Number 8 Series 1926

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS

RECONNAISSANCE SOIL SURVEY
OF
LAKE OF THE WOODS COUNTY MINNESOTA

BY

MARK BALDWIN, in Charge
J. AMBROSE ELWELL, and W. W. STRIKE

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RECONNAISSANCE SOIL SURVEY OF LAKE OF THE WOODS COUNTY, MINNESOTA

By MARK BALDWIN, in Charge, J. AMBROSE ELWELL, and W. W. STRIKE

COUNTY SURVEYED

Lake of the Woods County lies in the northern tier of counties in Minnesota. The detached part of the county, known as the "northwest angle," which comprises most of Angle Township, is the northernmost part of the United States. The international boundary runs through the waters of Lake of the Woods from the mouth of Rainy River to the Northwest Angle Inlet. In the water area thus made a part of Lake of the Woods County are Oak, Garden, Flag, Brush, Pine, and Magnusons Islands, ranging from about 160 to 1,600 acres in size, as well as 25 or more smaller islands. An area called the northwest angle, is entirely detached from the remainder of the county and is separated from it by the open water of the southern part of Lake of the Woods. The land area of the county thus falls into three main divisions which will, for convenience, be designated in the following report as the mainland, the northwest angle, and the islands.

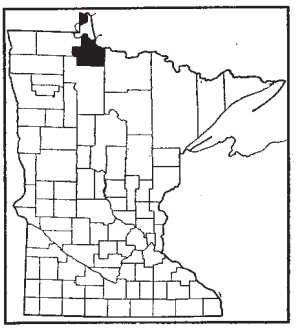


FIGURE 1.—Sketch map showing location of Lake of the Woods County, Minn.

The total land area of Lake of the Woods County is 1,313 square miles or 840,320 acres. Of this total, 1,180.6 square miles are in the 35 townships south of Lake of the Woods.[1]

On the mainland of the county, the land surfaces are generally flat, with a general slope to the north and east of about 7 feet to the mile. A number of undulating areas, however, by very gradual slopes attain elevations as much as 50 feet higher than the surrounding lands. These higher areas occur as narrow ridges and irregular-shaped "islands." The largest of these areas extends over southwestern Park Township, eastern and northern Clover Dale Township, south-central Eugene Township, northern Norris Township, and central Beaver Dam Township. During early investigations this higher land became known to geologists as Beltrami Island of Lake Agassiz, but that name never came into common usage. These higher lands serve to vary the direction of slope from that of the

[1] BALLINGER, R. A. DRAINAGE SURVEY OF CERTAIN LANDS IN MINNESOTA. (Letter from the Secretary of the Interior, transmitting a detailed report of a drainage survey of certain wet, overflowed, or swampy lands ceded by the Chippewa Indians in Minnesota.) House Document No. 7 (27), 40 pp., illus. (61st Cong., 1st sess., Doc. No. 27). 1909.

general land surface, but the general degree of slope is only a little greater in the descent to the east through Park Township. The other elevated land surfaces are smaller and of little consequence topographically. However, with respect to natural drainage conditions, soils, and agricultural utilization, local differences in elevation of only a few feet are of great importance, as they may mean the difference between poor and good natural drainage. In the northern part of Prosper Township, adjacent to the shore of Lake of the Woods, lands are sufficiently elevated to provide good drainage, and sparsely distributed over the county are rounded, narrow ridges, generally 8 or 10 feet high, marking former beach lines of the lake which in recent geologic time covered the northwestern part of Minnesota. One of these narrow ridges is of considerable length, extending almost without interruption from central Chilgren Township southeastward to east-central Spooner Township.

The surface features of the northwest angle and of the islands are more diversified than those of the mainland. Though most of the land is flat there are in the northern part of the angle and on the northern islands, such as Flag and Oak Islands, conspicuous rounded ridges of igneous and metamorphic bedrock. These ridges rise to elevations ranging from 50 to 75 feet above the lake and the bogland. In places where bedrock meets the waters of the lake, there are low but precipitous cliffs or rounded rock slopes which add interest and beauty to the shore line. Sandy or stony elevated ridges occur where the bedrock is buried beneath lake-laid or ice-laid glacial débris. The stream valleys are small and most of them are U-shaped. Flood plains are small or are lacking. The stream beds lie from 2 to 30 feet below the level of adjacent lands.

The elevation ranges from 1,310 to 1,060 feet above sea level. The water level of Lake of the Woods is variable. It was reported in 1917 as 1,060 feet.[2]

The elevations of the stations along the Canadian National Railway show an ascent from 1,084.9 feet above sea level at Baudette to 1,163 feet at Roosevelt, Roseau County. The average increase in elevation is between 3 and 3½ feet to the mile.[3]

The drainage waters of the county find their way into Lake of the Woods from all save parts of Beaver Dam, Hiwood, Noyes, and Norris Townships, and T. 158 N., R. 35 W., which drain to Red River through Roseau River. An area of about 300 square miles, comprising roughly the lands between the Canadian National Railway and Lake of the Woods, is drained by several small streams, many of which disappear in the large peat bog in Zippel and Wabanica Townships. The only natural outlets of these bog waters into Lake of the woods are South Branch and West Branch Zippel Bay and Bostic and Wabanica Creeks. East Branch Warroad River drains an area of about 85 square miles in Hiwood, Noyes, Beaver Dam, and Norris Townships. Rainy River, through its tributaries, Winter Road, Rapid, and Baudette Rivers, and Wabanica, Miller, Sensky, and Silver Creeks, carries the remainder of the county's drainage water

[2] MEYER, A. F., and WHITE, A. V. REPORT TO INTERNATIONAL JOINT COMMISSION RELATING TO OFFICIAL REFERENCE RE LAKE OF THE WOODS LEVELS. TEXT. volume 1. 314 p., illus. Washington [D. C.]. 1917.

[3] See footnote 1.

to Lake of the Woods. Of these tributaries, Rapid River has a watershed of about 500 square miles in the two southern tiers and the eastern tier of townships, Winter Road River, with its tributary, Peppermint Creek, of about 125 square miles; Baudette River of about 90 square miles; Miller Creek of about 12 square miles, and Silver Creek of about 25 square miles. All these watersheds are inadequately drained by the streams. Little or no tributary development has taken place, the streams being confined to shallow valleys with occasional short tributaries which soon lose themselves in broad, flat boglands. The greatest tributary development in the county is that of Rapid River in Swiftwater Township, where the main channel forks into the North Branch and South Branch. Three fair-sized tributaries of South Branch Rapid River in Swiftwater Township furnish fair or good natural drainage to about one-fourth of the township.

Likewise about one-fourth of the area of Walhalla Township and one-eighth of the area of McDougald and Chilgren Townships are served by Canfield, Willow, Williams, and Peppermint Creeks and Winter Road River. Rather large areas without well-defined natural drainage ways are well drained, owing to the undulating relief and comparative porosity of the soil and substratum. Such areas are those indicated on the soil map as Hiwood loamy fine sand, Faunce sand, and Marquette gravelly sandy loam, which comprise about four-ninths of the area of Myhre Township, one-third of Clover Dale Township, one-fourth of Lakewood, Prosper, and Noyes Townships, and one-fifth of Park, Beaver Dam, and Eugene Townships. In Rulien and Boone Townships, and T. 157 N., R. 35 W., and T. 158 N., R. 35 W. are the smallest acreages of such lands. In the aggregate, in about 200 square miles or about one-sixth of the land in the 35 townships of the mainland natural drainage is fair or good; in about 75 square miles natural drainage is poor or fair; and in the remaining 900 square miles (about 725 square miles of which are occupied by peat) natural drainage is poor. To supplement the inadequate natural drainage about 600 miles of open ditches have been constructed to discharge the water which is retained on the more level areas and on areas of peat and moss. The fall in this drainage system varies from 1 to 10 feet to the mile and averages about 7 feet. In the 10 years or more that this ditch system has been operating the water level of the most poorly drained areas served by ditches in the southern part of the county has been lowered 2 or 3 feet below the surface. A rather large area of the lands of originally fair or poor natural drainage are now furnished adequate outlets.

