U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF THE SUPERIOR AREA, WISCONSIN-MINNESOTA.

BY

THOMAS A. CAINE AND W. S. LYMAN.

[Advance Sheets—Field Operations of the Bureau of Soils, 1904.]

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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 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.]

CONTENTS.

ILLUSTRATIONS.

TEXT FIGURE.

MAP.

Soil map, Superior sheet, Wisconsin-Minnesota.

SOIL SURVEY OF THE SUPERIOR AREA, WISCONSIN-MINNESOTA.

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LOCATION AND BOUNDARIES OF THE AREA.

The area is located at the head of navigation on the Great Lakes, and includes parts of Wisconsin and Minnesota. It is bounded by meridians 91° 48′ and 92° 10′ 30″ longitude west from Greenwich, and by parallels 46° 19′ 35″ and 46° 50′ north latitude. It includes ranges 12 to 14 and townships 45 to 50. Deducting the portion of the area occupied by Lake Superior and St. Louis Bay, there are 308,800 acres, or about 482 square miles in the survey.

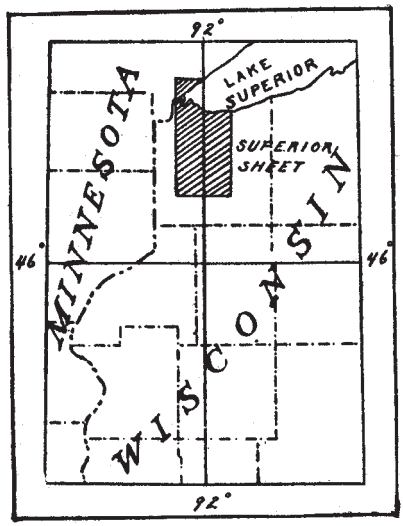

FIG. 1.—Sketch map showing location of the Superior area, Wisconsin-Minnesota.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Douglas County, in which almost the entire area surveyed lies, was organized in 1854, being detached from La Porte County. The population of the county was small until the era of railway building began in 1885, and the cities of Duluth and Superior grew rapidly, owing to the building of docks and railroad terminals. In 1885 and 1886 a great many settlers came in and took up homesteads, but many left as soon as they had acquired legal possession of the land and had removed the pine. Those who remained formed a nucleus for agricultural development. During the past ten years the farming population has increased sixfold, and a steady increase continues.

About two-thirds of the farming population of the area is composed of Scandinavians, most of whom are foreign born. About 5 per cent of the population is from Finland, and the remainder is about equally divided between immigrants from Canada and from Iowa, Illinois, and Indiana.

Only about 1 per cent of the land in the area is under cultivation, but probably as much as 5 per cent is being prepared for cultivation, and the area cropped is constantly increasing. Farm operations have now advanced beyond the experimental stage, and permanent farm buildings are being erected throughout the area.

CLIMATE.

The winters are long and severe; the springs are short—in fact, almost wanting; the summers are short, but warm, with cool nights; and the falls are long, cool, and pleasant. The presence of so large a body of water as Lake Superior has a marked influence upon the climatic conditions of the region adjoining. Through its influence the delightful autumns are prolonged until late in November, and severe weather continues until late in March.

In the lake basin the average date for the last killing frost in spring is about May 15, while that of the first in fall is about September 1, so that the length of the growing season is about three and one-half months. In the sandy region in the southern part of the area the average date of the last killing frost in spring and the first in fall is about ten days earlier than in the lake basin. This difference is believed to be due not alone to the influence of the lake, but in some degree to the difference in the soils. The cool lake tends to retard the springs, and the stiff, tenacious red clay adjoining does not dry out and warm up readily. The cool lake winds in the spring are tempered before reaching the southern part of the area, and the sandy soils dry out and warm up more readily than the clay of the lake basin. In the fall, however, the conditions are reversed. The sandy soils in the southern part of the area lose the heat absorbed during the summer more rapidly than does the clay of the lake basin, while the lake water, warmed somewhat during the summer, tempers the air and aids in prolonging the growing seasons of the region immediately adjoining.

The climatic conditions of the growing season may be judged to some extent by the fact that field corn can not be produced, and tomatoes do not mature, as a rule, unless transplanted from a hotbed. It has been observed by the old settlers that as the clearings progress the conditions become more favorable for long-season and all other crops, the soils becoming dryer, as well as warmer, and better adapted to growing crops. Some of the old settlers are even hopeful enough to believe that in time a hardy variety of field corn can be successfully grown.

The annual precipitation is usually sufficient and well distributed throughout the growing seasons. The climate of the region, though

cool, with long, severe winters, is bracing and healthful. The following table shows the normal monthly and annual temperature and precipitation throughout the year, as compiled from records of the Weather Bureau stations at Duluth, Minn., and Hayward, Wis.:

Normal monthly and annual temperature and precipitation.

