and hay crops, including clover. The type is farmed in practically the same way as the Merrimac loamy fine sand. Yields probably average a little higher. Land values range from \$50 to \$100 an acre.

PEAT.

To a depth of 10 to 12 inches the typical Peat consists of a brown to black, spongy, more or less resistant mass of partly decayed roots, stems, and other vegetable remains, intermixed with more finely divided and more thoroughly decomposed peaty matter. The underlying material to a depth of 3 to 10 feet or more is uniformly more dark in color, and is composed of more finely divided vegetable matter, resting on a substratum of grayish fine sand, or in places of marl or calcareous deposits.¹

Peat is an extensive type. It occurs throughout the county in areas ranging in size from a few to several thousand acres. The largest developments are encountered in the eastern half of the county.

The surface of the type is flat or nearly flat. Some areas show a slight slope in the direction of the natural drainage. The Peat is prevaillingly poorly drained. Considerable ditching has been done, but much systematic work is necessary before the land can be used for farming. Much of the former ditching was done at the heads of the natural drainage ways, or even above their sources, with the result that the channels were unable to carry off the extra volume of water, and large areas of Peat along the lower courses were flooded. Some of this inundated land had formerly been used for hay production. At the present time steps are being taken to deepen the natural drainage channels and to dig large, deep main ditches through the larger Peat areas to be connected with laterals. A State law provides that check dams may be placed in ditches when these will cause no injury

¹ Tests made by the Division of Soils, University of Minnesota.

to adjacent lands. This provision is important to farmers who use marshland areas for growing wire grass, which flourishes only under swampy conditions.

The typical Peat supports a varied vegetation. In the wetter open marshes there is a dominant growth of wire grass. The less wet, partly drained open marshes have a cover of various marsh grasses, with "brown top" often the dominant growth. These better drained marshes are locally known as "meadows," and at present they are the source of most of the wild hay produced. About two-thirds to three-fourths of the Peat area is open marsh. Much of the remainder has a mixed cover of native grasses, with swamp willow, alder and other brushy shrubs, and a second growth of poplar on burnt-over patches. In some places there is a rather dense growth consisting principally of tamarack trees ranging from 3 to 6 inches in diameter, with a scattering undergrowth of grass and brush. The areas forested with tamarack at one time yielded considerable timber for railroad ties and cordwood.

Most of the type at present may be used, and much of it is used, as pasture land. A considerable proportion is used for the cutting of wire grass for the manufacture of matting and a large total area is cut over for hay. Cultivation is limited to the growing of corn, tame grasses, and some other crops in an experimental way, the total acreage of deep Peat brought under the plow to date amounting to less than 200 acres. Wild hay is cut in August and September. Under average conditions at this season of the year even areas ordinarily wet are sufficiently dry to permit the use of horses, shod with bog shoes, in the cutting of wire hay, the spongy surface material being sufficiently firm to carry the teams, even though the peaty material beneath is wet and plastic.

The yields of wild hay on the typical Peat range from about three-fourths ton to $1\frac{1}{2}$ tons per acre. Any extensive utilization of Peat for the growing of cultivated crops is dependent on adequate drainage. The land is ordinarily most completely drained in the fall, and plowing and seed-bed preparation could well be done during that season. When the land has been sufficiently drained, the use of heavy teams in cutting hay and the tramping of live stock in pasturing are beneficial in breaking down and compacting the material. In some other counties heavy traction engines are employed on Peat to compress the mass. Where there is an abundance of tough roots and brush, burning has been found beneficial. This must be done at a time when only the surface 3 or 4 inches is dry enough to burn, as otherwise fires may get beyond control. According to the limited investigation that has been made, phosphatic preparations and barnyard manure are the best fertilizers to use in farming the Peat of Anoka County.

Prices for land composed of the typical Peat range from less than \$10 an acre to as much as \$30 an acre. There are no farmsteads on this land, the buildings being placed on adjoining upland soils.

Peat, sandy-subsoil phase.—The Peat, sandy-subsoil phase, consists of black peat, containing a small percentage of sand, to a depth of 10 to 18 inches, underlain by a grayish fine sandy subsoil which usually rests upon a sandy substratum. The peaty accumulation ranges in thickness from a deep deposit in some places to a very thin layer next to the upland. The surface material ranges considerably in texture, owing to various admixtures of fine sand. With good drainage and continued cultivation the peaty material would gradually be worked into the underlying sand, giving rise to a dark-gray or black sandy surface soil.

The Peat, sandy-subsoil phase, is not extensive. A few areas lie in the east-central part of the county, where they are associated with larger areas of typical Peat and are either surrounded by or adjacent to the Merrimac loamy fine sand. As in case of the typical Peat the surface of this soil is nearly level and the drainage prevailing poor. The phase in some places occurs on low shelves next to the uplands, and here has slightly better natural drainage. The installation of ditches in the areas of the deeper, typical Peat would materially improve the drainage of the sandy-subsoil phase.