The general drainage conditions on the northwest angle are similar to those on the mainland part of the county, except that no extensive artificial drainage has been attempted. There are large areas of poorly drained land, largely peat bog; narrow strips of better-drained lands along the few small streams which penetrate the area and, in places, along the shore of the lake; and a few well-drained elevated areas of solid rock or mineral soil. On the islands in Lake of the Woods there is a similar diversity of drainage con-

ditions, the land ranging from wet bogs, in places overflowed by water from the lake, to excessively drained stony or sandy ridges.

Water for drinking purposes is of good quality and is plentiful at a slight depth. Several flowing wells furnish a steady, permanent flow of excellent drinking water. These wells average about 85 feet in depth, the deepest being 225 feet.

This county was originally covered with timber. Black spruce, tamarack, and in places cedar (arborvitae) were the characteristic and dominant trees on peat land. In places alder, mountain maple, dwarf birch, and willow constituted the shrub growth on such lands. Smaller plants, mostly on the more open bogs, were the mosses, Sphagnum and Hypnum, Leatherleaf, Labrador-tea, Cassandra, dwarf Kalmia, low-bush cranberry, lingberry, snowberry, pitcher plant, and cotton grass. Where unduly high water tables precluded thrifty tree growth on these peat lands sedges and rushes were prominent in the native vegetative cover.

On only part of the total area of deep peat land are there young growth stands of black spruce, cedar, or tamarack, and on such land these trees seem to grow very slowly. Once burned over or logged off, these lands usually show only the burned dead trees or stumps, with a thick cover of shrub, sedge, and wire grass choking out all other growth. The narrow stream meadows have a grass growth of finer quality, such as redtop and bluejoint. In some parts of these valleys there is a thick shrub growth of alder and willow, with a fairly dense stand of black ash, elm, balsam, and spruce. On the lands not covered with peat three types of forest growth were native, namely: (1) Pine, including Norway and jack pines, with some white pines; (2) hardwood, including birch, elm, ash, hard maple, basswood, balm-of-Gilead or balsam poplar, and ironwood; and (3) mixed conifers and hardwoods, including the common hardwoods with mixed stands of spruce, balsam fir, pines, cedar, and tamarack. Following logging or firing these three types of forest have given way to a second growth consisting largely of poplar,[4] birch, and balm-of-Gilead, with jack pine on the sandier soils. The shrub growth common to lands of this kind includes hazel brush, sumac, blackhaw, and chokecherry. Wild currant, gooseberry, blueberry, high-bush cranberry, and raspberry bushes are found in scattered stands. The grass growth consists largely of redtop and bluejoint, with an admixture in places of alsike clover.

Lake of the Woods County was organized November 28, 1922, from a part of Beltrami County. Prior to 1889, the date of cession to the United States Government of Chippewa lands, the entire county, except the northwest angle, was a part of the Red Lake Indian Reservation. The population was 131 in 1900 and, according to the fifth decennial census of the State of Minnesota, was 1,085 in 1905.

At present the entire population is classed as rural. A large percentage of the population is distributed in the county within 12

[4] The trees referred to as poplar in this report are mostly *Populus tremuloides*, with, in places, some *P. grandidentata*. Both species are included in the common designation "popple." Elsewhere in the country they are called aspen. The tree locally known as balm-of-Gilead or balsam poplar is *Populus balsamifera*.

miles of the Canadian National Railway or along the shores of Lake of the Woods.

Baudette, the county seat, had in 1920 a population of 960, Spooner of 571, and Williams of 164. Graceton and Pitt are smaller unincorporated villages on the Canadian National Railway. A number of inland trading centers and post offices are scattered over the county, Bankton, Lovedale, Rako, and Carp in the southern part; Faunce and Hiwood in the western part; Arnesen and Lude in the northern part; Clementson in the eastern part; Oak Island on Oak Island; and Penasse on the northwest angle.

At the present time the Canadian National Railway, traversing the northern part of the county from east to west, is the only railroad in the county. By this railroad the St. Paul and Minneapolis markets are reached by way of Duluth. Practically all the grain and seeds and a part of the dairy and poultry products are marketed at Duluth, and livestock is shipped to South St. Paul.

Lake of the Woods and Rainy River to the foot of Long Sault Rapids, 15 or 20 miles east of the county, are navigable for gasoline and steam boats with as much as 8 or 10 feet draft. The towing of logs and a small freight and passenger traffic are the chief forms of navigation. No large market is at present accessible by water.

In 1925 there were in the county about 60 miles of graveled roads and 99 miles of State-aid roads. This system of roads connects Roosevelt and Clementson and the intervening railroad towns from Williams north to Lude; from Roosevelt north to Arnesen and south to Faunce; from Pitt south to Lovedale, then west to the southwest corner of the county along South Branch Rapid River and out of the county; north from Pitt to Wheelers Point, from Baudette and Spooner northwest to Wheelers Point and south to Carp and Rako, and south from Rako. The 60 miles of graveled roads are maintained in excellent condition at all seasons, except in occasional short periods during heavy snowfall in winter.

In addition to this system of State-aid and graveled roads there are about 725 miles of public and private roads, of which about 425 miles are ditch-bank grades. When wet many of these unimproved roads are not passable by automobile. In the southern, most sparsely settled part of the county at the present time only the ditch grades needed by the present settlers are kept in condition for travel. The untraveled ditch grades are, however, in good condition as a rule and can be made passable by cutting off weeds, leveling and filling, and repairing ditch bridges. The expense of repairing a few grades badly burned out by peat-bog fires would be considerable. The sand-ridge roads and trails are well traveled and passable under practically all weather conditions. The road system of the northern half of the county, which is the most thickly settled part, is well maintained for the present demands of travel. Rural mail routes reach all settled parts of the county, and in the more thickly settled parts there are rural telephone lines. School facilities are provided by four consolidated schools at Baudette, Spooner, Williams, and Roosevelt, and by 39 country schools well distributed over the settled parts of the county.

CLIMATE

The climate of Lake of the Woods County is temperate, with rather long winters and short, pleasant summers. In summer the variation in monthly temperatures is 10° or 12°, but the monthly variations in the spring, fall, and winter are 20° or 25°.

The mean annual rainfall is 21.78 inches, and 16 or 17 inches of this fall from April to September, inclusive. May, June, July, August, and September have from 8 to 10 days each of 0.01 inch or more rainfall. As a rule snow stays on the ground, except for short periods of thaw, from December 15 to April 1.

The frost-free season ranges from 100 to 120 days. The average date of the latest frost is May 21 and of the earliest is September 15. The latest recorded frost was on June 9 and the earliest on August 26. It is undoubtedly true that on the lands close to Lake of the Woods and on the islands in the lake killing frosts do not occur quite so early in the fall or so late in the spring as elsewhere in the county.

Variations in precipitation, temperature, and date of frost have considerable bearing on agriculture. Rains in the spring may prove inconvenient by interfering with the preparation of the seed bed and the planting of crops on all but the better-drained or sandier lands and in the fall may interfere with the threshing of grain, fall plowing, and the fall seeding of rye. Hay curing and small-grain harvesting during the summer are sometimes delayed by rainy spells. Although less rain falls here than in the southern part of Minnesota, the cooler climate probably compensates in a measure for this and, except on the more porous, droughty soils, the supply of moisture is usually sufficient to support good grop growth. Also the moisture is well absorbed by the soil, as heavy downpours or high winds seldom occur. Hail seldom damages crops. Snow usually forms a permanent cover during the coldest winter months, affording protection for winter crops. The growing season is normally too short and the nights too cool for the maturing of dent corn. Squaw or flint corn and small grains mature well, however, in a season not abnormally backward or short, and two cuttings of alfalfa and clover hay are produced. Occasional light frosts during July and August cause damage to the more tender crops and arrest their growth. Although the normal frost-free season is shorter than in the agricultural sections of southern Minnesota, a more rapid crop growth, especially marked in the case of alfalfa, clover, and small grains, is noticeable. The longer hours of daylight may have a slight counteracting influence on the shorter growing season.

