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

SOIL SURVEY OF RAMSEY COUNTY, MINNESOTA.

BY

WILLIAM G. SMITH AND N. M. KIRK.

CURTIS F. MARBUT, INSPECTOR IN CHARGE.

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

WASHINGTON:
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1916.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Soils,
Washington, D. C., December 8, 1915.

Sir: The accompanying report and soil map cover the survey of Ramsey County, Minn., one of the projects undertaken by the bureau during the field season of 1914.

I recommend the publication of this report as advance sheets of Field Operations of the Bureau of Soils for 1914, as provided by law.

Very respectfully,

Milton Whitney,
Chief of Bureau.

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

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SOIL SURVEY OF RAMSEY COUNTY MINNESOTA.

By WILLIAM G. SMITH and N. M. KIRK.

DESCRIPTION OF THE AREA.

Ramsey County is located in the east-central part of Minnesota. It is bounded on the north, east, south, and west sides, respectively, by Anoka, Washington, Dakota, and Hennepin Counties. It is about 12 miles wide east and west and its greatest length north and south is about 16 miles. The south boundary for the most part follows the Mississippi River, and is irregular. The county has an area of 161 square miles, or 103,040 acres.

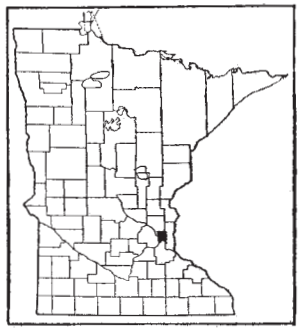

FIG. 1. — Sketch map showing location of the Ramsey County area, Minnesota.

Approximately 93 per cent of the area of Ramsey County is upland, the remainder being about equally divided between terraces and low bottom lands along the Mississippi River.

The upland surface of Ramsey County is that of a drift plain that holds one general altitude but presents minor relief features consisting of morainic hills and ridges with intervening depressions. The configuration is mainly constructional, the surface not having been influenced by the structure or hardness of the underlying rocks, nor modified to any great extent by erosion. The range in elevation is from 860 to 1,080 feet above sea level, and the greater part of the county lies between the 900 and 1,000 foot contours. The higher points may occur in any part of the county, as there is no perceptible slope of the upland in the direction of the general regional drainage. The surface features, though not strikingly prominent, are of great importance in influencing the character of the soil. In the northeastern and northwestern parts of the county there are large bodies of flat to gently undulating land, much of it poorly drained and interspersed with lakes and swampy tracts. Between these is a morainic region of comparative roughness, which contains several large lakes and numerous smaller lakes. The central and southwestern parts have a more even distribution but less extensive development of moraines, with smaller depressions. In

the southeastern part of the surface is roughened by the presence of moraines and to some extent by erosion.

The Mississippi Valley has an S-shaped course along the southern border of the county. Above Fort Snelling the river flows in a deep channel, there being an abrupt break of more than 100 feet from the plain to the river channel. Below Fort Snelling the valley widens to a mile or more and below St. Paul the alluvial lowland attains a width of about 2 miles. Here the slope from the upland begins with a slightly eroded border drained by small streams and draws, and ends with an abrupt descent of 100 to 200 feet to the bottoms. The latter are flat and poorly drained. Sloughs, old river channels, and cut-off lakes traverse the lower bottoms.

Drainage is incompletely established over a large part of the county. Two streams, Rice Creek in the northwestern corner and Phelan Creek entering the Mississippi at St. Paul, drain a few square miles each, and they, with a few small drainage ways along the bluff line overlooking the Mississippi River Valley, give the only surface drainage for the entire county. A chain of lakes through the center of the county is connected by drainage ways, but the system has no active natural outlet. It is extensively drawn upon by the city of St. Paul as a source of water supply. Over most of the county the run-off finds its way by swales and shallow, indefinite valleys to the lakes and depressions.

The population of Ramsey County is given by the census of 1910 as 223,675, having increased 31 per cent during the preceding decade. Ramsey County is by far the most densely populated in the State, and leads also in the density of rural population, with 55.5 persons to the square mile. Of the total population, the census shows 28.6 per cent to be born of native parents, 43.7 per cent native born of foreign or mixed parentage, and 26.2 per cent foreign born. Foreign nationalities most largely represented are German, Swedish, Irish, Norwegian, Russian, Canadian, and Austrian.

St. Paul, the capital of the State and the county seat, contains 96 per cent of the population of the county, 214,744 persons being accredited to it in the Thirteenth Census. Minneapolis, the largest city in the State, lies in the county adjoining Ramsey County on the west. These cities not only provide exceptional markets for every variety of farm product, but have extensive industries that utilize these products, including creameries, packing plants, and canneries. The flour-milling industries of these cities are of national importance.

Ramsey County has excellent transportation facilities. Main lines of several important railroads connect St. Paul and Minneapolis with Milwaukee, Chicago, Duluth, and the Pacific coast. Railway stations are numerous in every township, and lines radiate in all

directions. The Mississippi River was extensively used for traffic before the railroads reached their present efficient development, and boats still ply upon it between St. Paul and St. Louis. St. Anthony Falls, between St. Paul and Minneapolis, which furnishes water power used in milling, is the northern limit of navigation.

As Ramsey County is largely semiurban, schools, churches, and other institutions are numerous, and all rural improvements are well advanced.

CLIMATE.

Ramsey County lies in the northern part of the North Temperate Zone. The climate is characterized by moderate precipitation, cold winters, and warm summers. In summer the days are sometimes hot, but the nights are usually cool.

The mean annual temperature is 43.9° F. The absolute range of temperature is from 104° F., recorded in July, to —41° F., recorded in January. Freezing weather has occurred in every month except June, July, and August, but the average growing season is 159 days, which is sufficient to permit the production of a good range of crops. The average date of the last killing frost in the spring is April 27, and that of the first in the fall, October 3. Killing frost has occurred as late as May 23, and in the fall as early as September 8. The ripening of corn is uncertain, except with early maturing varieties, which are being developed.

The mean annual precipitation is 27.80 inches. The year of minimum rainfall had 14.86 inches, and 49.69 inches was the greatest rainfall observed in any one year. The annual fall of snow, unmelted, averages 37.1 inches. Snow has fallen in every month except June, July, and August.

The rainfall is well distributed for agriculture. Nearly three-fourths of the precipitation falls during the growing season, from April to September, inclusive. Droughts are of rare occurrence, though not unknown in years of abnormally low precipitation. The alternate freezing and thawing that occurs during the fall, winter, and spring months has a very beneficial effect on the physical condition of the soils, especially the clayey types, and the benefit is accentuated on soils that have been plowed early in the fall. This has led to the rather common practice of fall plowing. On the other hand, the alternate freezing and thawing is injurious to exposed vegetation, such as strawberries, grapes, and raspberries. Such plants are often covered with straw, or buried in the fall under a thin cover of soil, which is removed in the spring. A good depth of snow serves the purpose of protection equally well, but the continuance of snow cover is rather uncertain.

The following table, compiled from records of the Weather Bureau station at St. Paul, covering a period of 72 years, shows climatological conditions in Ramsey County:

Normal monthly, seasonal, and annual temperature and precipitation at St. Paul.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	18.8	58	−39	0.97	0.71	1.95	5.7
January	11.9	49	−41	0.89	0.38	1.00	7.7
February	15.4	61	−33	0.79	0.00	0.61	6.2
Winter	15.4			2.65	1.09	3.56	19.6
March	28.2	76	−22	1.44	1.28	4.11	8.8
April	45.8	87	7	2.41	0.56	5.62	3.6
May	57.7	94	23	3.44	0.47	6.57	0.2
Spring	43.9			7.29	2.31	16.30	12.6
June	67.2	96	36	4.10	1.62	3.14	0.0
July	72.0	104	45	3.53	4.01	7.59	0.0
August	69.7	100	40	3.47	2.00	9.60	0.0
Summer	69.6			11.10	7.63	20.33	0.0
September	60.5	96	28	3.39	1.14	2.75	Trace.
October	48.4	87	12	1.99	1.60	5.35	0.2
November	31.0	74	−24	1.38	1.09	1.40	4.7
Fall	46.6			6.76	3.83	9.50	4.9
Year	43.9	104	−41	27.80	14.86	49.69	37.1

AGRICULTURE.

Ramsey County was one of the first organized in the State, being one of the nine counties created in 1849 by the first legislature of Minnesota. In 1850, when the county included a larger area than now, the population was only 2,197.

The early activities of the settlers were largely along the line of marketing forest products, such as railroad ties, cordwood, and some lumber. Clearings were gradually made for field and truck crops. One of the most important products in the early history was cranberries. It is said that the swamps and marsh land yielded 2,135 barrels of wild cranberries in 1849, and during succeeding years large quantities were marketed at St. Paul.

The total acreage of cultivated land is shown by the census to have been about the same, 20,000 acres, in 1880, 1890, and 1900. The census

of 1910 shows 32,268 acres in use, indicating a gain of a little over 50 per cent during the preceding decade. The cultivated land in 1909 comprised only about 31.3 per cent of the area of the county, the remainder being largely in city and suburban property, parks, lakes, and marshes, tracts of woodland, and pasture lands.