Month.	Duluth, Minn.		Hayward, Wis.		Month.	Duluth, Minn.		Hayward, Wis.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*		° *F.*	*Inches.*	° *F.*	*Inches.*
January	10.4	1.07	9.6	1.36	August	64.7	3.34	66.5	3.57
February	14.5	1.11	12.0	1.01	September	56.2	3.86	56.8	3.73
March	24.0	1.66	23.0	1.90	October	44.9	2.59	46.1	3.28
April	37.9	2.42	42.0	2.50	November	29.4	1.61	26.7	1.35
May	48.0	3.40	54.0	3.70	December	17.8	1.36	15.3	1.12
June	57.8	4.59	63.2	4.40	Year	39.3	30.73	40.4	31.68
July	65.9	3.72	69.4	3.76					

PHYSIOGRAPHY AND GEOLOGY.

There are three distinct topographic divisions in the area. Beginning at the lake, the first is a plain, the boundaries of which are indicated on the soil map by the boundaries of the soil type Miami sandy loam. This plain is made up of lacustrine deposits of silt and clay that were laid down at the close of the Glacial period, at which time the waters of the Superior Lake basin stood at a considerably higher level than at present. The city of Superior is built upon this plain. Bordering the lake and St. Louis Bay there are cliffs of clay averaging about 25 feet in height, and from there the country extends southward with a gradual rise of about 30 feet to the mile for a distance varying from 5 to 15 miles, where the plain terminates rather abruptly with a range of hills.

The plain is crossed by a number of streams flowing directly north or northwest into the lake or the Nemadji River. These usually flow in narrow channels, which in places have been cut to a depth of 100 feet or more. The interstream areas are broad and flat.

The greater portion of the plain is underlain at considerable depths by the Potsdam sandstone of Cambrian age, but these rocks nowhere enter into the composition of the overlying clay and can only be seen in the bottoms of deep stream courses in the southern part of the plain. Farther to the south, however, where these clay deposits thin out along the ranges of hills, the underlying basic lava flows of the lower Keweenawan formation appear and impart to the clay of the plain a somewhat loamy texture.

The second topographic division of the area begins with the basic lava flows just mentioned. On the Wisconsin side these lava flows constitute a wide belt of country to the southward, but on account of

their general concealment by the drift only that portion of them which appears on the surface and enters into the soil formation need be considered. A ridge, known as the Douglas Range, with an average width of about one-half mile, crosses the area in a west-southwesterly direction from the vicinity of Poplar to Black River Falls, and in many places the rocks appear as a distinct escarpment. The soil on top of the ridge and for some distance southward is partly residual. On the Minnesota side, in the vicinity of Duluth and along the north shore of the lake, the base of the lower Keweenawan formation appears and forms a continuous escarpment rising in places as high as 600 feet in a distance of 1 mile back from the lake. The soil on the escarpment and for some distance back is also partly a residual soil derived from the weathering of the rocks below. The red clay of the valley is found in places upon this escarpment, but it has been largely removed by erosion, and where found it is usually intimately mixed with fragments of rocks from the underlying formation and with gravel from the glacial deltas above.

The third topographic division of the area includes a rolling country in which prominent elevations are uncommon and in which the surface is so level in places that considerable swamp areas and a number of small lakes exist. It is composed largely of a blanket of glacial till, and the underlying lava flows of the lower Keweenawan formation seldom come to the surface, although fragments of the rock are more or less intimately mixed with the glacial material.

In the southeastern corner of the area there are a few sections of land which belong properly to another topographic division. It is a portion of the sandy plateau of the State known as "the Barrens." It is in this vicinity that the waters flow partly toward the Mississippi River and partly into Lake Superior.

The altitude of the area ranges from 602 feet, the present level of Lake Superior, to about 1,400 feet at a point within the city limits of Duluth. In the southern part of the area, along the divide which separates the waters of the Mississippi from those of the St. Lawrence, the elevation above sea level is about 1,200 feet.

SOILS.

The soils have been classified into eight types, but only five of these are agricultural soils. The others, Rock outcrop, Rough stony land, and Dunesand, are of relatively small extent. Muck occupies a comparatively large area, viz, 47,808 acres, or over 15 per cent of the territory covered by the survey. Under present conditions this may also be classed with the unproductive soils. None of it is under cultivation, and probably will not be for some time to come, as it will require considerable expenditure to reclaim it, and land of the more easily reclaimed types is very cheap.

The following table gives the names and areas of the several soils:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Superior clay	122,880	39.8	Rock outcrop	5,632	1.8
Miami sandy loam	105,536	34.2	Miami sand	4,608	1.5
Muck	47,808	15.3	Dunesand	1,536	.5
Superior sandy loam	14,208	4.6	Total	308,800	
Rough stony land	6,592	2.1			

SUPERIOR CLAY.