The prevailing winds are westerly and northwesterly. Except in the larger unprotected areas and on the shores of Lake of the Woods, wind velocity is low. When the velocity is highest, the wind seldom if ever damages crops.

Table 1 is compiled from data of the Weather Bureau station at Baudette and is representative of conditions in the county.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Baudette*

[Elevation, 1,084 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1920)	Total amount for the wettest year (1909)
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*
December	9.8	52	−40	0.77	0.82	1.23
January	2.6	44	−49	.62	.84	1.19
February	5.8	49	−43	.52	.37	.19
Winter	6.1	52	−49	1.91	2.03	2.61
March	21.5	76	−36	.76	.61	.72
April	39.9	84	−2	1.30	.64	.47
May	52.9	93	19	2.27	2.98	1.80
Spring	38.1	93	−36	4.33	4.23	2.99
June	60.9	99	28	2.85	2.16	2.52
July	67.1	100	38	3.68	1.58	6.46
August	64.4	97	30	3.12	1.87	2.88
Summer	64.1	100	28	9.65	5.61	11.86
September	55.7	92	24	2.61	4.12	4.69
October	42.6	83	3	2.26	1.14	4.12
November	27.6	65	−17	1.02	.60	1.65
Fall	42.0	92	−17	5.89	5.86	10.46
Year	37.6	100	−49	21.78	17.73	27.92

AGRICULTURE

The first settlers in Lake of the Woods County engaged in fur trading. Agriculture was conducted only by the native Indians inhabiting the islands and the shores of the lakes and rivers. A record of the sale of corn, raised on Garden Island, to traders in 1810 shows that agriculture was more or less developed by the Chippewa Indians. Fort Francis, about 50 miles east of the county on Rainy River, was in those times an established trading post of the Hudson Bay Co. The first timbering in the county was carried on prior to 1900 by Canadian woodsmen along Lake of the Woods and Rainy River. About the same time, fishing the waters of Lake of the Woods first began to assume a commercial scale. In 1901, the present railroad was built through the county as the Minnesota & Manitoba Railroad. It has since been leased and operated by the Canadian National Railways. Timbering prospered, and in 1905 the Spooner sawmill started and remained in operation until about 1920. This period from 1900 to 1920 saw the practical exhaustion of saw lumber in the county, but there still remain possibilities for logging cedar poles, posts, railway ties, and bolts for small lathe mills.

The majority of the early homesteaders were lumbermen who used the land only for collateral on loans, and forfeited title. The peat lands of the southern and western parts of the county, in their poorly drained, inaccessible state, did not attract settlers. In 1907

a drainage survey of the ceded Chippewa lands was completed under authorization of Congress [5] and within a few years the present comprehensive system of drainage ditches was undertaken. In the meantime, from 1905 to 1910, settlement slowly was becoming established. A small-scale agriculture persisted, but it was wholly inadequate for the local demands of the sawmill centers. Clearing for farming was laborious and slow, and clearings were small, only a few being as large as 40 acres. In October, 1910, a forest fire which devastated a small part of Roseau County, the northern part of Lake of the Woods County, and a little of Koochiching County and almost entirely destroying the town of Baudette, left in its wake large tracts of land which were much more easily cleared. A large part of this burned-over area was peat land and following the fire, in which much of the peat itself was consumed, it was more easily cleared of remaining débris than were the mineral soils.

The years from 1910 to 1915 saw the beginning of a system of good roads in the northern part of the county. Except for a few settlers along Rainy and Rapid Rivers and on the sandy lands south and southwest of Williams, the chief settlement in 1915 was within 10 miles of the railway. With the completion of the ditch system, the ditch banks were leveled and made into passable roads which made more accessible for settlement the better-drained mineral soils and shallow peat lands of the southern and western parts of the county.

Settlement became more active and widely distributed and by 1920 had reached a peak from which a decline occurred during 1921. During the last few years of general agricultural depression new settlement has about balanced the abandonment. An increase from 794 to 881 farms is indicated by the 1922 and 1924 Minnesota State farm censuses. Following the drainage improvement of 1915 a large part of the public lands affected passed into private hands under the provisions of the Volstead Act of May 20, 1908, whereby for the payment of the drainage taxes accruing to the land all other settlement provisions of homesteading were waived. Consequently ownership was largely absentee. The land was taken largely for speculative rather than for improvement and settlement purposes. Scarcely any of the settlers of this county were financed for the period of low earnings until clearings of sufficient size were completed for crops and their farms made self-sustaining. They were required to seek employment off the farm for income. Work in the sawmill or logging camps during the winter provided earnings without undue interruption in the work of clearing and improving the homesteads. Now, with the earnings from such winter work limited to the logging of cedar poles, posts, and railway ties and to work on crews of small lathe mills, a number of the settlers go to the Dakota harvest fields for outside earnings until the homestead clearings are of sufficient size to support them. This work is less remunerative, of shorter duration, and requires absence from homesteads at a less convenient time of the year than the local lumbering work. For this reason, real pioneering at the present does not seem so advantageous as it did in the past, and some capital is practically a necessity for the settler.

[5] BALLINGER, R. A. Op. cit.

According to a checking of the records at the Cass Lake, Minn., land office in August, 1925, there remained 45,600 acres in the northwest angle and 29,960 acres in the 35 townships south of Lake of the Woods, or a total in the county of 75,560 acres of public land available for homestead entry. Practically all of the 29,960 acres south of Lake of the Woods could be purchased under the Volstead Act or under the isolated tracts law, without residence and cultivation requirements.

The discussion of soils, crops, and agricultural possibilities in the following pages is based largely on observations made during the course of the soil survey, mostly in 1925 and 1926, on local information, on figures published in the 1925 agricultural census, and on other published data. In newly developed regions, like Lake of the Woods County, changes in agricultural practice and land utilization are often rapid, and the three or four years elapsing between the time of the field work and the publication of the report may have witnessed considerable change in agriculture and the general economic conditions in the county. In this particular area there may even have been some minor changes in the distribution of soils, as a result of the burning or shrinkage by desiccation of peat areas.

The present marketing facilities do not, as a rule, justify the shipping of the bulkier agricultural products. Dairy and poultry products, grain, potatoes, and hay-grass seeds comprise the biggest part of the produce marketed. Within the last few years, following the increase in feed production made possible by the increased acreage of cleared land, dairying has become important on the better-established farms.

The 1925 agricultural census reports 3,263 head of cattle in the county. About two-thirds of this number are dairy animals, mostly purebred and grade Holsteins and Guernseys. About one-half the total number of beef cattle are grade Shorthorn and stock of mixed blood. A cooperative creamery is at Spooner, and creameries at Warroad, International Falls, and Duluth receive the bulk of the cream shipped from the county. Beef and veal production is on a small scale, supplying home demands and a small local market demand.

A fair grade of work horses is kept. The 1925 census reported 1,341 head in the county. The farmers in poorer circumstances and those having small acreages of plowland do not keep work animals but pay to have their plowing done.

Sheep and hogs are kept on the better-established farms of the county. The 1925 census reports 707 sheep and 881 hogs in the county. No farmer kept a large number of hogs, but a few herds of sheep were rather large. Pork production little more than supplies home demands. Sheep and wool are marketed almost entirely through the State cooperative agency, but some small local sales are made.

The census for 1925 reported the total number of chickens in the county as 18,648. Flocks are largely of mixed breeds, but a few are of White Leghorn and Barred Plymouth Rock. Local markets handle the produce, except during three or four months of the year when some is shipped to Duluth. Dairy products bring in the greatest income of any branch of the livestock industry in Lake of

the Woods County. Wool and poultry products are also marketable commodities.