The census of 1880 showed 8,460 acres in wheat, 6,386 acres in hay, 2,258 acres in oats, 1,675 acres in corn, and 311 acres in barley, rye, and buckwheat combined. The production of potatoes amounted to 101,522 bushels. Market-garden produce was valued at $46,122, forest products at $8,236, and fruits and nuts at $2,110. The tobacco grown in 1879 amounted to 1,320 pounds. Later census reports do not mention tobacco.

By 1890 there was a marked reduction in the wheat acreage. Hay crops and potatoes showed pronounced increases and oats and corn showed slight increases in acreage over 1880. The value of the market-garden products was more than double that of 10 years earlier, reaching $156,115. The 1890 census reports indicated a development in fruit and truck production, including especially potatoes.

Between 1890 and 1900 there was a gain in the acreage of the cereal and forage crops. The value of orchard products, grapes, and small fruits produced in 1899 reached $14,632, while products of the forest amounted to only $5,881. The live-stock industries were an important source of income. Dairy products were used on farms or sold to the value of $426,890. Animals sold and slaughtered brought $43,415, and poultry products $15,771.

The agricultural interests of Ramsey County are widely diversified. The accessibility of good markets has favored the development of dairying and market gardening. As a source of income the dairy products exceed all others, their value above home consumption as shown by the 1910 census being $611,854. Special crops grown in market gardens are of almost equal value. The production of oats, corn, wheat, and other grains, as well as of hay and forage crops, is scarcely sufficient for home and local consumption.

Of the special crops, potatoes are the most important. This crop occupied 3,931 acres in 1909. The production was 497,939 bushels and the value of the crop almost $200,000. The potato crop is gathered in September and October and is mostly taken by the local markets. Vegetables other than potatoes almost equal the potato crop in value. They are also consumed almost entirely in the near-by cities. In addition to these vegetables a number of products are grown under intensive-farming methods near the city, including nursery stock, fruit, and mushrooms. These reached a total value of more than $200,000 in 1909.

It is estimated that about one-half of the farmers are engaged in the production of the various special crops, and these, according to the last census, occupied almost one-fifth the entire farmed land.

Hay and forage crops occupied almost 46 per cent of the total acreage under cultivation in 1909. More than half of the hay land is in timothy or timothy and clover mixed. The hay, with the exception of part of the timothy, is fed on the farm. The high price obtained in the city for timothy sometimes influences farmers to change from dairying to hay production, but such changes are not usually permanent.

The cereal and seed crops are almost exclusively consumed on the farm, with the exception of oats, a part of which is sold. Oats are the leading grain crop in acreage and value, with corn second. Most of the corn produced is consumed on the farm. Only 635 acres of wheat were grown in 1909, according to the census, and the production is not sufficient for the needs of the farming population. Barley, rye, spelt, and peas are grown, but on a very small scale.

The live-stock industries, of which dairying is the most important, produce more income than any other branch of agriculture. Most of the dairy farms sell only milk and cream, but small quantities of butter and cheese are made. Animals sold and slaughtered, including calves, beeves, and hogs, reached a value of $108,397 in 1909, and poultry products brought $92,162.

The type of agriculture in Ramsey County is based upon the production, as far as possible, of the means of subsistence for the family, of feed for the live stock, and the conversion of the surplus, together with special crops and dairy and live-stock products, into cash. Near the city there is a tendency toward specialization, that is, there may be dairying exclusively or market gardening, but the tendency over the greater part of the county is to carry on a combination of these special branches, with general farming as the main type of agriculture. In more remote parts of the county, where land is cheaper, more attention is given to grain and forage crops. Dairying is more general where there are tracts of land not suited to cultivation, as such land can be used for pasture and the production of wild hay. Winter pasturage is not available for dairy cattle. The winter feed consists largely of ensilage and hay.

The demands of the Twin Cities have had a greater influence in determining the distribution of crops than the factor of soil adaptation. There is in Ramsey County a wide variation of soils, ranging in texture principally from fine sand to loam. All these soils are suitable for general farming, dairying, and market gardening. Where attempt is made to select the soils according to their crop value, the heavy soils are used for general farming and the lighter soils for

vegetables, but, the practices being determined mostly by location, nearly all the soils close to the cities are used for truck crops and in more distant parts of the county all the types are indiscriminately utilized in some way for dairying. Under such circumstances, there is naturally little recognition of the adaptation of crops to certain soils, except where there are certain extremes in texture or composition as, for instance, where patches of Peat or Muck are used for celery, radishes, etc.

On account of the large number of crops grown there is a constant changing of crops upon any given field, but this is not from any direct intention to practice crop rotation. There is no legume in extensive cultivation, as would be necessary in a proper rotation. Clover is cultivated only to a small extent, usually with timothy, so that its full effect as a soil improver is not obtained.

Some of the soils of the county are exceptionally strong, the good effects of manuring lasting for years. On the other hand, there are several soil types of low natural productiveness that yield well when heavily manured, but soon decline under faulty cropping methods. Barnyard manure has been relied upon largely to maintain the producing power of the soils, and in general has been quite effective. The demand, however, for manure by market gardeners and mushroom growers exceeds the available supply, and more attention to the improvement of soils by crop rotations and the growing of legumes may be necessary, as well as the more extensive use of commercial fertilizers, which are at present little employed.

Fall plowing is a common practice. Heavy double and single riding plows are used to a great extent, though not to the exclusion of ordinary walking plows. Intertillage of such crops as corn and potatoes is usually done with riding cultivators. Potatoes are planted and harvested to a considerable extent with machinery.

The expenditure for labor in 1909 amounted to $329,953, about 60 per cent of the farms reporting outlay. By the month, farm laborers are paid $25 to $35. Day laborers receive $1.75 to $2.50 per day. These figures are in addition to board.

The 1910 census reports 1,067 farms in Ramsey County, of an average size of 56.7 acres. Of the total number, 707 range between 2 and 50 acres in size. These smaller tracts comprise largely the truck and dairy farms. Farms in the county range up to 500 acres in size. The census reports 58.8 per cent of the county in farms, and 68 per cent of the farm land as being improved.

The average value of all property per farm is reported by the 1910 census as $9,116, of which 69.4 per cent represents land, 20.6 per cent buildings, 2.4 per cent implements, and 7.7 per cent domestic animals. The average land value per acre in 1910 is given by the census as $111.47.

Lands in cultivation are at present held at about $75 to $400 an acre. There are many tracts of land with lower valuations, including swamps or rough or leachy land, and on the other extreme considerable land is held at more than $400 an acre, such values being due largely to city advantages.

According to the 1910 census, 78.1 per cent of the farms of the county are operated by owners, 19.5 per cent by tenants, and 2.4 per cent by managers.

The farms, as a rule, are well equipped for the type of farming that prevails. The barns, silos, and farm machinery are of the latest improved designs. The farm dwellings are, as a rule, of good appearance and comfortable, and indicate a general condition of prosperity.

SOILS.[1]

The upland soils of Ramsey County owe their origin directly and indirectly in large measure to glacial action in various forms. There are primarily two rather distinct glacial-drift sheets and these with their derivatives appear to form the basis of most of the soils of the area. Figure 2 shows the character and origin of the soil material of Ramsey County.

A sheet of red drift covers the entire upland area to considerable depth. This is in turn partly overlain by a sheet of gray drift, which covers more or less completely the northwest half of the area of the county to a depth of about 15 feet. The surface exposures of the original glacial-drift materials of both sheets are rather irregularly distributed in the county.

The Miami soils are derived largely from the till or bowlder clay of the gray drift, while the Gloucester soils are derived largely from that of the red drift till.

Different glacial-till sheets laid down in a readvance of the glaciers over their own and other outwash plains (aqua-glacial deposits) formed some hilly areas with thick gravelly, sandy substrata. Soils of the Hinckley and Thurston series are derived largely from this material.

The outwash plains that remained undisturbed, and which form rather level areas between areas of glacial till or bowlder-clay hills, give rise to the Merrimac and Hempstead soils.

The lacustrine deposits exposed within the upland area give rise to the Clyde silt loam, while the swampy areas have been mapped as Marsh.