The Superior clay is a heavy red clay with apparently no difference in color or texture between the soil and subsoil, being close, compact, and almost impervious either to air or water. When wet it is of a bright, brick-red color, and quite adhesive and gummy, sticking to wagon wheels in great lumps. When dry, cracks an inch or more in width are common on the surface and the soil breaks up into cubical blocks. Occasionally there are small fragments of rock in both soil and subsoil, and usually upon new ground there is an inch or so of vegetable mold.

This is the most extensive soil type in the area, occupying an extensive plain reaching from the lake edge inland for a maximum distance of 15 miles. Along the lake it occurs as cliffs of clay with an average height of about 25 feet, and the surface rises gradually inland at the rate of about 30 feet to the mile, and is terminated rather abruptly with a range of hills. The surface is traversed by a number of streams flowing in deep, narrow channels, as described in the chapter on physiography and geology. The interstream areas are broad and flat.

With the inclination of the surface toward the lake, and with the number of deep, narrow water courses intersecting it and leading direct to the lake, the opportunity for drainage is good. The type is exceedingly retentive of moisture, and owing to its almost impervious nature it is greatly improved by open drains. Underdrainage is not thought practicable, as in order to escape damage by frost the tiles would have to be laid too deep to be efficient in a soil of the impervious nature of this type. The crops are much benefited when the fields are plowed in narrow lands in the direction of the slope.

The Superior clay is lacustrine in origin, having been deposited in the lake bottom at the close of the glacial period, at which time the basins of lakes Superior and Michigan stood at a considerably higher level than at present. The inflowing glacial streams carried gravel, sands, silt, and clay; the coarser materials—sand and gravel—fell near shore, while the finer silt and clay particles were carried in sus-

pension by the water and spread over the lake bottom farther from shore. Later the lake level lowered between 400 and 500 feet and exposed these fine sediments. As the color would indicate, the material contains a considerable proportion of iron, due doubtless to the fact that there is so much iron in the near-by ranges to the northward, from which the material was probably largely derived.

This type of soil is unusually well adapted to timothy and clover, and as yet these are the leading crops, mainly for the reason that with the present demand and high prices for hay in the Duluth and Superior markets and in the near-by logging camps nothing else pays so well. The clover grows waist high, and is usually grown with timothy, which also makes a luxuriant growth. A few fields of wheat were seen, and the average yield is about 15 bushels per acre. The soil is too cold and the season too short for corn to mature. It can be grown successfully for fodder, however, and sweet corn does fairly well.

The yields of all crops on newly broken areas of this soil are often unsatisfactory, but the second crop is always better, and the soil shows more improvement with use and more lasting effects of manuring than any other type in the area. All yields are greatly increased by the incorporation of coarse manure, the beneficial effects of which seem to be due not so much to the addition of plant food as to the change which is brought about in the texture of the soil. Good crops of potatoes, rutabagas, pease, beets, and, in fact, all root crops, are grown in the gardens upon this type.

The following table gives the results of mechanical analyses of typical samples of this type:

Mechanical analyses of Superior clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11941	Poplar	Red tenacious clay, 0 to 10 inches.	0.3	1.8	2.0	6.4	7.3	38.8	43.4
11943	3 miles W. of Coyne.	Red stiff clay, 0 to 10 inches.	.8	5.4	4.0	6.4	5.1	30.5	48.0
11939	Superior	Red tenacious clay, 0 to 10 inches.	.2	1.1	1.5	5.4	5.3	28.6	58.2
11942	Subsoil of 11941	Red tenacious clay, 10 to 36 inches.	.1	1.5	2.9	8.0	5.4	36.9	45.2
11940	Subsoil of 11939	Red tenacious clay, 10 to 36 inches.	.4	1.2	1.2	5.6	4.7	30.7	56.0
11944	Subsoil of 11943	Red tenacious clay, 10 to 36 inches.	.1	.7	.8	2.5	2.0	34.5	59.3

MIAMI SANDY LOAM.

The Miami sandy loam, to an average depth of 10 inches, consists of a grayish to brownish sandy loam containing considerable silt, underlain to about 30 inches by a medium-textured, incoherent red sandy loam. Below 30 inches the subsoil becomes somewhat heavier in texture and retains moisture better than that immediately above. The surface soil varies considerably in texture within short distances, being loamy in depressed and level areas, and rather sandy and gravelly upon the small knolls. The knolls, however, are not extensive enough to be mapped upon a scale of 1 inch to the mile. Sometimes rocks varying from 4 inches to 4 feet in diameter are strewn upon the surface and disseminated through the soil and subsoil in such quantities as to interfere seriously with cultivation and to add greatly to the cost of clearing.