According to the 1925 agricultural census, the total crop acreage was 22,224 acres, and the total farm acreage was 139,146 acres, or 16.2 per cent of the land area of the county. Pasture occupies about 20 per cent of the total farm acreage, and 60 or 65 per cent is idle land in need of clearing or draining before cropping is possible. The Minnesota State farm censuses from 1922 to 1925, inclusive, indicate the general rate of agricultural development for that period. The farm acreage expanded, during that time, by 18,691 acres, an increase of 17 per cent; the crop acreage gained about 5,621 acres, an increase of 42.5 per cent; and the pasture acreage increased 1,899 acres, or 9 per cent. The Minnesota farm census reported that in 1922 and 1923 a total of 4,403 acres was cleared or drained and that brush was removed from 2,644 acres.

Timothy and clover, alone or mixed, occupy a larger acreage than any other crop in Lake of the Woods County, and alfalfa is increasing in favor. (Pl. 1, A and B.) Between 1922 and 1925, inclusive, the acreage of tame-hay crops increased 74 per cent. Soil and climate are well adapted to timothy and are particularly favorable to clover. Fair stands have been obtained without any preparation of the soil, and plants grow wild in the woods. Sown in a wild-hay meadow or on stump or light brush land the clovers, especially alsike, compete for a stand with the wild grasses. (Pl. 1, C.) Difficulty in obtaining a stand is experienced only on the sandier soils, where moisture is insufficient, and yields on such areas are very uncertain. Mixed timothy and red clover yields 1½ or 2 tons to the acre. Red clover averages 2 tons to the acre and usually makes two cuttings a season; sweetclover produces two cuttings a season, with an average of 2½ tons to the acre; alsike yields one cutting of about 1¾ tons to the acre; and timothy averages 1½ or 2 tons to the acre. In favorable seasons on the heavier well-drained soils double these yields are produced.

The clovers produce good seed crops in normal seasons and constitute one of the most marketable cash crops in the county. Between 1918 and 1922 there were reported several especially good crops, which at the prevailing high market prices were extremely profitable. Prices of 1925 were about one-third of those obtained in 1919. Owing largely to this condition, no doubt, is the decrease from 252 acres of clover for seed in 1921 to 59 acres in 1924. However, at current prices and average yields clover seed would give a good return. Timothy seed was harvested from 98 acres in the county in 1924 and from only 9 acres in 1922. Local demands are usually supplied, and little or no surplus is marketed. Timothy seed is ordinarily not so profitable a crop as the clover seeds. Yields average about 5 or 6 bushels to the acre, but a maximum yield of 22 bushels has been reported. Timothy is sown with and without clover and a small grain as a nurse crop, on prepared seed beds, or is sown on wild-grass meadows without preparation of the soil. Home-grown seed is generally used. On all but the sandy soils, where stands are difficult to maintain because of lack of moisture, clover and timothy make good meadows for several years before weeds seriously encroach. Reseedings are usually very successful in competing with weed growth.

Oats rank second in acreage and constitute the main grain crop of the county. This crop occupied 3,452 acres in 1924, according to the 1925 census. Much of the oats is sown as a nurse crop for clover and timothy and alfalfa. Crops of small grains on the sandier lands are not ordinarily followed by clover, owing to the difficulty of securing stands on these droughty soils. Timothy, alfalfa, and sweetclover are sometimes seeded, but ordinarily the small grain is seeded alone on the sandy soils. As a rule oats are seeded between May 1 and May 10. The seed used is almost entirely home grown and is mostly of mixed strains. Among the strains grown are Swedish Select and Victory and medium-early varieties. Oats are usually harvested between August 10 and 20. The bulk of the grain is fed, but when prices are good a small tonnage is sold. Oats seeded too late to mature for grain are cut for hay. The average yield reported by the 1925 census was 31.6 bushels to the acre. Yields vary with the variation in growing seasons and soils. Ordinarily the lower yields are obtained on the sandier, droughty soils and on the heavier, wetter soils. A soil of medium moisture-holding capacity and fertility is most dependable. In wet seasons the sandy soils produce well, but on the heavier soils, particularly Wildwood silty clay and Chilgren clay loam, losses are large from weed contamination, lodging, and rust.

Wild hay ranks third in acreage, in 1924 occupying 2,797 acres. On the farms of larger improved acreages the cultivated hay grasses are preferred to and displace the wild grasses. On the farms with a large proportion of poorly drained land wild hay provides most of the roughage, and on the better-improved farms small acreages are usually cut. The wild hay of the county consists mostly of redtop, Italian brome grass, wild wire grass, bluejoint, and pea vines. The best cuttings are obtained from the stream-bottom meadows and open treeless areas of drained and burned-over peat lands, where cuttings can be made and the surface is sufficiently dry to effect proper curing. Where the peat land has too high a water table so it is not firm enough to support a mower, the grass growth provides pasture.

The 1925 agricultural census reports 669 acres in barley in 1924. This is a considerable increase in acreage since 1922. Barley is usually planted between May 5 and 20, and the grain matures for harvest between August 5 and 15. It is the quickest maturing of the spring-seeded grain crops and is the surest to mature. However, by reason of its earlier maturity it is seeded on the latest-prepared seed beds, often too late to insure maturity under backward growing conditions or before an unusually early fall frost. Yields of 20 or 30 bushels to the acre of matured grain are common. The average in 1924 was 22.1 bushels. The greater part of the crop is used for feed for dairy cattle and hogs, and as a rule large acreages are grown only on farms where there is livestock to consume the grain. A small part of the crop is sold locally, and in good market years some is shipped out.

Alfalfa, a very minor crop in 1922, in 1924 occupied 655 acres, according to the census. The production of this crop was first attempted only on the better-drained, more productive soils. Its success led to seedings on other soils. Except in a few places no marked success has resulted from attempts to grow this crop on the sandier,

droughty lands, though it seems to produce better on these lands than does red clover. Few if any farmers have limed the soil for alfalfa or inoculated the seed, but some have first grown sweetclover in order to effect inoculation. These preparations seem unnecessary in most cases, though they may prove beneficial.

In most fields the stand of alfalfa is only 2 or 3 years old and is just coming into full production. Just how long alfalfa will maintain itself on the soils of this county remains to be seen. A very few 8-year-old fields are not seriously contaminated by weeds or volunteer grasses. The heaviest yields are obtained from fields which have been seeded between three and six years. The third-year crop is ordinarily the first good seed producer, yields ranging from 2 to 8 bushels to the acre. Only a very small acreage is cut for seed. Homegrown seed and small quantities of imported Grimm seed are used for seedings. Hay yields range from 2 to 4 tons to the acre in usual seasons, depending on the age of the stand and the number of cuttings each season. Two cuttings usually are obtained from all but the 1-year-old and 2-year-old fields, and occasionally three cuttings are made from the older, heavier stands.

The largest acreages of alfalfa are on farms with fair-sized clearings and on farms where livestock is kept. On farms with small cleared acreages and on those where little or no livestock is kept, there is no present need for alfalfa. Most of the seedings are made without a nurse crop, between June 15 and July 15. Only one small cutting is obtained the first year. There is a small demand locally for alfalfa hay, but the greater part of the hay is fed. In dry years when the hay crop is short, a greater tonnage is sold locally. Ordinarily surpluses are not much in demand on the local markets, and shipping to outside markets is usually unprofitable on so bulky a product.

According to the 1925 census, potatoes occupied 578 acres in 1924. Owing to lower market prices, the 1922 potato acreage was cut in half in 1923, and small decreases occurred in 1924 and 1925. The decrease in acreage was general over the county. Potatoes are grown in all sections of the county for home use and for market. They are the cash crop most generally grown, and the income from them constitutes about one-fourth of the cash income from farm produce. Average yields between 150 and 200 bushels to the acre of good-quality potatoes are common, and yields as high as 600 bushels to the acre are reported. The Bliss Triumph is the most popular early variety. Late varieties grown are Green Mountain, Late Petoskey (Dibble's Russet), Russet Burbank, and Rural New Yorker No. 2, and early varieties are Early Ohio and Irish Cobbler. Homegrown seed is used. The ordinary season insures maturity of the crop. Harvesting is usually done between September 1 and October 1. A few growers in the last two years (1924 and 1925) have raised certified seed potatoes, but most of the crop is placed on the produce market. The culls and, in years when prices are low, a certain proportion of the marketable crop, are fed to livestock.