Some exposures of the Platteville limestone occur in the southwestern part of the county, and the weathered product of this rock gives rise here to the Sogn clay loam type. Soil from the glacial

[1] Acknowledgment is made to F. W. Sardeson for data on the geology of the county.

river débris that lies as a high terrace overlooking the present Mississippi River gorge is mapped as the Millsdale loam, and the bold

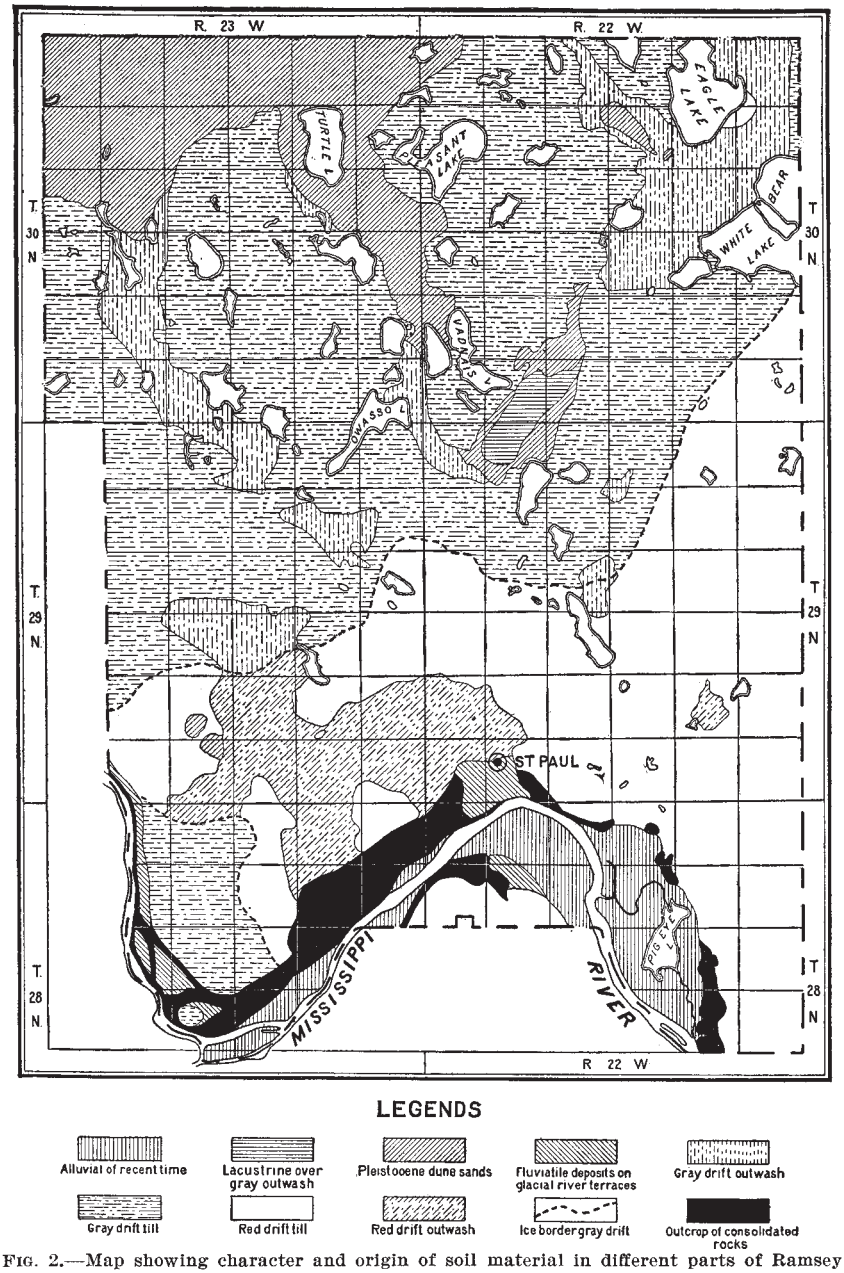

FIG. 2.—Map showing character and origin of soil material in different parts of Ramsey County.

cliff exposures of the limestone and St. Peter sandstone of the Mississippi gorge are shown as Rock outcrop.

The Pleistocene fluviatile deposits, built up at a time when the Mississippi River was fed by the melting away of the great glaciers and now represented by high terrace remnants, give rise to the Waukesha fine sandy loam and the recent alluvial deposits of the Mississippi River to the Wabash soils.

In subsequent pages the characteristics of these various series and the individual soil types are discussed in detail.

The following table shows the actual acreage and relative extent of the several soils mapped in Ramsey County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Gloucester loam	16,576	16.1	Merrimac fine sand	2,560	2.5
Merrimac loamy fine sand	13,760	13.7	Hempstead silt loam	2,496	2.4
Colluvial phase	384		Millsdale loam	[1] 2,240	2.2
Miami loam	11,648	11.3	Wabash loamy fine sand	1,600	1.5
Merrimac loam	11,520	11.2	Clyde silt loam	1,152	1.1
Marsh	10,880	10.6	Hempstead fine sandy loam	704	.7
Thurston loam	6,784	6.6	Waukesha fine sandy loam	640	.6
Miami fine sandy loam	6,400	6.2	Rock outcrop	640	.6
Gloucester fine sandy loam	5,632	5.5			
Hinckley loamy fine sand	4,032	3.9	Total	103,040	
Wabash silt loam	1,472	3.3			
Mucky phase	1,920				

[1] Including Sogn clay loam.

MIAMI SERIES.

The soils of the Miami series are brown to light brown in color, underlain by brown, yellowish-brown, mottled brown or yellow and gray subsoils, usually slightly heavier than the soils. The heavy members alone have mottled and therefore somewhat imperfectly drained and aerated subsoils. The Miami soils are derived from glacial-drift deposits containing a considerable percentage—usually more than 25 per cent—of limestone material. The topography is smooth to gently rolling, rarely being bolder. In Ramsey County the series is represented by the fine sandy loam and loam types, small areas of the clay loam type being mapped with the loam and distinguished by inclusion symbol.

MIAMI LOAM.

The surface soil of the Miami loam consists of about 8 to 16 inches of gray to dark brownish gray loam. Some local variations within the type as mapped include a range in texture from a rather fine sandy loam on one hand to a silt loam or clay loam on the other.

The subsoil to a depth of 3 feet or more consists of a brownish to grayish clay loam. In dry sections the subsoil appears rather hard

and compact, but when wet it is soft and plastic. The texture and structure are such that the type admits of normally free movement of ground water, but at the same time is retentive of moisture for crop use.

Bowlders, cobblestones, and gravel particles of varying size are found on the surface and throughout the 3-foot section, but rarely in such quantity near the surface as to interfere with cultivation. Where formerly troublesome, they have been removed in the course of cultivation until only a few remain. The bowlders and gravel are mainly of crystalline rock. Geological investigations have shown that limestone fragments once present have been almost entirely disintegrated to a depth of 3 or 4 feet by weathering.

The substratum is mainly a gray heavy clay of considerable depth, containing bowlders, cobblestones, and gravel particles similar to those in the 3-foot profile, with the exception, however, that here limestone, as well as crystalline bowlders and gravel, are common. In some areas of the type the substratum is reddish gray to brownish instead of gray, as is characteristic. Local variations noted in the substratum include gravelly, sandy cones and lenses of considerable extent, showing cross-bedding, the mass lying about 3 to 6 feet below the surface. These sandy and gravelly pockets are often utilized as a source of material for surfacing roads and for concrete construction.

The soil does not effervesce with hydrochloric acid. The subsoil rarely effervesces, except in the lower part, and it does not respond invariably even there. At depths of 4 to 8 feet or more, however, there is, as a rule, strong effervescence.

The Miami loam is found in two large areas and numerous smaller ones. The most extensive body of the type occurs along the western border of the county about midway between the north and the south boundaries, and near the city of Minneapolis. The second area in importance lies southeast of New Brighton and extends to Owasso Lake. The smaller areas occur mainly northeast of these two larger ones.

The surface of the type varies from gently rolling to hilly or bumpy, such as characterizes typical morainic areas. None of the land is too rough to cultivate. The type is well drained, although regional drainage is not well established in this part of the county. Much of the rainfall sinks into the porous soil and is retained, while the relatively small run-off finds its way by imperfect channels to the small lakes and depressions.

The Miami loam owes its origin to weathering of the more finely divided part of the gray glacial drift. The type as mapped probably includes some local areas having an admixture of the older red glacial-drift material.

The type is well adapted to the various general farming and truck crops. The soil is naturally productive, and, as a rule, is kept in good condition. Barnyard manure is used rather liberally on the type and rotations are often practiced. The soil is easily worked.

Land values on the Miami loam range from about $50 to $400 an acre.

MIAMI CLAY LOAM.

Areas of Miami clay loam included with the Miami loam type are distinguished by the inclusion symbol. The clay loam occurs mainly in the form of "clay galled spots" or local variations in areas of the Miami loam or fine sandy loam. It consists of about 8 to 10 inches of brown to gray clay loam, ranging in some places to a rather clayey loam, underlain by a brown to mottled gray and yellow clay subsoil that extends to a depth of 3 feet or more. The surface soil and subsoil are rather compact when dry, and somewhat plastic when wet. Bowlders and pebbles occur as in the contiguous Miami loam. The top soil does not effervesce with acid, but the subsoil shows more or less reaction. The moisture-holding capacity is good, although water movement is rather free.

The Miami clay loam lends itself less readily to tillage under varying moisture conditions than either the loam or fine sandy loam. It is of equal productiveness, however, under good management.

MIAMI FINE SANDY LOAM.

The Miami fine sandy loam to a depth of about 8 to 12 inches consists of a gray to dark brownish gray fine sandy loam, underlain to a depth of 3 feet or more by a brownish to grayish clay loam. There are included variations in which the texture is either lighter or heavier than typical. The subsoil is fairly uniform in texture. It is hard and compact when dry, and soft and plastic when wet. The 3-foot section is of such structure as to admit of normally free ground-water movement, but at the same time is retentive of moisture for plant use.