The Peat, sandy-subsoil phase, supports a native growth similar to that on the typical Peat, except that tamarack and wire grass are almost entirely lacking. The phase is used to a considerable extent for pastures and the cutting of wild hay. Corn and tame grasses are grown to a small extent. The yields of wild hay range from three-fourths to 1½ tons per acre. Corn, tame grasses, and other crops give promise of good yields after the land has been well drained.

This soil where under cultivation may safely be plowed in the fall and prepared long in advance of planting. Harrowing or otherwise loosening the surface soil in the spring aids in warming up the seed bed.

Prices of Peat, sandy-subsoil phase, have about the same range as for the typical Peat, from less than \$10 to about \$30 an acre. The phase is usually sold in conjunction with upland soils, and the price depends largely on the state of improvement, the transportation and market facilities, and the nearness to high-priced lands.

Peat, heavy-subsoil phase.—The Peat, heavy-subsoil phase, consists of black sandy peat or muck 10 to 18 inches deep, underlain by a grayish, clayey to fine sandy clay subsoil, which rests upon either a clayey or a fine sandy substratum. As in the case of the sandy-subsoil phase, the peaty accumulation is deep in some small areas and very thin in some places next to the uplands. The surface material also varies widely in texture, owing to various admixtures

of fine sand and clay. Under good drainage conditions and with continued cultivation the peaty material would gradually disappear, leaving a black, mucky, sandy or clayey material.

The Peat, heavy-subsoil phase, occurs in association with upland soils of clayey texture or underlain by clayey subsoils, such as the Miami and Gloucester soils. It is of small extent, occurring in a few areas in the southeastern and northwestern parts of the county. The surface is nearly level, with in places a slight slope in the direction of natural drainage.

A shelflike position of some areas occurs as in the sandy-subsoil phase. Drainage is slightly better here, but as a whole the phase is poorly drained.

The Peat, heavy-subsoil phase, supports a native growth similar to that on the typical Peat, except that there is practically no tamarack or wire grass. Some of the phase is being drained. It is used to a considerable extent as pasture and the cutting of wild hay. A small total area is used in growing corn and tame grasses. The yields of wild hay probably average somewhat higher than on the sandy-subsoil phase. When drained it will be more productive and more durable. The land ranges in price from \$10 to \$30 an acre.

SUMMARY.

Anoka County lies southeast of the center of the State of Minnesota, just north of Minneapolis. The greater part of the county comprises glacial-drift and outwash plains, and has a rolling to nearly level surface. The upland ranges in elevation from 850 to 1,060 feet above sea level. The Mississippi River flows in a deep channel along the southwestern boundary of the county, and is bordered by a very narrow strip of alluvial land. A large part of the upland is traversed by peaty depressions and marshes.

The population of Anoka County in 1910 was 12,493. Anoka, the county seat and largest town, had a population of 3,972. The county has excellent railroad facilities. St. Paul and Minneapolis, which are only a few miles from the southern county line, furnish a steady demand for farm products.

The winters are marked by periods of below-zero weather, alternating with periods of thawing. The summers are short and warm. The average growing season is 163 days in length. The annual rainfall, averaging 29.31 inches, is well distributed with respect to the growing season.

Farming began in Anoka County in 1848, and crop production has shown a steady increase since that year. The census reports nearly one-fourth of the county in cultivation in 1909, the total value of all farm crops produced in that year amounting to \$1,118,212. Corn,

potatoes, and hay are the most important crops. The income from live-stock industries reached the sum of \$566,137 in 1910.

The soils of Anoka County range in texture from light sands to loams. The soils of heavier texture are productive and durable under cultivation. Commercial fertilizers have not been used to keep up the productiveness, but manure is extensively used and crop rotations including clover are followed by most farmers.

In addition to Peat, nine types of soil are mapped in Anoka County, representing five series.

The Miami soils are light colored, derived from glacial drift. They have a higher lime content than the other upland soils. The fine sandy loam and the loam of this series are mapped. These are very desirable agricultural soils, and about 90 per cent of their total area is farmed.

The Gloucester series comprises light-colored soils derived from glacial drift made up mainly of crystalline-rock material. They have a somewhat lower lime content than those of the Miami series, but do not differ greatly in agricultural value.

The Hinckley soils are sandy and gravelly. They are derived from the granitic material of the moraines, and have been reworked in places by the wind. The topography ranges from gently rolling to rough and broken. On account of the unfavorable topography and their porous nature, these soils are not so productive as the other upland types.

The Merrimac soils cover the greater part of the sand plain. They comprise brown to dark-brown surface soils, with light-brown, sandy subsoils. They are retentive of moisture and productive. The surface varies from nearly level to gently undulating.

The Buckner series includes the soil of the river terraces. The surface soil is brown to dark brown, and the subsoil light brown and sandy in texture. Except in position, the Buckner series does not differ greatly from the Merrimac. Moisture conditions are somewhat better on the former.

The typical Peat consists of dark-brown to black, partly decomposed organic matter more than 3 feet deep. It occurs in depressions and has poor natural drainage. Two divisions are shown in the shallow Peat, a sandy-subsoil phase and a heavy-subsoil phase. The typical soil and its phases together cover two-thirds the area of the county.

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