Flax occupied 496 acres in 1924, according to the 1925 agricultural census. About the same acreage or slightly more has been planted each year since 1922. Eighteen townships, chiefly those which are more inaccessible, reported no flax acreage in 1925. As a cash crop,

flaxseed ranks with potatoes, wheat, and seeds. Seedings are made between May 15 and June 15, commonly on newly broken land where the preparation of the seed bed is not so thorough as on cultivated fields. Home-grown seed of the wilt-resistant varieties is used, North Dakota Resistant No. 114 being the most popular. The seed is harvested between August 25 and September 15. Yields average about 9 bushels to the acre.

In 1924, corn occupied 646 acres, according to the census. This is a rather large decrease since 1922. The decrease was general in all farming sections of the county save Wabanica, Wheeler, and Baudette Townships. Twelve townships in 1925 did not report a corn acreage. A large proportion of the corn is annually harvested as fodder or silage. The varieties grown are Northwestern Dent and Minnesota 13, and squaw and flint corns. The dent varieties are not sure to mature grain every season, but in a favorable season yields average 30 bushels to the acre and may be as high as 50 bushels. The squaw and flint corns are surer to mature every season. The dent varieties are preferred, however, and in poor growing seasons are utilized for fodder or, on a few farms equipped with silos, for silage. Corn is planted between May 15 and June 1, or a little later if a fodder crop is desired. Most of the seed is home grown. Fodder is cut between September 15 and October 1, as a rule. Most of the crop is fed on the farm, but small quantities are marketed locally.

The 1925 agricultural census reports the acreage of rye in 1924 to be 446 acres. This acreage is considerably smaller than that grown in 1922. The decrease in acreage was general over the county, except in Hiwood and Norris Townships, where substantial increases took place. No acreage was reported in 12 of the 35 townships south of Lake of the Woods. Planting is between August 15 and September 15, and home-grown seed is commonly used. Rye is the first of the small grains to mature and is cut between August 1 and August 5, as a rule. Yields averaged 18.8 bushels to the acre in 1924, but yields as high as 45 bushels have been reported. Although yields are heavier on the better soils, rye is commonly a better producer than the other small grains on the droughty, sandy soils. The crop is fed on the farm, or small quantities are marketed locally.

In 1924, wheat occupied 435 acres. Slightly more than half of this was spring wheat. Yields of winter wheat appear to be a little more sure than of spring wheat. The total wheat acreage during the period from 1922 to 1925 remained nearly the same, but that of winter wheat increased and of spring wheat decreased slightly. Winter wheat is planted between August 15 and September 1. Spring wheat is sown between May 1 and May 10. Home-grown seed of fairly pure strain is used. The Minturki is perhaps the most popular variety of winter wheat and the Marquis the most common of the spring wheats. Harvesting is done from about August 15 to August 25, as a rule. The winter wheat matures a little earlier than spring varieties. The average yield in 1924 was 18.5 bushels to the acre, but yields as high as 45 bushels to the acre are reported. Wheat is one of the cash crops of the county. Small quantities are fed on the farm, and the remainder is marketed.

The root crops grown for forage and livestock feed are rutabagas, turnips, mangels, and sugar beets. Rutabagas and turnips are also grown as garden crops for table use and local markets. Root crops in this county are noted for their high quality.

Soybeans are seeded for forage either with corn or alone. Rape and sorghum are other minor fodder or forage crops occasionally grown on very small acreages. They are not enumerated by the census. Buckwheat, a short-season crop adapted to cool summers, under favorable conditions produces on lighter soils than the other grain crops. Garden crops are of excellent quality. In addition to supplying the needs of settlers, a few farmers produce surplus truck for local markets. The supply does not meet the demand, however. Potatoes, beans, peas, onions, cabbage, carrots, beets, parsnips, turnips, rutabagas, sweet corn, lettuce, radishes, rhubarb, and cucumbers are among the common garden crops grown.

A small acreage of small fruits, such as currants, strawberries, gooseberries, and raspberries, is grown. Red raspberries, blueberries, and cranberries grow wild. Where the patches are thick enough to justify picking for market, small quantities are sold in addition to those picked for the settlers' use. Blueberries are the only small fruit marketed to any extent. The Baudette canning factory packs only blueberries. The season's pack is almost entirely harvested from the islands in Lake of the Woods.

The growing of tree fruits has received little attention in Lake of the Woods County, and the fruit trees started are not as a rule well cared for. Plums and apples (principally crab apples) are being started. Some heavy-bearing trees have been reported, but thus far yields have been very uncertain and low, owing either to lack of care or lack of hardiness in the stock, or both.

SOILS [6]

Nearly 64 per cent of the land area of Lake of the Woods County is covered by peat, and much of the mineral soil which at present constitutes the surface material was, until a few years ago, also covered by peat. These peat lands, are, or originally were, poorly drained, though not necessarily covered with standing water. In addition to the peat lands, much of the mineral soils was developed under poor drainage conditions. In fact the total area of naturally well-drained land is very small. Well-drained areas occur only in narrow strips along the stream ways and lake shores, or gravelly sandy ridges and small sand plains, and as irregular-shaped "islands" which rise above the general level of the region. Some of the "islands" consist of rock.

Thus the soils for the most part are imperfectly weathered and have formed under excessive moisture conditions. Aeration and leaching have progressed very slowly and ineffectually in the soils

[6] The soil map of Lake of the Woods County is based on a reconnaissance survey. In this survey all of the roads were traversed, and, on the mainland, areas between roads were covered, in general, at 1-mile intervals. Owing to the inaccessibility and present lack of agricultural development in the region, the northwest angle was covered in less detail, and the map, especially in the interior, indicates only roughly the position of the areas of the various types of land. The base map was in part compiled from various sources, including the General Land Office plats, the surveys of the International Boundary Commission, and the surveys of the Corps of Engineers, U. S. Army, and was in part based on plane-table traverse, made in conjunction with the soil mapping.

over the county as a whole, and only the best-drained soils located in narrow strips adjacent to the more deeply dissected stream ways or on higher elevated lands of good surface and internal drainage exhibit the influence of the aerial forces of weathering, and even there this influence is in most cases not strongly shown.

Although the better-drained soils comprise a total of only about 16 per cent of the area of the county, they are comparatively important from the viewpoint of agriculture and of soil classification. It is their wide distribution over the county which has largely made possible such agricultural development as has taken place. The stream banks and the "islands" of these soils have furnished the farmstead sites and most of the arable land for 60 per cent or more of the farms.

Although there are wide differences, especially in texture, between these naturally well-drained soils, characteristics which they have in common with each other and with other soils of the region warrant their being grouped together in a broad way and set apart from equivalent groups which occur in other regions of the country. Characteristic of this particular group of soils, as typically developed in the region of their occurrence, is the following sequence of natural layers, which may be termed the regional soil profile: (1) A surface covering of organic matter composed of litter, leaf mold, and humus; (2) light-gray comparatively light-textured soil, leached of lime, with an apparent loss of iron oxides and alumina and a corresponding increase in silica; (3) a brown layer containing a higher percentage of clay, hydrous oxides of iron and aluminum, and organic matter than those above or below; (4) a very slightly weathered layer, underlain by (5) the parent soil material which to all appearances is practically unaltered by surface weathering. These layers are most distinct where the soil has occupied well-drained positions and the weathering agencies have been most active.