Bowlders, cobblestones, and gravel are scattered on the surface and throughout the 3-foot section. They are seldom so abundant as to interfere seriously with cultivation. Where most numerous the exposed stones have been gathered from time to time following the plowing of the land, so that very few remain in fields long in use. They are mainly made up of granite and other crystalline rocks, though calcareous rocks seem to have been at one time present within the 3-foot section, as they are found in the material below this depth, where weathering has not progressed as far as in the mass near the surface.

The substratum of the Miami fine sandy loam does not differ from that of the loam type.

The surface soil does not contain a very large percentage of lime, but at depths of 4 to 8 feet the content is sufficient to cause effervescence with acid.

The Miami fine sandy loam occurs in several irregular areas usually bordering and sometimes surrounding the larger lakes in the north-central part of the county. The largest surrounds Round Lake, lying east and northeast of New Brighton.

The topography varies from gently rolling to hilly, the surface in some localities being truly morainic, though nowhere so rough as to prevent cultivation. The rolling topography insures good drainage, although stream channels have not been developed. The run-off finds its way by swales and depressions to the lakes. Most of the rainfall sinks into the porous soil and finds its way by underground passages to the lakes.

This type is used for a wide variety of general-farming and truck crops. It is naturally best adapted to truck crops but its location at a distance from the city is a disadvantage in trucking. The soil is productive and is maintained in good condition by the growing of clover and the incorporation of manure.

Land values on the Miami fine sandy loam range from about $50 to $400 an acre.

Gloucester Series.

The soils of the Gloucester series range in color from brown through light brown to yellowish brown or reddish brown. The subsoils are typically yellowish brown, grading into grayish or bluish in the deeper subsoils of the heavy members, but in certain areas the subsoil color may be reddish. The latter color of soil and subsoil, so far as known, is confined to the types of this series occurring in Wisconsin, Minnesota, and Michigan. The red, however, is not due to oxidation, but is the color of the parent material, the red drift of that region. These soils are derived from glacial till, made up mainly of crystalline-rock material. The topography ranges from smooth in some places to mountainous in others. In Ramsey County the Gloucester loam and fine sandy loam are mapped.

GLOUCESTER LOAM.

The Gloucester loam consists of 8 to 16 inches of gray to reddish-gray or brown loam, underlain by a brown to reddish clay loam subsoil. Locally the top soil may be a fine sandy loam, silt loam, or clay loam. The soil is more or less compact after heavy rains, but in newly tilled land has a rather loose, friable structure. The subsoil when dry is rather hard and compact in structure. When wet it

becomes soft and moderately plastic. Its texture and structure allow a comparatively free though not excessive movement of ground water.

Bowlders, cobblestones, and gravel are scattered on the surface, as well as throughout and below the 3-foot section. The bowlders and cobbles are seldom so numerous as to interfere greatly with cultivation. Where most abundant they have been gradually removed and old fields are largely stone free. The stones are mainly of crystalline rocks, but some are sandstone. Limestone bowlders are rare.

The substratum is mainly a rather friable reddish-brown to red clay of considerable thickness, containing bowlders, cobblestones, and gravel of the same kind found in the soil section. Coarse-textured cones and lenses are often encountered, usually 3 to 6 feet below the surface, though occasionally they are exposed at the surface or lie near it.

Neither soil nor subsoil effervesces with acid. The substratum also shows no reaction, except occasionally, apparently where a fragment of limestone has been incorporated in the drift.

The Gloucester loam occurs principally in detached bodies in the southern and southeastern parts of the county. The topography varies from rolling to hilly and bumpy, such as typifies glaciated regions. The land is practically nowhere too rough for cultivation and is naturally well, though not excessively, drained.

Much of the Gloucester loam is cleared and in cultivation, though some of the land retains the natural cover, consisting mainly of oak, with undergrowth of brush, briers, vines, and wild grasses.

The Gloucester loam is well adapted to the common general-farm crops of the county, as well as to truck. It is a productive soil, and the prevailing farming methods are good. Manure is used on this land to a considerable extent, and a legume is often grown in rotations to maintain the productiveness.

Land of the Gloucester loam type ranges in value from about $50 to $400 an acre.

GLOUCESTER FINE SANDY LOAM.

The surface soil of the Gloucester fine sandy loam consists of 8 to 16 inches of gray to reddish-gray or brown material ranging in texture from a light sandy loam on one extreme to a loam on the other, though the predominant texture is that of a fine sandy loam. The soil bakes slightly after a heavy rainfall, but with tillage under normal moisture conditions the soil readily assumes a loose, mellow structure. The subsoil is typically a brown to reddish clay loam, with a depth of 3 feet or more. It is heavier than the soil, ranging in texture from loam to clay loam. When dry it is rather hard, but

when moist it is soft and moderately friable, and shows slight plasticity. Below the 3-foot section a rather friable substratum of reddish-brown to red clay extends to considerable depth. Neither soil nor subsoil is calcareous. This is also true of the substratum as a rule.

Scattered bowlders, cobblestones, and gravel particles are encountered on the surface, throughout the 3-foot soil section, and in the substratum. These stones are seldom so abundant as seriously to interfere with cultivation. Most of the larger ones have been removed from fields that have been under cultivation. They are mainly of crystalline rocks, with some sandstone, and occasionally limestone, fragments.

The Gloucester fine sandy loam occurs in the uplands in several disconnected areas; some of the largest bodies are found near McCarron, Snail, and Pleasant Lakes. The surface of the type varies from rolling to hilly but is nowhere too rough to cultivate. The type, by reason of its surface features, is naturally well though apparently not excessively drained. Its texture and structure enable it to hold a good supply of soil moisture.

A large part of the Gloucester fine sandy loam is cleared and in cultivation. Some areas remain in the native growth, consisting mainly of oak. The type appears to be well adapted to the general-farm crops of the region, and is also a good trucking soil. The farm practices are on the whole good.

Land values on the Gloucester fine sandy loam type range from about $50 to $400 an acre, depending on the location and improvements.

The results of mechanical analyses of samples of the soil and subsoil of the Gloucester fine sandy loam are given in the following table:

Mechanical analyses of Gloucester fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
320831	Soil	4.3	14.3	10.0	38.9	11.6	16.9	4.0
320832	Subsoil	2.7	11.0	8.9	29.4	9.8	23.6	11.5

THURSTON SERIES.

The soils of the Thurston series range in color from light brown to dark brown and, in rare cases, to almost black, and the subsoils from yellow to light brown, sometimes with a reddish tinge. The soils have a considerable range in texture, but usually contain coarse sand and fine gravel. The subsoils consist of a mass of loose sand and gravel of low water-holding capacity. The soils of this series

are derived from sandy and gravelly glacial materials usually of the Aftonian glaciation and occur where these beds are exposed on stream slopes. The gravel is noncalcareous. This series differs from the Otisville in the prevailingly darker color of its soils and in topographic position. Only the loam type is recognized in Ramsey County.

THURSTON LOAM.

The Thurston loam consists of about 8 to 14 inches of grayish-brown to dark-brown loam, underlain by a brown to yellowish-brown silty clay loam subsoil which extends to a depth of about 3 feet. The type contains the usual large number of stones characteristic of the soils of the region, practically all of them, however, having been rounded. As a rule, they are somewhat smaller than those in the Miami and Gloucester types.

The top soil averages a loam in texture and, as a rule, is slightly compact in structure, while the subsoil is unusual among the members of this series in its heavy texture and the depth to the gravel layer. Above the latter it has a texture and structure very much the same as that of the Gloucester loam and under normal climatic conditions does not differ much from that soil in its crop production. It is probably inferior, however, in seasons of unusual dryness on account of its droughty substratum. This latter statement is based on a consideration of the nature of the substratum rather than on any experiments showing the actual behavior of the soil under droughty conditions.

In several discontinuous areas in the northern and eastern parts of the county, ranging in extent from a few acres to about 1 square mile, the soil differs from the typical in having a considerable admixture of gravel, the quantity varying from small to large. These areas are shown on the map with gravel symbols. This variation is similar to the typical soil in other respects, except in its somewhat heavier subsoil, the latter being a silty clay loam instead of a loam, and in its origin, the soil of this gravelly variation having been derived largely from materials of water-laid origin and in places, according to Sardeson, from the decomposition of a layer of glacial till over preexisting beds of water-laid sands and gravels.

The substratum consists invariably of thick cross beds of rather clean gravel and sand. It is open and leachy, and in a general way it follows the configuration of the surface of the type, which is hilly. In places this coarse substratum is at or near the surface, and in other places it is 3 to 6 feet or more below. Variations in the depth to the gravelly, sandy substratum cause pronounced differences in the productiveness of the type from place to place, but they occur on such a small scale that they can not be shown on the map, there often being considerable difference in the extent of a few acres.

The Thurston loam is found in upland situations, mainly in the southern half of Ramsey County. A large area lies within the city of St. Paul. Its well-drained substratum makes this land excellent for building sites.

The topography ranges from rolling to hilly and in places knolls are encountered. The surface configuration and porous substratum insure good drainage at all times. As a matter of fact, the type may be termed rather excessively drained, and it is more or less subject to drought.