The Miami sandy loam is confined to the southern part of the area, and lies wholly outside of the Superior lake basin. The surface is more or less rolling, with many kettle-hole depressions, shallow lakes, bogs, and peat marshes. These irregularities of surface, however, are not great enough to interfere with cultivation. The rolling character of the surface, together with the porous nature of the subsoil, insures good drainage, except in the above-mentioned marshy depressions.

This soil type is of glacial origin, being composed of a heterogeneous mass of silt, sand, gravel, and rocks transported from the north and more or less intimately mixed with the fragments of local trap rocks. The more loamy character of the soil in the depressions is the result of wash of the finer material from higher ground, and a relatively greater quantity of organic matter. Where the soil is unusually stony the underlying trap rock comes close to the surface, and has been incorporated with the glacial material. The watershed between the Mississippi and St. Lawrence systems occurs along the southern boundary of this type, where the bogs, marshes, and shallow lakes increase in size and number.

Very little of the Miami sandy loam is under cultivation, the largest areas being in the vicinity of Chaffey and Hawthorne. It is locally known as " hardwood " land, and is recognized as a safe soil for potatoes and all root crops. It is very well adapted to raspberries, blackberries, gooseberries, currants, and strawberries; and the fact that it is a warm soil and removed from the direct influence of the cold spring winds from the lake makes it especially desirable for those products. With proper care and attention potatoes yield as much as 150 bushels per acre. It is a fair type for pasture and meadow. Some oats are grown, but are fed in the sheaf. On account of the character and number of stumps and stones it is more difficult and expensive to clear than the Miami sand, but owing to its superior

water-holding capacity it is more desirable than the latter type for trucking purposes. This type should be used for root crops and small fruit to supply the near-by markets, and enough stock should be kept upon the farms to consume the hay and straw, thereby keeping up the productivity of the soil through the manure thus produced.

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

Mechanical analyses of Miami sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11927	4 miles SW. of Solon Springs.	Gray sandy loam, 0 to 10 inches.	1.9	13.7	21.8	35.5	9.4	15.0	2.7
11929	2½ miles E. of Hawthorne.	Sandy loam, 0 to 10 inches.	2.3	12.3	13.8	29.9	14.7	21.2	5.8
11928	Subsoil of 11927	Red sandy loam, 10 to 36 inches.	2.9	13.1	15.8	37.3	13.7	12.8	4.4
11930	Subsoil of 11929	Red sandy loam, 10 to 36 inches.	3.4	12.3	13.5	29.8	14.8	19.4	6.7

SUPERIOR SANDY LOAM.

The soil of the Superior sandy loam is a gray to reddish sand or light sandy loam of medium texture, varying in depth from 12 to 24 inches. In places the surface is strewn with small rocks and bowlders in such quantities as to interfere with cultivation. The subsoil is a stiff, tenacious, impervious red clay similar to the material forming the Superior clay. Sometimes the subsoil is interstratified with thin layers of fine sand.

The principal area of this type of soil is found bordering the southern edge of the Superior clay area, from the eastern limit of the survey more than half way across the area. It lies south of the Douglas Range and occurs as a strip varying in width from one-half mile to 3 miles. There are also four smaller bodies of this soil type lying within the Superior clay area. The surface is usually quite level and in places gently rolling, with sufficient rise to the southward to insure good natural drainage.

This part of the area lay along the shore of the lake, when it stood at a higher level, and was covered by comparatively shallow water. The red clay subsoil represents deposits upon the bottom of the lake in comparatively quiet times, while the thin layers of interstratified fine sand represent periods of disturbance, and the stony portions represent the places where the underlying trap rock comes close to

the surface. The sandy soil is the result of wash from the higher lying sandy region to the southward. Within the territory occupied by this type there are some limited flat areas of medium to coarse sand entirely free from rocks and underlain by red clay at the usual depth, as if the sand had washed from higher ground before the lake level receded and had been subjected to the assorting action of waves or shore currents. There are also some small knolls of fine sand, under which the red clay subsoil lies deeper than usual. These knolls are too small to be shown on the map, and probably represent wind-blown material.

The Superior sandy loam is well adapted to all crops grown in the region. It has all the advantages of the Superior clay without possessing its disagreeable features. Like the Miami sandy loam, it is a warm soil and easily tilled, but it is more desirable than the latter, in that it is not so leachy and the effects of fertilizers are more lasting. Clover and timothy do nearly as well as on the Superior clay, and the pastures are excellent. Potatoes will yield from 100 to 200 bushels per acre, and the quality is better than that of those grown on the Superior clay. All of the root crops do as well as on the Miami sandy loam. The type is very well adapted to strawberries, raspberries, gooseberries, and currants. As to its possibilities for wheat, oats, rye, and barley nothing can be definitely said, because as yet not much of the land has been cleared and these crops have been grown only in small patches.