Soil mapped as Taylor very fine sandy loam has the most characteristically developed profile of the group of soils described in this county. The heavier-textured third layer in this soil is noticeable for its more granular structure and heavier texture, and its brownish color contrasts with the very light gray of the layer above it. Baudette very fine sandy loam has the characteristic soil layers described, but they are less distinctively developed than in the Taylor soil. Hiwood loamy fine sand commonly has the gray layer, but the brown layer is only in faint color contrast with the underlying light grayish-yellow soil and is similar in texture and structure, owing to the composition of the parent material which is 90 per cent or more quartz sand. Faunce sand, although it is a well-drained soil, has only faintly developed the visible features of the characteristic regional profile. Marquette gravelly sandy loam in places shows the brown layer developed faintly, as in Hiwood loamy fine sand, but in few places is the distinctive gray soil layer present. About 40 per cent of these well-drained soils, including members of the Taylor and Baudette series, are heavy textured and 60 per cent, including soils of the Marquette, Faunce, and Hiwood series, are sandy in texture.

On the surface of the poorly drained mineral soils in the county under natural conditions there is a layer of peat of variable thickness. The weathered layer of mineral soil is in most places absent

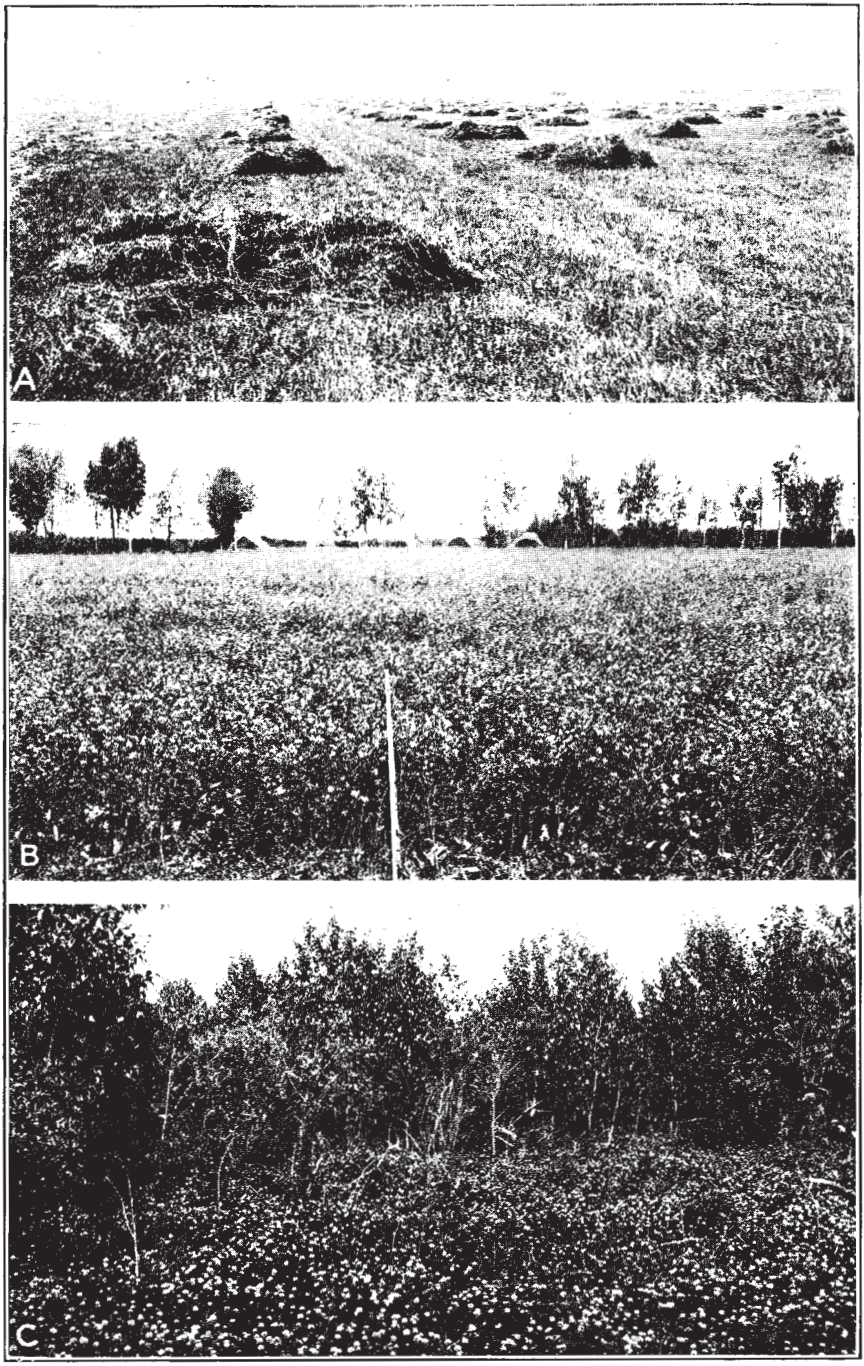
or very thin, very slightly altered, and partaking in a large measure of the characteristics of the underlying parent material which is composed of the unconsolidated sands, silts, and clays of the late Wisconsin drift. In places this material is unassorted and elsewhere it is more or less assorted by the waters of glacial Lake Agassiz. The original peat covering, which has been destroyed by fire, varied in thickness from 1 foot or less to about 4 feet. In Wildwood silty clay black humus has been mixed with the mineral soil to a depth of 4 or 5 inches. Other weathering effects, such as translocation and accumulation of the finer soil particles (clay and silt) and the leaching of water-soluble chemical constituents, such as lime, from the surface downward are only slightly evident in this and similar soils.

The separation of the soil series and types is based primarily on the varying composition of this slightly altered soil and the underlying parent soil material. Thus, Wildwood silty clay, which has a black surface soil, and Chilgren clay loam, which has a grayish-brown surface soil, are both heavy in texture in surface and subsoil layers. Rulien fine sandy loam, Rulien sandy loam, and Spooner very fine sandy loam have light-textured surface soils underlain by heavier-textured subsoils. Potamo loamy sand is light textured both in surface soil and subsoil. Of these poorly drained mineral soils about 75 per cent are heavy textured, 12 per cent light textured or sandy throughout, and 13 per cent light textured in the surface layer and heavy in the subsoil.