The native growth on the Thurston loam consists of various kinds of oak. The type is largely uncultivated. On the whole the agricultural value is rather low, although some areas are very productive and are used to good advantage by truck farmers.

Land values are markedly variable, ranging from about $20 to $400 an acre, the higher valuations being due to influence of city improvements rather than to value for agricultural uses.

The results of mechanical analyses of samples of the soil and subsoil of the Thurston loam follow:

Mechanical analyses of Thurston loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
320813	Soil	0.9	7.0	5.6	16.1	17.2	42.1	11.1
320814	Subsoil	.4	3.6	3.0	8.4	16.0	55.2	13.2

HINCKLEY SERIES.

The Hinckley soils are brown to light brown in color, as a rule, ranging to rather dark brown in rare cases. The subsoils are yellowish brown to faintly reddish brown and always of lighter texture than the soils, consisting of sands and gravel, though in rare cases this coarse layer may not appear much above the 3-foot level. The topography is uneven, varying from rolling to hilly. The soils are derived from the materials of kames and eskers and other water-laid glacial deposits, the uneven topography either having remained from the original conditions of deposition or having been caused later by erosion. The material is noncalcareous, usually of crystalline origin. In Ramsey County the soils of the series are darker in color than the average, but not so dark as the Hastings soils. Only the loamy fine sand type is mapped.

HINCKLEY LOAMY FINE SAND.

The Hinckley loamy fine sand consists of a gray to grayish-brown loamy fine sand, passing at about 8 to 14 inches into a grayish-brown loamy fine sand subsoil, which extends to a depth of 3 feet or more.

The subsoil is somewhat lighter in texture than the soil and looser in structure.

A few bowlders, cobblestones, and gravel particles occur in places, but are less prominent than on the Thurston loam. They come mainly from crystalline rocks.

The substratum consists of fine sandy material similar to that of the subsoil, except that it may be somewhat coarser textured and more leachy. The substratum probably ranges in thickness from 6 to 30 feet.

The Hinckley loamy fine sand occupies upland positions. It is mapped in several detached areas in the northern and central parts of the county, ranging in extent from a few acres to about 1 square mile. The largest development occurs in the vicinity of McCarron Lake.

The surface varies from rolling to hilly. The type, by reason of its uneven surface and rather open, leachy structure, is thoroughly drained, and crops are likely to be injured by drought.

The Hinckley loamy fine sand seems to be derived from water-laid sands with some modification by wind-blown material.

Not much of the type is in cultivation. The natural growth consists of various kinds of oak, usually scrubby. The type as a whole ranks rather low in agricultural value. With careful management and thorough manuring it can be used advantageously for truck growing, while the best areas give fair yields of the common farm crops. Owing to the leachy structure the beneficial effects even of heavy applications of barnyard manure are lost within two or three years. Much of the type would be best utilized for forestry and pasturage.

Land values on the Hinckley loamy fine sand range from about $20 an acre to $100 an acre, according to location with reference to the city.

Merrimac Series.

The Merrimac soils are light brown to brown in color, overlying yellowish-brown to brown subsoils. The latter are usually lighter in texture than the soils, often consisting of sands and gravel, though in some cases the lighter textured material is not reached in the 3-foot section. The soils are derived from water-laid material, usually of glacial age, consisting of outwash plains and old river terraces, and the source is mainly crystalline rocks. The topography is smooth and constructional. Three types of this series are identified in Ramsey County, the loam, fine sand, and loamy fine sand, the latter having a colluvial phase.

MERRIMAC FINE SAND.

The Merrimac fine sand to a depth of about 8 to 12 inches consists of a gray to light-brown fine sand. The subsoil, extending to a depth of 3 feet or more, is a brown to light-brown fine sand. The substratum consists of rather open fine sandy material, similar to that of the subsoil, extending to considerable depths. Gravel, of crystalline-rock origin, is scattered sparsely over the type in places.

On the whole, the top soil is rather loose and open in structure, and consequently where the unprotected surface is exposed more or less drifting takes place. The subsoil is also rather loose and open, and the movement of ground water is sufficiently free to make it somewhat droughty. In places where the soil had been heavily manured stain was observed throughout the subsoil section.

The Merrimac fine sand is developed in the northern and northwestern parts of Ramsey County, occupying areas contiguous to the Merrimac loamy fine sand. It is not extensive.

The topography varies from gently undulating to rolling, the type on the whole occupying rather elongated, ridgelike areas. It is amply drained, even to excess over considerable areas. Heavy manuring is quite effective in inducing better moisture-conserving capacity over the type as a whole, thus increasing the yields, but the beneficial effect of heavy applications of organic matter seem to disappear in 2 or 3 years, in marked contrast to the effect on soils having more retentive subsoils.

The Merrimac fine sand owes its origin largely to the weathering of glacial outwash plain material, with more or less material of wind-blown accumulation.

The native vegetation consists of rather scrubby oak, with an undergrowth of the usual brush, vines, and wild grasses. Not much of the type is in cultivation, its productiveness being rather low. Where heavy manuring is practiced fairly good yields of fruit, truck, and general-farm crops common to the county are obtained. It is difficult to maintain the soil in a high degree of productiveness.

Land values on the Merrimac fine sand are variable, ranging from about $20 to $100 an acre. The higher figures are due to the influence of city improvements and are not based on the producing capacity of the soil.

MERRIMAC LOAM.

The Merrimac loam consists of about 8 to 16 inches of grayish-brown to dark-gray loam, underlain by a brown to yellowish-brown silty clay loam subsoil. The latter extends to about 3 feet below the surface. The soil as a whole is typical both in its series and textural characteristics, except in depth to the coarse-textured underlying material. In most of the types of the series this material appears at

less than 3 feet from the surface, though in general the depth to the coarse-grained material is greater in the more western States than in New England. In local variations the texture approaches a silty loam and in others a very fine sandy loam. No bowlders or cobbles are encountered, but some areas show a scattered admixture of gravel, mainly crystalline, in the soil.

The substratum consists of a bed of rather clean gravel and sand, showing both horizontal and cross-bedded strata. In the main the material is apparently of crystalline-rock and sandstone origin. The substratum varies in depth, but is apparently rather thick. It underlies the type at depths of about 2 to 6 feet below the surface. It does not seem to have the effect of inducing excessive drainage of the type, as in the case of the Thurston and Hinckley soils, but aids materially in draining a soil that otherwise, because of its flat topography, would probably not be well drained.

The Merrimac loam occurs, in bodies mostly of rather large extent, in the uplands in the southern half of the county. The surface varies from level to gently undulating. On the whole it is plainlike. The type appears to be well drained naturally, and at the same time, under proper cultural methods, it appears to have good drought-resisting qualities.

The Merrimac loam owes its origin to the weathering of glacial outwash-plain material, and as mapped the larger portion of it includes materials of red-drift origin.

The native vegetation on the type consisted of a forest of large oak trees with the usual underbrush. Very little of this remains now, as practically all of the type is in cultivation or included in city improvements. The soil ranks high in agricultural value. It appears to be well adapted to all the common fruit, truck, and general-farming crops. It is naturally a good soil and the agricultural methods that have been practiced on it have been such as to keep it in good condition. Clover is grown in the rotation and barnyard manure is in general use.

Land values are high on the Merrimac loam, ranging from $100 to $600 or more an acre where influenced by city improvements.

MERRIMAC LOAMY FINE SAND.

The Merrimac loamy fine sand consists of about 8 to 12 inches of gray to dark grayish brown loamy fine sand, underlain by a brown to light-brown fine sand to loamy fine sand subsoil, the latter continuing to a depth of 3 feet or more. Gravel is found in places, but usually in small quantities. The organic content of the soil is not constant, varying with the color, which ranges between light brown and dark brown, although the latter color is rare. Some areas of

the type exposed to wind action are more or less subject to drifting, but this was nowhere observed to have been of conspicuous effect. The subsoil material appears to be somewhat coarser textured and more open than the top soil. It has a lower content of organic matter.

The substratum consists of fine sandy material not unlike that of the subsoil, possibly averaging somewhat coarser in texture. It does not appear to render the soil leachy and droughty, as is the case with the Hinckley and Thurston soils.

The Merrimac loamy fine sand is an extensive and important upland type. It occurs in more or less connected areas in the northern half of Ramsey County.

The topography is predominantly level, ranging to rolling in some areas. The type is naturally well drained, though apparently not to excess. The good cultural methods usually employed improve its moisture-retaining qualities. As the type lies at a lower level than most of the bordering glacial-till land, and only a few feet above the level of numerous lakes, it possibly receives some water by seepage. Ground-water movement is rather free, but the type conserves enough water to carry crops through ordinary droughts.

The Merrimac loamy fine sand is made up mainly of gray-drift material, but being predominantly sandy and therefore essentially noncalcareous its relation to the drift is not important. In the northern part of the county, where it is mainly of wind-blown sand, accumulation is less influenced by the nature of the drift than over the remainder of the type.

This land originally supported a growth of oak, both massive and scrubby, with the usual undergrowth. Most of it has been cleared and is in cultivation. It probably ranks a little lower in agricultural value than the loam type. It, however, produces fair yields of the field and truck crops common to the region. Agricultural practices on the type as a rule are good.