Owing to the dense forests of pine which formerly grew on this type it is the most expensive in the area to clear, but altogether it is the most desirable type for general farming in the area.

The following table gives the results of mechanical analyses of the soil and subsoil of the Superior sandy loam:

Mechanical analyses of Superior sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11937	3 miles SE. of Coyne.	Sand, 0 to 24 inches.....	2.0	10.6	12.7	42.0	20.0	7.9	4.9
11935	¼ mile N. of Poplar..	Sandy loam, 0 to 16 inches.	3.5	14.1	13.8	31.9	17.4	13.6	5.4
11933	1½ miles NW. of Rockmont.	Brown sandy loam, 0 to 18 inches.	4.0	14.3	12.8	29.4	14.2	15.7	9.2
11936	Subsoil of 11935	Red clay, 16 to 36 inches..	.2	2.0	2.2	5.7	11.0	53.1	25.5
11934	Subsoil of 11933	Red sandy clay, 18 to 36 inches.	1.0	7.5	8.9	24.3	13.6	17.1	27.6
11938	Subsoil of 11937	Red tenacious clay, 24 to 36 inches.	.9	4.9	5.3	15.4	10.5	21.8	41.0

MIAMI SAND.

The Miami sand is an incoherent, loose, grayish to reddish sand of medium texture, with an average depth of about 8 inches, underlain to great depths by loose, incoherent, yellowish to reddish sand of the same texture. The soil has a tendency to drift when exposed to the wind. The sand particles are largely quartz, and disseminated through both soil and subsoil are a few rounded pebbles of various kinds of rock, ranging in size from one-tenth of an inch to 1 inch in diameter. Occasionally a glacial bowlder is seen.

The Miami sand occupies a single area covering several sections in the southeastern corner of the area, in the vicinity of Lake St. Croix, and is representative of a belt of country to the southward, 10 to 20 miles wide, and extending from Polk County through Douglas County to the Bayfield peninsula. The belt is known as the "St. Croix Barrens."

The surface of the type as a whole is an undulating plain sloping toward the southwest, over which are scattered a great number of small lakes, ponds, kettle holes, and springs. In the vicinity of Solon Springs the surface slopes rapidly toward Lake St. Croix, and this, together with the number of deep, narrow valleys cut by the inflowing streams, makes this part of the type rather hilly and rough. The soil, too, is a little more stony in this place. Immediately adjoining the lake is a narrow area which is still more stony, due, doubtless, to the fact that in earlier times this was the bed of a glacial river.

Owing to the loose, open texture of the type, its power to retain water is low, and in many places the crops, except in wet seasons, are apt to suffer from drought. Successful farm operations so far have been confined either to very level uplands or to the depressions along streams.

The Miami sand owes its origin to the assorting action of flowing water as it issued from the melting ice at the close of the glacial period.

The soil responds readily to a dressing of barnyard manure, but the effects are not so lasting as upon the closer-textured Miami sandy loam lying to the northward. In localities where the moisture conditions are favorable and where a liberal application of manure is used the soil is especially adapted to potatoes, and judging from the cauliflower growing in gardens the possibilities for the production of that crop on a commercial scale would appear to be good.

The following crops are also grown in favored localities with very good results: Cabbage, turnips, rutabagas, cucumbers, radishes, beets, carrots, pease, beans, citrons, pumpkins, squash, and strawberries.

Green tomatoes for pickling are also grown, but unless the plants are transplanted from a greenhouse the seasons are a little too short to mature this crop. Sweet corn does well, but the seasons are too short for field corn.

The chief value of this soil will be for special crops, like potatoes or cauliflower, and, in fact, nearly all kinds of light truck crops. It is not well adapted to general farming and is too light for profitable crops of the cereals and grasses. Clover and timothy do fairly well in the low areas, where the moisture conditions are favorable.

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

Mechanical analyses of Miami sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11921	Solon Springs	Gray incoherent sand, 0 to 8 inches.	3.1	27.6	27.4	26.0	4.1	7.1	4.7
11923	2 miles SW. of Solon Springs.	Red incoherent sand, 0 to 8 inches.	3.2	32.4	27.9	21.4	3.1	6.9	5.0
11922	Subsoil of 11921	Red incoherent sand, 8 to 40 inches.	3.8	24.2	32.2	32.6	3.1	1.8	2.1
11924	Subsoil of 11923	Red incoherent sand, 8 to 36 inches.	3.7	29.2	33.8	26.3	1.5	2.9	2.5

DUNESAND.

This type consists of several feet of loose, incoherent fine to medium sand, with no difference either in color or texture to a depth of 40 inches or more. It is found at the head of Lake Superior, in the vicinity of the cities of Superior and Duluth, and occurs as a series of low-lying bars varying from a few feet to several rods in width. The largest and most important of these bars forms the excellent natural harbor of Superior and Duluth.