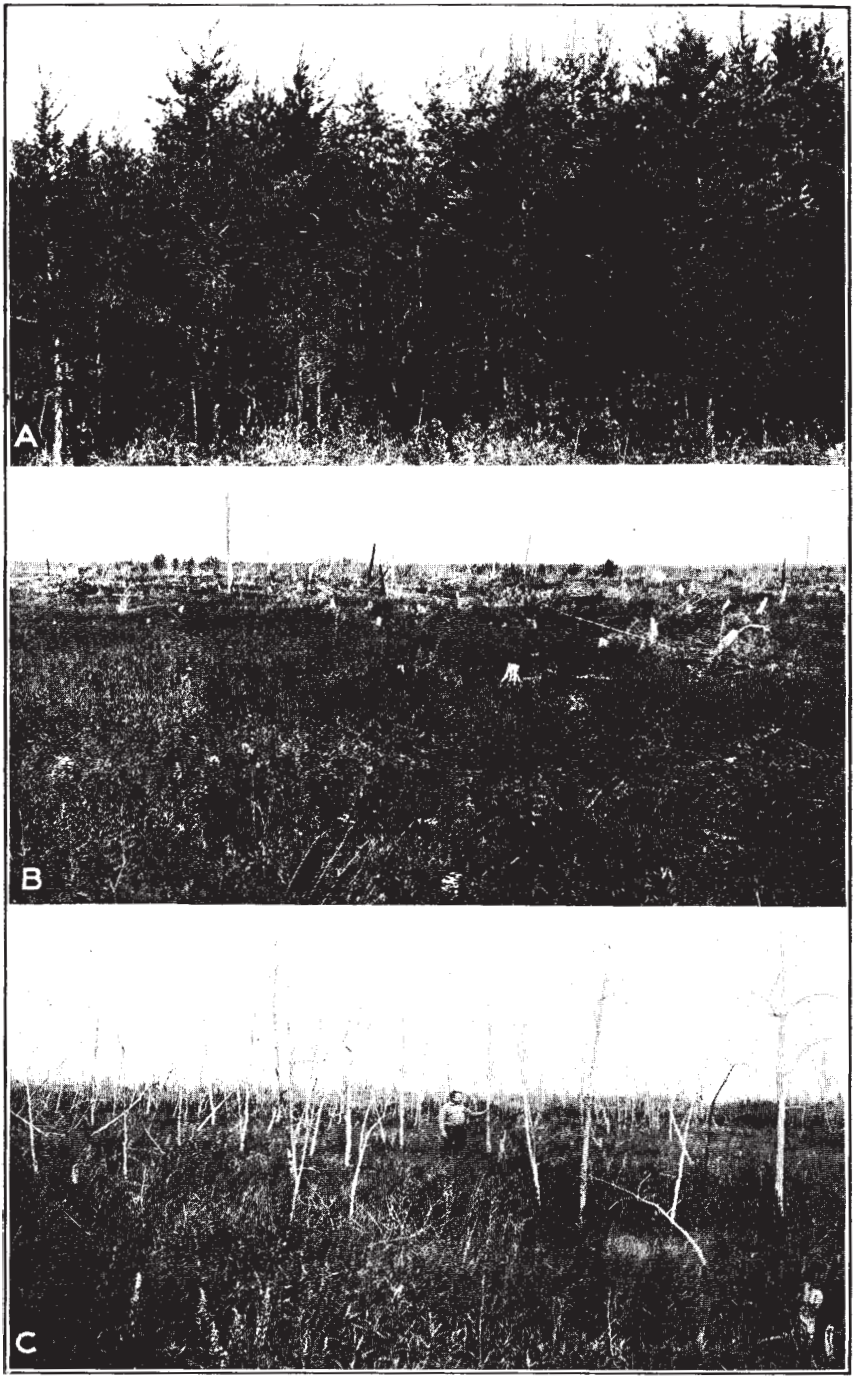
Gudrid fine sandy loam and McDougald fine sandy loam can not consistently be classed in either the poorly drained or well-drained group of soils. They are largely intermediate between the poorly drained soils formerly covered with peat and the well-drained soils not now covered with peat or showing evidence of a peat covering, and in their variable soil characteristics they represent the various stages of weathering between the two main soil groups. These soils have light-textured surface soils and heavier-textured subsoils. A characteristic difference between them is that the upper layers of Gudrid fine sandy loam are free of drift gravel, pebbles, and bowlders, and apparently consist of water-washed or wind-worked material, whereas McDougald fine sandy loam contains stones and bowlders and is more typically glacial till.

Although the presence or absence of glacial stones and bowlders in the soil is, to some extent, used as a basis for separating soil types, this difference is not markedly or consistently exhibited in Lake of the Woods County and is, therefore, not a factor of prime importance in soil classification. To have arbitrarily designated a group of soils containing glacial stones and bowlders as weathered from till deposits and another group of soils containing no evidence of gravel and bowlders as weathered from lacustrine glacial-lake deposits would have created a distinction not plainly present or discernible in the field. The parent materials of all the soils were originally deposited by the late Wisconsin ice sheet, and the surface mineral materials were largely reworked and assorted by the waters of glacial Lake Agassiz. In some places the materials show considerable reworking and are definitely of lacustrine deposition.

Marquette gravelly sandy loam is entirely weathered from old lake-beach material. Gudrid fine sandy loam and Spooner very



A, Mixed clover and timothy hay on Wildwood silty clay near Baudette; B, alfalfa field in bloom on Taylor very fine sandy loam, near Graceton; C, alsike clover invading an opening in second-growth stand of poplar, balm-of-Gilead, and willows



A, Vigorous stand of young jack pine on Faunce sand; B, present appearance of large areas of deep peat, with fire-killed dwarf black spruce and tamarack, and ground cover of willows, fireweed, wire grass, and other species; C, burned-over area of shallow peat. Fireweed is prominent in the foreground

fine sandy loam and parts of the areas of Wildwood silty clay, Potamo loamy sand, Taylor very fine sandy loam, and Faunce sand are, in part at least, derived from lacustrine deposits. The upper soil layers are in places lacustrine material, and the lower layers appear more like ice-laid drift which has been subjected to little or no reworking. This seems to be true in Hiwood loamy fine sand, McDougald fine sandy loam, Rulien sandy loam, and Rulien fine sandy loam. A characteristic common to the heavier parent soil materials of this county is the high content of lime carbonate, which in places is as high as 40 per cent below a depth of 2 or 3 feet. The deeper sandy deposits in well-drained areas originally contained little or no lime and the lime, if originally present, has been removed to a depth below 5 or 6 feet in some places.

Although differences in color, texture, structure, and other visible features of peat were noted in the course of the survey of Lake of the Woods County, no attempt was made to separate the different kinds of peat on the soil map. A shallow phase of peat includes areas where the peat covering is, in general, less than 3 feet thick. The partly burned-over areas of peat land could well have been mapped as mixed organic and mineral soils, but owing to the changes taking place in these areas as more of the peat hummocks are removed, it was decided to class them either with shallow peat or the mineral soil exposed, depending on the proportion of the area of peat remaining at the time the county was surveyed. Thus, areas mapped as shallow peat and even as deep peat may be found to have been denuded of this covering.

Three miscellaneous classes of material, rock outcrop, meadow, and beach sand, have also been mapped in this county.

In the following pages the various soils are described in detail, and their agricultural importance is discussed. The soil map shows their distribution and Table 2 gives their acreage and proportionate extent in the county.

TABLE 2.—*Acreage and proportionate extent of soils mapped in Lake of the Woods County, Minn.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Taylor very fine sandy loam	23,744	2.8	Wildwood silty clay	28,416	3.4
Baudette very fine sandy loam	26,304	3.1	Chilgren clay loam	41,024	4.9
Hiwood loamy fine sand	34,112	4.1	Potamo loamy sand	20,032	2.4
Faunce sand	28,416	3.4	Peat	243,712	63.8
Marquette gravelly sandy loam	12,544	1.5	Shallow phase	292,160	
Gudrid fine sandy loam	11,008	1.3	Meadow	7,936	.9
McDougald fine sandy loam	45,056	5.6	Beach sand	768	.1
Stony phase	1,920		Rock outcrop	1,024	.1
Rulien fine sandy loam	16,448	2.0			
Rulien sandy loam	2,112	.2	Total	840,320	
Spooner very fine sandy loam	3,584	.4			

TAYLOR VERY FINE SANDY LOAM

Taylor very fine sandy loam consists of the following layers: (1) A surface cover, a few inches thick, of forest litter and leaf mold; (2) a layer of friable gray loamy very fine sand or loamy fine sand, ranging from 3 to 6 inches in thickness; (3) a layer of pale yellowish-

gray loamy fine sand or very fine sand, 3 or 4 inches thick; (4) dark brownish-gray silty clay, from 6 to 14 inches thick, which is plastic when wet and when dry breaks up into granules characteristically sharp edged and angular in shape and from one-sixteenth to one-fourth inch in diameter; (5) the unweathered parent material consisting of gray calcareous silty clay having a slight-yellowish tinge, which is less plastic when wet than the layer above and when dry is more friable, forming slightly smaller but just as distinctly angular granules as the overlying layer. This layer also contains more sand, gravel, and pebbles than the layer above. Limestone pebbles are prominent among these coarser soil particles. With depth little change is noticeable, except a more heterogeneous mixture of soil particles. On much of the area bowlders are on the surface and embedded in the soil. The tests made for acidity indicate in general that the three upper layers range from slightly acid to neutral in reaction.

This soil occurs on well-drained areas adjacent to the main stream ways or on the more decided slopes and crests of elevations. The total area mapped in the county is about 37 square miles. Half of this area is in the four townships of Swiftwater, Victory, Gudrid, and Walhalla. A few variations from the typical soil are worthy of note. Areas totaling about 15 square miles, largely in Swiftwater, Walhalla, and Gudrid Townships, are comparatively free from bowlders, drift gravel, and pebbles. The bowlder-free areas are a little easier to till than the typical soil, but in all other respects the typical soil is equally desirable. In places the bowlder-free areas show distinct laminations. Another notable variation is in the texture and thickness of the gray layer. The thickness varies from 1 to 8 inches and the texture from fine sand to silt loam. Much of the Taylor very fine sandy loam mapped in the northwest angle has a silt loam surface soil and a very high content of lime carbonate in the parent material. Under cultivation a part of the heavier brown layer beneath it is mixed with the thinner gray layer.