Land values range from about $50 to $400 an acre, according to location and improvements.

Merrimac loamy fine sand, colluvial phase.—The Merrimac loamy fine sand, colluvial phase, consists of about 8 to 14 inches of brown to dark-brown loamy fine sand, underlain by a brownish fine sand to loamy fine sand subsoil to a depth of 3 feet or more. The local variations within the phase as mapped are considerable, the texture ranging from rather silty on one extreme to rather sandy on the other. The areas over which these extremes occur are too small to show on a map of the scale used.

This phase is developed to a small extent in the southeastern part of the county. It occupies colluvial slopes along the Mississippi River bluffs, ranging from steep to gentle, and by reason of this

favorable topographic position is naturally well drained. Groundwater movement appears to be free, but not excessive, the phase not being droughty.

The phase owes its origin to colluvial wash from adjoining upland material as well as to the weathered product derived from outcrops of St. Peter sandstone. In places the phase occupies a terracelike position, formed perhaps at a time when the Mississippi flowed at a much higher level than at present.

A large part of the colluvial phase is covered with a forest cover consisting of large oak trees, with the usual underbrush.

The cultivated land is found, as a rule, on the slopes of easier gradient, the rougher land still retaining the native forest growth. The cultivated areas appear to be well adapted to the small fruits, truck, corn, and the other general-farm crops. The phase, as a whole, includes many variations in agricultural value.

Mechanical analyses of samples of the soil and subsoil of the Merrimac loamy fine sand, colluvial phase, gave the following results:

Mechanical analyses of Merrimac loamy fine sand, colluvial phase.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
320839	Soil	0.2	1.1	4.0	66.4	16.9	5.2	6.3
320840	Subsoil	.2	1.0	4.2	71.4	15.4	4.9	2.8

HEMPSTEAD SERIES.

The Hempstead soils are dark brown to black in color, underlain by brown to yellowish-brown subsoils. The latter are lighter in texture than the soils, often consisting of coarse sand and gravel. The coarse-grained layer may not lie, however, within the 3-foot section. The soils are derived from water-laid material consisting of glacial outwash plains, glacial river terraces, and river terraces of later age. The material is derived from crystalline rocks. The topography is constructional. These soils differ from the Merrimac soils only in their darker color. In Ramsey County the Hempstead silt loam and fine sandy loam types are identified.

HEMPSTEAD SILT LOAM.

The surface soil of the Hempstead silt loam consists of about 10 to 18 inches of black to dark-brown silt loam, underlain by a subsoil consisting of brown to yellowish-brown silty clay to silty clay loam, which extends to a depth of about 3 feet. Local variations include a somewhat open and loamy texture on the one hand, and a rather heavy and compact structure on the other. When it is plowed wet rather hard clods form, but plowing or cultivation under normal

moisture conditions promotes a loose, friable structure. Dry sections of the subsoil show a hard, compact structure, but when moist it is plastic or friable. Movement of ground water is reasonably free, but nevertheless the moisture-conserving qualities appear to be excellent.

The substratum consists of a bed of rather clean gravel and sand, showing both horizontal and cross-bedded strata. In the main the gravels and sands indicate crystalline-rock and sandstone origin. The proportion of limestone origin is small. The substratum underlies the type at depths varying from about 2 to 6 feet below the surface. It does not cause excessive drainage, as in the case of the Hinckley and Thurston soils.

The Hempstead silt loam occupies upland positions in the southwestern part of the county. It is not extensively developed. It is upon this type that most of the experiment plots of the Minnesota agricultural experiment station are located.

The surface varies from level to gently undulating, being on the whole plainlike. The type is fairly well drained naturally, only a few depressions here and there needing artificial drainage. The type, under proper cultural methods, appears to have good drought-resisting qualities.

The Hempstead silt loam owes its origin to the weathering of glacial outwash-plain material, the latter perhaps being largely derived from the gray drift.

The native vegetation consisted of a growth of massive oak, with the usual undergrowth. Little of the original cover remains now. Practically all of the type is in cultivation or devoted to some other use. It ranks high in agricultural value. It is well suited to fruit and truck, and all the common grain and forage crops do well. The agricultural practice is good.

Land values are high on this type, about $200 to $600 an acre, and much higher where influenced by city values.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the Hempstead silt loam:

Mechanical analyses of Hempstead silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
320809	Soil	0.8	3.2	2.0	3.9	11.4	64.6	14.4
320810	Subsoil	.1	.4	.4	1.0	15.3	70.9	11.7

HEMPSTEAD FINE SANDY LOAM.

The surface soil of the Hempstead fine sandy loam to a depth of about 8 to 14 inches consists of a black to dark-brown loamy fine sand. It is darkest in color and most loamy where the organic con-

tent is highest. The subsoil is a light-brown to mottled yellow and gray loamy fine sand which extends to a depth of 3 feet or more. The subsoil is in places heavier or lighter than typical, but, on the whole, it is moderately heavy and fairly compact, especially so when dry. When in a wet condition it is plastic. The surface soil is more or less compact after heavy precipitation, but cultivation under normal moisture conditions easily works it up to a loose, mellow tilth. The substratum consists of fine sandy material not unlike that of the subsoil, possibly averaging somewhat coarser in texture.

The Hempstead fine sandy loam is not an extensive type. It occurs mainly in the northeastern part of the county, usually occupying rather level areas, with some slight undulations. On the whole, the topography is plainlike. Some areas are slightly basin-shaped. The type is fairly well drained naturally, though some local areas have been much improved by artificial drainage. Under proper methods of cultivation the type withstands drought well.

The Hempstead fine sandy loam owes its origin to the weathering of glacial outwash-plain material, and, as mapped, the type may include material of both red and gray drift outwash. The latter has probably contributed most.

Large oak was the chief growth on this type. Most of the land suitable for agriculture is under cultivation, the remainder being largely given over to city improvements. The type is an excellent soil for the field crops common to the region. Small fruits and truck do well. The type is naturally high in productiveness, which is apparently not declining under the present methods of farm management.

Land values are high on this type, owing largely to city influences.

Clyde Series.

The soils of the Clyde series are black or very dark gray or dark-brown in color and overlie gray or mottled gray and yellow, imperfectly aerated subsoils. These types are derived from water-laid or ice-laid glacial material and have been subjected since deposition to conditions of imperfect drainage. They are usually low in lime, though in this respect they vary considerably. They are not so high in lime as the Fargo soils. The topography is smooth, usually flat or basinlike. In Ramsey County only the silt loam type of this series is mapped.

CLYDE SILT LOAM.

The Clyde silt loam consists of about 9 to 18 inches of black to grayish-brown silt loam, underlain by a mottled gray and yellowish clay to silty clay loam. This extends to a depth of 3 feet or more. On the whole the subsoil material appears to be noncalcareous,

though in places it was found very strong in lime, even to the extent of showing a beneficial effect upon crops, not unlike that of marl, when taken from ditches and spread over the surface soils. The substratum is a rather wet, more or less plastic, grayish clay of considerable thickness.

The aggregate area of the Clyde silt loam is not large. It occurs in relatively small areas in the eastern and southwestern parts of the county. The largest body is found to the northeast of New Canada. The type has a smooth, nearly level surface, and it occupies lower positions than soils of the surrounding glacial till and glacial outwash plain material.

The type, by reason of its rather level surface, heavy subsoil and substratum, and relatively low position, is rather poorly drained naturally. In places, however, it admits of artificial drainage. In well-ditched land the subsoil, while allowing a reasonably free movement of ground water, has good moisture-retaining power.

The Clyde silt loam is derived from material accumulated on the bottoms of shallow lakes and ponds and is of local origin.

The native vegetation includes oak, willow, brush, briers, vines, and coarse grasses. Much of the type is cleared and in cultivation.

The Clyde silt loam when drained is a good, strong soil, and as a rule the agricultural practices on it are good. It is well suited to the various small fruits, truck, and field crops. Fall plowing of this soil appears to be particularly desirable. Exposure to alternate freezing and thawing during the winter has a beneficial effect on the physical condition.

Land values are high on this type where the land is used for trucking or intensive farming.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Clyde silt loam:

Mechanical analyses of Clyde silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
320833	Soil	0.1	0.7	1.9	15.5	14.5	54.0	13.0
320834	Subsoil	.6	1.0	1.0	7.1	20.0	55.2	14.8

MILLSDALE SERIES.

The soils of the Millsdale series are black in color and the upper subsoil is brown. At a depth ranging from about 12 to 30 inches the subsoil rests on limestone bedrock. The material is of water-laid accumulation and occurs usually as glacial river terraces. The soils and subsoils as a rule are calcareous or neutral. The topography is smooth. In this county the loam type only is recognized.

MILLSDALE LOAM.

The Millsdale loam consists of about 6 to 18 inches of black loam, underlain by brownish, silty, more or less stony loam of a thickness of about 3 to 12 inches. This in turn rests on massive limestone. The top soil is quite variable in depth and textural composition. In places the silt and clay admixture is large, and again the proportion of fine sandy material is high. In some areas the soil contains glacial bowlders of crystalline rocks, as well as flint rock and limestone fragments. In places the soil rests directly on the rock without any true intervening subsoil, while in others the subsoil may be several inches thick, consisting of a mass of small limestone fragments with silt and clay fine-earth admixture. The color varies from rather white to yellow and brown. The subsoil is highly calcareous.