The existence of these bars and points is due to the combined action of waves and wind upon the sands brought down by the St. Louis River and deposited in the shallow water at the head of the lake. The sands are first piled up by the waves and later shifted by the winds. The areas covered by the type are limited in extent and almost devoid of vegetation. They have no agricultural value.

The following table gives the results of a mechanical analysis of a sample of the Dunesand:

Mechanical analysis of Dunesand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11945	Minnesota Point, Minn.	Gray sand, 0 to 40 inches.	0.0	5.5	49.0	44.2	0.6	0.4	0.3

ROUGH STONY LAND.

The interstitial soil of the Rough stony land is a very fine sandy loam or silty loam. The only apparent difference in soil and subsoil is that the former has a little less organic matter than the latter. The surface of the ground is so strewn with bowlders that one can in most places easily step from stone to stone. In fact, about 70 per cent of the surface is covered with rocks, the size of which ranges from 6 inches to 5 feet in diameter.

This type occupies the tops and slopes of the hills back of Duluth, and is characteristically developed in the vicinity of Duluth Heights. It is found only as a strip of country from 2 to 4 miles wide north of the rock outcrop areas. To the northward it passes gradually into a much better agricultural region, where the same general character of material is found, but with less rock.

The surface features are rough, hilly, and broken and the drainage is excessive. The type is derived from material laid down or reworked by torrential floods at the close of the glacial period. The movement of the waters was greatly accelerated as they reached the slope of the hills above the lake, and all material except rocks and bowlders was borne along with the water. As shown in road cuts and borings, the number of rocks and bowlders diminishes rapidly at a depth ranging from 2 to 4 feet below the surface.

Except in a few favored patches, which are used for growing vegetables, the land is too rough, stony, and droughty to be of any value for farming. During part of the year it furnishes a fair pasture for cattle.

ROCK OUTCROP.

Under the head of Rock outcrop are classed all areas where the underlying rock of the region is exposed or is so near the surface as

to render the soil too stony and droughty for anything except a scanty vegetation.

In Douglas County, Wis., such areas are found in a few places along Douglas Range, while in Minnesota a strip occurs within the city limits of Duluth, covering a ridge rising abruptly to 600 feet above the lake.

These outcrops belong to the oldest rocks on the continent, and consist principally of a series of lava flows of the lower Keweenawan formation.

Within the city limits of Duluth there are patches of red clay from 1 to 4 or 5 acres in extent, which was deposited in the depressions or "pockets" on the hillside when the lake stood at a higher level. This clay has not been entirely removed by erosion, and is more or less mixed with rock fragments and gravel. A few patches of gravel, remnants of the ancient beach and deltas, also occur as a veneering upon the rock outcrop areas in Duluth. The rock, gravel, and sand are used locally for building purposes and street construction. The type has no agricultural value.

MUCK.

The Muck is a mass of roots, fibers, and moss in various stages of decomposition, and varying in depth from 1 to 15 feet. In the deepest areas there is little difference in color or texture to a depth of 3 or 4 feet. Below this the structure of the organic matter is not so apparent, and the whole mass is more thoroughly decomposed.

The Muck is found in large bodies in the southern part of the area, principally in the Miami sandy loam areas. It occurs as low-lying, level tracts, which were formerly lakes or depressions, but which have been built up into level areas by the accumulation of organic matter.

The drainage of these areas is naturally poor, and the material is always saturated with water. Since the timber of the adjoining region has been largely removed and ditches have been constructed along some of the county roads, many of these swampy areas have become dryer, and some shallow lakes have been converted into swamps. Undoubtedly most, if not all, of these areas may be drained by artificial means.

This soil is the result of drainage and climatic conditions that tend to retard the decomposition of organic matter. At the close of the glacial period ponds and shallow lakes doubtless occupied the depressions now mapped as Muck. Vegetation gradually encroached upon these, and the accumulation of moss, sedge grass, leaves, and trunks of trees was more rapid than the natural processes of decay.

In most regions the muck areas are among the last to be reclaimed. In a newly settled country they are usually held in low esteem, prob-

ably because of the expense involved in draining and preparing them for cultivation. In Ohio and Michigan such areas, when reclaimed, are used extensively for onions and celery and are valued at from $100 to $200 or more an acre. As yet practically none of the type has been brought under cultivation in the Superior area.

AGRICULTURAL METHODS.

Twenty years ago the whole of the Superior region was covered with heavy coniferous and hardwood forests, but now nearly all the merchantable timber has been removed and the slashings have been further cleared by forest fires.