The Millsdale loam is found on the high limestone benches overlooking the Mississippi River gorge, along the southern border of the county. It covers only 3.5 square miles.

The surface of the type is in the main rather level. Here and there low swells and elongated depressions run more or less parallel to the river gorge. The type is amply drained as a rule, though some of the depressions retain standing water for a long time following rains. Many of such areas have lately been drained. As a whole, the type is more or less subject to drought.

The Millsdale loam owes its origin largely to alluvium deposited along the old channel of the Mississippi River, prior to the cutting of its present gorge. The subsoil has been more or less modified by residual material from the decomposition of the underlying Platteville limestone.

Most of the type is treeless, with a more or less thick covering of native grasses. Some of the deeper portions of the type are used to good advantage for truck and field crops, but on the whole it is probably best utilized as permanent pasture, its general susceptibility to drought making it more or less unsuited to cultivated crops. Agriculturally it is of small importance in the county, as much of it is occupied by the city.

Samples of soil and subsoil of the Millsdale loam gave the following average results under mechanical analysis:

Mechanical analyses of Millsdale loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
320843, 320845.....	Soil.....	0.9	4.1	5.1	24.6	12.5	38.7	14.1
320844, 320846.....	Subsoil.....	2.1	3.6	1.7	6.5	13.6	42.9	29.5

SOGN CLAY LOAM.

The inclusion symbol is used on the map on certain areas in the southwestern part of the county, otherwise shown as Millsdale loam, to indicate small areas of the Sogn clay loam. This soil consists of about 8 to 12 inches of black loam to clay loam, underlain by gray to bluish-gray calcareous clay containing numerous limestone fragments of various sizes. At a depth of about 3 feet the underlying massive limestone is reached. Gravel and occasionally glacial bowlders of crystalline rocks and limestone are found in the top soil.

The Sogn clay loam occupies in part rather steep slopes. In places it occurs on easy slopes that grade into rather level or rolling lands skirting the hillside areas. The movement of ground water is free, aided possibly by the rock fragments, so that on the whole the type is fairly well drained naturally, only a few local areas requiring artificial draining.

The top soil of the Sogn clay loam appears to owe its origin in part to residual material derived from weathering of the underlying massive limestone and in part to admixture of glacial-till material. On the other hand, the subsoil appears to owe its origin largely to the weathered product derived from the underlying limestone. Some areas of the subsoil show evidences of transposition, but residual origin appears to prevail.

The native vegetation consists of massive oak with the usual underbrush and grasses. Most of the Sogn clay loam is cleared and in cultivation. It is friable and is easily worked under normal moisture conditions. The common fruits, truck, and field crops do well on it. The producing capacity of the type is good.

WAUKESHA SERIES.

The soils of the Waukesha series are brown to dark brown, occasionally black in color. The subsoils are yellowish brown to brown. The types are derived from glacial outwash and river-terrace material, usually of limestone derivation or containing originally a large amount of limestone. At present the lime has been largely leached from the soil and upper subsoil, though the substratum contains large numbers of limestone pebbles. In Ramsey County only one Waukesha type is mapped—the fine sandy loam.

WAUKESHA FINE SANDY LOAM.

The Waukesha fine sandy loam to a depth of about 6 to 12 inches consists of a brown to dark-brown fine sandy loam. Gravel particles, from one-eighth to one-half inch in diameter, are scattered in varying abundance through the top soil. The gravel is noncalcareous.

The structure is rather loose and open under normal moisture conditions.

The subsoil is a compact, brown to reddish-brown, silty to gravelly fine sandy loam. The embedded gravel, which varies in quantity, ranges from one-eighth to 1 inch in diameter, the complex in some places forming a rather compact, resistant mass. The subsoil material varies in depth from about 1 foot to 2 or 3 feet. There is, as a rule, a gradation zone a foot or more in thickness between the subsoil and substratum section, which contains a much larger proportion of gravel and pebbles and a correspondingly smaller proportion of fine earth than the subsoil itself. The substratum consists of limestone cobblestones, 3 to 9 inches in diameter, interbedded with gravel, the size of that in the subsoil, and silt. This section is unstratified, presenting a heterogeneous appearance. It ranges in thickness from about 4 to 15 feet, and appears at a depth of 2 to 5 feet below the surface of the type. The substratum material is highly calcareous, though some gravel and other material is found which indicates crystalline-rock origin.

The type has a rather level to gently undulating surface. It occupies a high terrace position. It is naturally well drained and is somewhat subject to drought.

The Waukesha fine sandy loam in this county owes its origin to local conditions. According to Sardeson, St. Anthony Falls at one time existed considerably farther down the river than at present, and the material composing this soil type was dropped at the foot of the falls and spread out a comparatively short distance down the old river valley. The type as mapped represents the remnants of this débris, which accounts for its high terracelike occurrence.

The Waukesha fine sandy loam is of small extent. It is found near the center of St. Paul and embraces highly improved city land.

Wabash Series.

The Wabash soils are brown, dark brown, or black in color, overlying subsoils ranging from nearly black through brown to faintly mottled gray and brown. The types are alluvial in origin, derived from successive deposits during overflows, and occur in regions in which drainage is from calcareous rocks. They are, as a rule, neutral in reaction. The topography is smooth. In Ramsey County two types are recognized—the loamy fine sand and the silt loam, the latter with a mucky phase.

WABASH SILT LOAM.

The surface soil of the Wabash silt loam consists of about 6 to 10 inches of dark-brown silt loam. In places the top soil is quite

black in color, and in other places rather grayish black, with gray and reddish mottling. The subsoil varies from brown to dark brown, with gray mottling. It consists of silt loam and extends to a depth of 3 feet or more. Variations in texture are of only local extent, and include textures approximating a silty clay on the one hand and a silty loam on the other. Wet sections of the subsoil are rather plastic; upon drying it assumes a rather hard, compact structure. It is sufficiently open, however, to permit ground water to circulate freely. The substratum material is similar to that of the subsoil. It is, however, as a rule, rather wet, undoubtedly owing in large part to the comparatively slight elevation above the river.

The Wabash silt loam occurs as first-bottom land in more or less elongated bodies parallel to the course of the Mississippi River, and about 2 to 15 feet above normal stream level. The surface is rather flat. Low, elongated depressions and long ridges, in a general way parallel to the river, break the otherwise uniform surface.

The Wabash silt loam is amply drained during the normal stage of stream level, excepting some of the lower lying areas, which have poor drainage. The type is more or less subject to overflow by waters from the Mississippi River.

The native tree growth consists of large soft maple and box elder, with a brushy undergrowth consisting of willow, alder, briers, vines, and wild grasses. A fairly large proportion of the type is farmed. Considerable hay is cut and some of the type is devoted to pasture, especially the lower land. Truck for the city markets is grown on the higher lying areas, as well as various crops incidental to general farming. Corn is planted after danger from late spring overflows is thought to have passed. Occasionally late inundations destroy the stand. In such case millet is often sowed for hay. It can, as a rule, be matured early enough for hay, and in this way the use of the land for the season is not lost. Inundations seldom destroy the hay crops.

Aside from its liability to overflow the Wabash silt loam is a productive and dependable soil. It is easily worked and when cultivated under normal conditions of moisture content no difficulty is experienced in working up a good, mellow tilth.

Wabash silt loam, mucky phase.—The mucky phase of the Wabash silt loam consists of a mass of swampy, peaty, and mucky material ranging from about 2 to possibly 8 feet or more in thickness. The surface few inches consists of a rather loosely woven mass of partially decayed roots and stems derived from a comparatively recent growth of swamp vegetation. In places the mass is rather springy under the weight of implements and animals. The underlying stratum is a more or less thin, plastic mass of peaty, silty material. The

proportion of silt and clay is considerably higher than in the case of the Marsh type.

The Wabash silt loam, mucky phase, is found in several large bodies in the southeastern part of the county, within the area of overflow bottom of the Mississippi River.

The surface of the type is apparently level, but, from the higher lands surrounding, the surface slopes gradually toward the center of the areas, where more or less typical pond or marsh conditions prevail. The type appears not to admit of drainage at the present time, as most of it lies but little above the normal stream level. It is the first land to be inundated with a rise of the stream.

The phase owes its origin to the growth and decay of swamp vegetation, with the deposition of silt during overflows. In origin it differs from the Marsh type, which has developed from the continued accumulation of vegetation in ponds.

The native vegetation consists of various coarse swamp grasses and brush. Some areas have a stand of tamarack. During low water stages and in dry seasons much of the phase affords wild hay, the remainder admitting of use as pasture for cattle.

WABASH LOAMY FINE SAND.