The first attempts at growing crops were upon small clearings in the midst of the timber, and the results were not very encouraging, owing, it is believed, largely to the fact that with the short summers the soil in small fields surrounded by tall forests dries and warms up very slowly. Since the clearings have been extended the crops have done much better. The first crops were sown or planted among the stumps, the surface of the ground being merely scratched in the preparation of the seed bed. These stump fields were satisfactory enough for pasture, but very unsatisfactory for cultivated crops. The hardwood stumps standing among the grass of meadows are easily removed in a few years, but the large white pine stumps, with their great sprawling roots, would long outlast the settler were it not for the use of the stump puller and dynamite. The clearing of every acre requires hard labor, and the cost per acre varies greatly with the type of soil, the length of time since the original forest was removed, and the judgment of the persons doing the work. The average cost of clearing the land of stumps and stones, including the first plowing, is between $20 and $30 an acre.

During the last few years considerable permanent improvements have been made. The stumps and stones upon some farms have been entirely removed and the soil is being tilled in accordance with modern methods. The first crops after deep plowing upon new ground are apt to be unsatisfactory, because the coarse litter, when turned under, forms a layer between the soil and the subsoil, thus destroying the capillary connection between the two. The first plowing should be shallow, and should be followed by some cultivated crop like potatoes. The following year the land should be sown to some cereal, to be followed by clover. After the coarse litter has been broken up and well worked into the soil deeper plowing can be safely resorted to.

As yet little attention has been paid to the matter of plowing different types of soil at different seasons and to different depths. On the Superior clay especially it is desirable that plowing be done in

the fall after the heavy rains, so that the soil may be exposed to the action of frost during the winter and may be ready for planting as early as possible in the spring. In this type it would also be well to plow the fields in narrow lands in th direction of the slope thus facilitating drainage. Better results will also be obtained with this soil if the crops be rotated with clover, the long, fleshy roots of which open the soil and improve the drainage and the circulation of air.

A great deal can be done by the use of better methods of cultivation to conserve the moisture in the sandy types of soil, but even with the most careful methods the Miami sand would better be used for the production of special crops like potatoes, cauliflower, cabbage, sweet corn, and root crops, rather than for general farming crops.

Upon the Superior clay hay farming has been such a profitable source of income that some tracts are being purchased to be used for the production of hay on a large scale to supply the local markets. No system of rotation is being planned in connection with these hay farms. It is thought that since clover has been known to grow for over twenty years in the openings and around old logging camps, it may also be grown year after year without reseeding. Such a system of farming will eventually exhaust the soil, and the plan should be changed to include other crops and the raising of livestock, and, in fact, some form of animal husbandry should be included in the farming operations throughout the area in whatever type of soil. The greater portion of the hay and straw produced upon the farm should be consumed there; the manure should be well cared for and returned to the fields, and this, together with the growing of clover, should be sufficient to keep the soils in a permanently productive condition. Too much stress can not be laid upon the desirability of raising stock both for dairy and beef purposes in the lake basin portion of the area, where the soil is heavy, cold, wet, and difficult to work. Here dairying might be made the chief industry, while farther southward, in the sandy types, it should be an important auxiliary to general farming. Throughout the area the natural conditions are favorable to dairying. The nights are always cool; there is an abundance of cool spring water and flowing streams, and ice is never necessary. The red clay of the lake basin is especially adapted to pasture, while throughout the area pastures remain green until covered with snow—at least one month longer than farther south in the State—which fact compensates for the later date at which stock may be turned out to pasture in the spring. There is a great temptation to produce hay at the present prices, and the expense of keeping stock through the long, cold winter is considerable, but this expense can be greatly reduced by housing the cattle in modern stock barns, and, moreover, dairy products command the best prices in the near-by

markets of Superior and Duluth, so that taking everything into consideration there should be as much, if not more, profit in dairying as in growing hay for sale.

AGRICULTURAL CONDITIONS.

The farm operations of the area are carried on largely by people who started without capital and without a proper knowledge of farming, and who, until recently, owing to the great demand for unskilled labor, were employed for all or a great part of the time in the shipyards, ore docks, and steel plants at Duluth and Superior. Others among the original settlers worked in the near-by lumber camps during the greater part of the year, and some found employment on the county roads, in the meantime neglecting the improvement of their farms.

The settlers from Iowa, Illinois, and Indiana, on account of their familiarity with American methods of farming, have made the best showing. Those from Sweden, though they make good citizens, are not usually progressive farmers. Their present conditions are so much better than those of the Old World that they are content with what they can make from small farms of from 20 to 40 acres. This is the case to an even greater degree with the settlers from Finland.

During the period of business depression following 1893 a few of the laboring class from Superior and Duluth moved to farms in the country adjoining, and these have been prosperous. The country has not been sufficiently developed to show great increase in individual wealth, but many farmers, starting without capital, have by industry and economy established for themselves permanent homes. With the development of the country these pioneer farmers will profit by the natural increase of land values.

Practically all farms are operated by the owners, and there will be little reason for renting farm lands here as long as the low price of virgin land continues. The price of unimproved land ranges from $3 to $15 an acre, depending upon the type of soil and the location with respect to the towns and railroads. There is an abundance of land which can be obtained upon easy terms and in any quantity desired. Large tracts formerly timbered, however, are still held by lumber companies, who expect the settlement of the surrounding country to enhance the value of their holdings. Some of these lands can not be purchased in smaller parcels than one section or more, thus placing them beyond the settler of limited means. Formerly some of the lumber companies were unwilling to sell lands to settlers, probably for the reason that the increased rate of taxation incident to the development of the country might be excessive on their remaining undeveloped tracts. There is also considerable

farm land in the country back of Superior which is held by eastern capitalists, who, having purchased it at "boom" prices, are unwilling to dispose of it for what it is worth for farm purposes.

The farms under cultivation range in size from 20 to 250 acres, with an average of about 100 acres. The holdings of unimproved lands range from a few acres up to 10,000 acres or more.

In the present stage of development of the area very little farm labor is hired, practically all of the work being done by the settler and his family. To the disadvantage of their farms, many of the settlers still spend a considerable part of the year in the lumber camps or working upon the county roads, but more labor is now being directed to clearing the land and founding permanent homes than formerly, owing to the decreased opportunities for work, and this tendency will become more and more marked from this time forward. The removal of the timber has made it less difficult to clear the land for cultivation, and agriculture has a much better footing now than it could possibly have had if the timber companies had not first exploited the heavy forests.

The products of the area are clover, timothy, potatoes, wheat, oats, rye, barley, sweet corn, pease, beans, the root crops and other vegetables, and berries. As already stated, field corn as yet can not be successfully grown, and tomatoes do not ripen unless started in a hot bed and transplanted.

The adaptation of the several soils to these crops and the opportunities for specialization being important conclusions in the survey work, will, at the risk of tiresome repetition, be summarized in a few succeeding paragraphs.

The Superior clay is especially adapted to the production of clover and timothy, the average annual yield when grown together being 2½ tons per acre. Wheat, under the most favorable conditions, will yield as much as 30 bushels per acre, but the average yield is probably not more than 15 bushels. Oats will average about 35 bushels per acre, but much larger yields are not uncommon. Oats have a tendency to rust upon this type of soil, probably because of the dampness from the lake. Potatoes and all root crops do well when well cared for, but the quality of the potatoes is not the best. Blackberries, raspberries, currants, and gooseberries do fairly well. This soil is excellently adapted to pasture.

The Superior sandy loam is the most desirable soil type in the area for general farming. It is usually very difficult and expensive to clear, owing to numerous large pine stumps, but when once under cultivation it is better adapted to all such crops as are grown in the region than any other soil type in the area.

The Miami sand is not naturally a productive type, but by careful

methods of cultivation and the application of barnyard manure it is recognized as a very desirable type for all kinds of root crops, cabbages, cauliflower, and sweet corn. In many places this type is apt to be deficient in moisture owing to the loose, open texture of the soil and subsoil materials, and this droughtiness makes it a poor soil for hay or pasture.

The Miami sandy loam is a type fairly well adapted to all general farm crops of the area. The soil is a little more compact than the subsoil at 24 inches, but at a depth of about 4 feet the type is underlain usually by a compact sand which is quite retentive of moisture. It is recognized as a safe soil for potatoes and all root crops, and produces a fine quality of cabbage and cauliflower. It is better adapted to hay and pasture than the Miami sand, but is not so desirable for those purposes as the Superior sandy loam and Superior clay. It is an excellent soil for berries, especially strawberries.

Very little of the muck of the area has been drained and put under cultivation, but in Ohio and Michigan and other parts of Wisconsin it is one of the best types for celery and onions. The few attempts so far made to grow these crops upon the muck areas of the Superior area indicate that they will also do well here.

The Rough stony land type is undesirable for anything except pasture. In a few places small patches have been cleared of stumps and stones and are being utilized to supply the Duluth markets with vegetables.

With the exception of the swamp region south of the Douglas Range in the southwestern part the area is well supplied with railroads. Considering the state of agricultural development in the area, the county roads are good. They are often far apart, but are ample to meet the present demand. In wet weather the red clay roads are well-nigh impassable for heavy loads, and much of the hay is marketed after the ground freezes, but the roads are usually in such condition that light loads of truck crops may be marketed.

The rapid growth of the cities of Superior and Duluth has caused an increase in the demand for all farm crops far beyond the ability of the adjoining country to supply. The only crop thus far produced in quantities approaching the demand is hay, but hundreds of carloads are still shipped in annually. There is a ready demand for all farm products, and the prices are good.

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