The Wabash loamy fine sand consists of about 10 to 16 inches of brown to dark-brown loamy fine sand, underlain by a subsoil of light-brown to brown loamy fine sand, extending to a depth of 3 feet or more. In places the surface soil contains more silt than typical, and in others it is more open and sandy. Under normal moisture conditions it is rather loose in structure, but when dry it assumes a compact structure. The subsoil averages somewhat coarser and more open in texture than the top soil. The substratum material is similar in character to that of the subsoil. Apparently it is quite moist throughout the season.

The Wabash loamy fine sand occurs as first-bottom land. It is developed in several small bodies and extends along the entire course of the Mississippi within the limits of the county.

The surface is rather level but is relieved by elongated, channel-like depressions and long ridges lying more or less parallel to the course of the river. It lies about 5 to 20 feet above the normal stage of the river.

The Wabash loamy fine sand is well drained for the most part. It is subject to overflow with any considerable rise of the Mississippi River, though perhaps somewhat less so than the silt loam. It is not droughty. The comparatively high ground-water level serves to stabilize moisture conditions.

The native vegetation includes a tree growth consisting of large soft maple and box elder, with some large willow and poplar, and

an undergrowth consisting of small willow, alder, various briers and vines, and wild grasses.

A large proportion of the Wabash loamy fine sand is farmed. Both truck and general-farming crops are produced. Yields are good where inundations do not damage crops. Corn and potatoes are commonly grown. Planting is done as a rule after danger from late spring overflows is thought to have passed. In case of injury or destruction of crops by a summer flood, millet may be sowed and matured for hay. The loamy fine sand is not quite so productive naturally as the silt loam, but is readily improved. Barnyard manure is highly beneficial.

Miscellaneous Material.

MARSH.

The type mapped as Marsh includes swampy, marshy areas consisting of black peaty material ranging in depth from 2 to 35 feet or more. The surface few inches much resembles that of the mucky phase of the Wabash silt loam. As a rule it consists of a rather loosely woven mass of partially decayed roots and stems derived from a comparatively recent growth of swamp grasses and moss. The underlying material consists of a plastic mass, black in color, largely peaty in character, with varying admixtures of silt and clay sufficient to give a somewhat mucky consistency on the whole.

Marsh is quite extensively developed throughout the county, the larger part of it being found in the northern half. The areas range in extent from less than an acre to 1 or 2 square miles.

The surface of the type is naturally almost level. From the higher land adjoining there is often a gradual slope toward the level of some pond or lake which the type surrounds. The type as a whole appears to offer very few practical opportunities for artificial drainage. A few small areas in depressions within the upland have been drained by cutting short but deep ditches through the obstructing rim.

The type has been formed by the growth and decay of swamp vegetation within ponds and lakes, the process continuing until the accumulated peaty material has taken possession of the tract to a greater or less extent.

The native vegetation consists of various swamp grasses and moss, with some willow and alder. At one time some portions of the type supported a considerable tamarack growth, but only a few scattered areas covered with this tree exist at the present time.

The Marsh type for the most part is best adapted to use as wild hay land or pasture, according to the local conditions. Land artificially drained is utilized to good advantage by truck growers in producing

celery and other special crops. In places the Marsh surface is not firm enough to support animals or implements.

ROCK OUTCROP.

Rock outcrop, shown on the map by symbols, includes mainly more or less vertical cliff exposures of massive limestone and St. Peter sandstone, forming the sides of the Mississippi River gorge. The cliffs rise about 50 to 150 feet above the floor of the gorge. At the base of the cliffs there is considerable colluvial débris, consisting of rock fragments and of soil material of various grades.

On the sides of the cliffs in places appears a brush and scrubby tree growth, with lichens and ferns, but often rather bare rock walls are exposed.

The limestone overlies the St. Peter sandstone. The limestone is quarried in places, but the white, soft, slightly coherent, extensive St. Peter sandstone underneath appears to have no value for building purposes.

This stratum is utilized to good advantage by mushroom growers. Caves or caverns are easily carved into the vertical exposures of this rock, and in these the moisture and temperature conditions are favorable to mushroom culture. The industry has an acreage basis of about 12 to 15 acres, and the daily output reaches about 1,000 pounds of mushrooms.

SUMMARY.

Ramsey County lies within the east-central part of Minnesota. The surface is hilly, with intervening areas of level to rolling lands. The upland portion lies mainly 860 to 1,000 feet above sea level, while the alluvial lands along the Mississippi River approximate the 700-foot level.

About one-third of the area of the county is in cultivation, the remainder being given over to city improvements or consisting of swamps and lakes, pasture lands or woodlots. The population of the county in 1910 was 223,675. St. Paul is within the county, with 96 per cent of the total population, and Minneapolis touches the county on the west. These cities provide excellent markets. Railroad facilities are ample. The country roads are in good condition, and rural improvements are advanced.

The winters are marked by temperatures near zero or colder, varied by occasional periods of thawing weather. The summers are short and warm, with occasional cool spells.

The average annual rainfall is 27.8 inches, nearly three-fourths of which falls within the growing season, from April to September, inclusive.

Ramsey County was organized in 1849. Since that time the population has increased over a hundredfold. The census shows the aggregate value of all farm products of 1909 as over $1,750,000. The special crops, including market-garden products, small fruits, vegetables, greenhouse products, mushrooms, etc., reached the value of $617,910; hay and forage crops amounted to $254,970, and cereals, $197,577. Income from live-stock industries in 1909 reached $816,424, of which dairy products alone contributed $611,854.

The soils of the county are predominantly loams. The types with heavy-textured subsoils and substrata as a rule are most lasting in productiveness. Manuring is largely relied upon to keep up fertility. Commercial fertilizers are not much used, though their value with special crops is becoming more generally recognized. Crop rotation is not generally practiced.

The soils of Ramsey County are derived from the weathering of glacial till or bowlder clay, morainic and glacial outwash-plain deposits, glacial lacustrine material, and deposits of alluvium.

Ten series of soils are recognized, in addition to small areas of Sogn clay loam, shown on the map with inclusion symbol, and the miscellaneous type, Marsh.

The upland soils include the Miami, Gloucester, Thurston, Hinckley, Merrimac, Hempstead, and Clyde series, the latter occupying old glacial-lake deposits in upland depressions. Marsh occurs also in the uplands.

The terrace soils include the Millsdale loam and Waukesha fine sandy loam.

The two Wabash soils occur on the first bottoms or overflow land of the Mississippi River.

Rock outcrop is mapped along the Mississippi River gorge.

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[PUBLIC RESOLUTION—No. 9.]

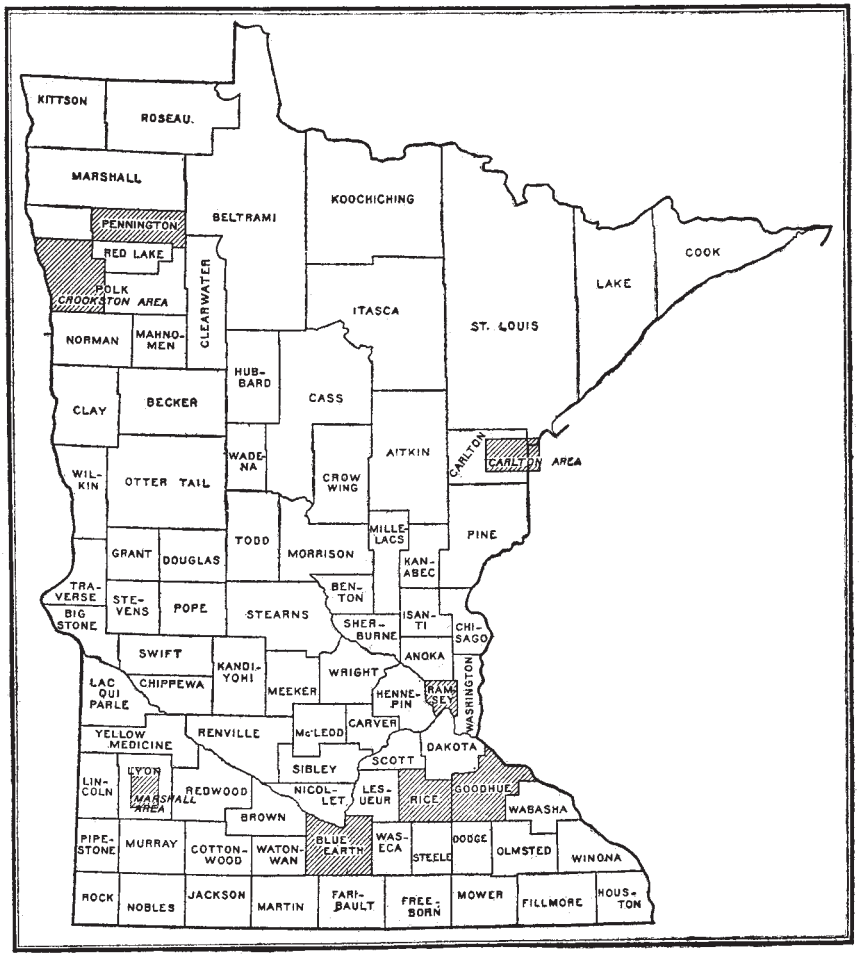
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils Department of Agriculture."

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

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

Approved, March 14, 1904.

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



Areas surveyed in Minnesota.

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