The forest growth on this soil is mixed hardwood and conifers. White pine, balsam fir, white spruce, and arborvitae (white cedar) compose the coniferous growth, and poplar, balm-of-Gilead, birch, and lesser numbers of elm, ash, basswood, hard and soft maple, ironwood, and cottonwood were seen. Following logging or fire destruction, the poplar, birch, and balm-of-Gilead make up the greater part of the forest cover. The soil supported thick timber stands, and clearing for farming was in most places laborious. The cost of clearing these thickly timbered areas has been estimated to be between $40 and $50 an acre. Individual clearings at this time range from 15 to 50 or more acres in extent. Large openings have been made along the streams in Swiftwater, Walhalla, Gudrid, and Spooner Townships.

This soil, because of its accessibility by water, was among the first soils in the county to be settled. At the present time, in proportion to its area, it is the most densely settled soil in the county. Rough computations show 3.4 farms to the square mile, and as a whole these farms are justifying the labor and expense of improvement. This soil is considered one of the most productive in the county.

There is considerable range in the market value of Taylor very fine sandy loam. No transfers of well-cleared farms close to local markets have occurred recently, on which to base an estimate. During 1925 two tracts, one 80 acres in extent and slightly improved, near town, and the other 120 acres in extent, well cleared and improved but 18 miles from the railroad, sold for $18.50 and $12.50 an acre, respectively.

BAUDETTE VERY FINE SANDY LOAM

Baudette very fine sandy loam consists of the following layers from the surface downward: (1) A layer of leaf litter and mold; (2) very dark-gray loamy very fine sand, 3 or 4 inches thick; (3) light grayish-brown very fine sandy loam from 4 to 10 inches thick, which is heavier textured and when wet is more plastic and more coherent than the layer above or below; (4) friable light yellowish-gray or gray calcareous silty or very fine sandy clay, laminated, and showing thin soil layers of slightly different texture. This layer extends to a depth of 4 or 5 feet, where there is generally more heterogeneous and variable-textured material containing more drift gravel and pebbles than the soil above. The tests made indicate that, in general, the three upper soil layers range from slightly acid to slightly alkaline in reaction. The soil both absorbs and retains moisture well. Very few bowlders are on the surface, but more are below a depth of 4 or 5 feet. In its lighter texture range, Baudette very fine sandy loam approaches Hiwood loamy fine sand in physical characteristics, and in its heavier texture range it resembles Taylor very fine sandy loam.

The more poorly drained areas of this soil somewhat resemble Spooner very fine sandy loam. Such areas occur in Chilgren Township along the west county line. In such locations the gray layer is not so distinct, and the layer beneath it is more yellowish than brownish and is more poorly oxidized than typical. An area on the south bank of Rapid River in Victory Township shows well the character of the lighter-textured phase of the soil. The humus from the surface organic matter has darkened and stained the gray layer and a layer of light yellowish-gray loamy fine sand beneath it. The brownish layer lying below differs little in structure or texture, and only a darker yellowish or brownish cast distinguishes it from the soil material above and below. The subsoil below this is very fine sandy loam, which does not become any heavier above a depth of 36 inches but below that depth is slightly plastic very fine sandy clay. In its heavier texture range Baudette very fine sandy loam has a gray silt loam layer not so distinctly gray as is typical, a more brownish slightly heavier-textured silt loam layer beneath, and beneath this light yellowish-gray friable silt loam or very fine sandy loam which, at a depth of 3 feet, commonly grades abruptly into gray, mottled, highly calcareous silty clay loam. This is the phase of the soil mapped in Baudette Township along Winter Road River.

Baudette very fine sandy loam comprises about 41 square miles in the county. No areas are mapped in 18 of the 35 townships south of Lake of the Woods. The soil is most extensive in Lakewood, Prosper, Wheeler, Baudette, Chilgren, Meadowland, McDougald, Walhalla, and Wabanica Townships. Smaller areas occur elsewhere. Most

areas occupy well-drained lands adjacent to stream ways and the lake shores.

The forest growth on Baudette very fine sandy loam is of mixed hardwoods and conifers similar to those on Taylor very fine sandy loam, with some scattered stands of scrub oak along the lake and Rainy River in Wheeler Township. The forest cover is very thick, and clearing is about as slow and expensive as on Taylor very fine sandy loam. Occurring as it does along the lake shore and Rainy River and the other main streams, this soil was among the first settled. Individual clearings ranging in extent from 15 to 50 or more acres are the average on this soil. Most of the large area along Rainy River is cleared. The timber standing is practically all a dense second growth of poplar, balm-of-Gilead, Balsam fir, and birch, which has persisted in spite of frequent ground fires and the logging operations of the individual farmers. In Walhalla, Wheeler, and Baudette Townships the soil is well settled, and the settlements have good-sized clearings and the necessary farm improvements.

The few land transfers of this soil recently made indicate that the less accessible lands as far as 20 miles from the railroad command from $3 to $10 an acre and that the most accessible lands in their present state of clearing and improvement bring from $16 to $30 an acre. Better-improved farms than those involved in these transfers are either not to be bought or are held at considerably higher prices.

HIWOOD LOAMY FINE SAND

Hiwood loamy fine sand comprises in soil layers from the surface downward: (1) A surface covering of leaf litter, 3 or 4 inches thick, where unburned; (2) a layer of loose, nearly white loamy fine sand or fine sand, ranging from 4 to 10 inches in thickness; (3) light yellowish-brown loose loamy fine sand or fine sand, from 12 to 18 inches thick, stained brown or rust brown by iron oxides, organic matter, or both; and (4) light yellowish-gray loamy fine sand. The fourth layer, which is but slightly altered, consists of rounded, subangular, and angular translucent quartz grains, most of which are clear though a few are yellow, together with scattered fragments of dark-colored mineral, probably one of the ferromagnesian group. This layer changes but little until the heavier-textured calcareous glacial till containing gravel, pebbles, and bowlders is reached, at a depth varying from 5 to 15 or more feet. Hiwood loamy fine sand has been weathered from a deposit of fine sand which was laid down by water or wind or both. In contrast to the underlying till stratum, this sandy material is not rich in lime and does not contain gravel or bowlders. Hiwood loamy fine sand does not have a consistent reaction. The layer of leaf litter, where unburned, is generally acid in reaction; the gray layer is generally acid but may be neutral or alkaline following fire; the third or brown layer ranges from acid to neutral but is variable from place to place; the fourth layer is, as a rule, neutral, but alkalinity increases with depth toward the calcareous till beneath.

In this county the variations in this soil are not so much in the character of the soil itself as in the varying depths of the sand formation from which the soil is derived. In association with Faunce

sand the sand formation is deepest and is the best weathered and leached of carbonates. The sand here approaches a medium texture, like that of Faunce sand, especially in the fourth soil layer. In association with the heavier-textured soils, such as McDougald fine sandy loam, Baudette very fine sandy loam, and Taylor very fine sandy loam, the sandy layer ranges from 3 to 5 feet in thickness. In such areas, Hiwood loamy fine sand is in places as heavy as light fine sandy loam. Boundaries between McDougald fine sandy loam and Hiwood loamy fine sand on the map are in many places arbitrarily drawn, each area as mapped containing small areas of the other soil. The separation was in many places based solely on the depth to the heavier-textured till, which in McDougald fine sandy loam occurs at a depth of 2 or 3 feet.

Hiwood loamy fine sand occupies a total area in the county of about 53 square miles, half of which is mapped in the five townships of Myhre, Hiwood, Noyes, T. 158 N., R. 34 W., and T. 157 N., R. 33 W. Areas occur in all the other townships, except Boone and the northwest angle.

Hiwood loamy fine sand occurs with the Taylor and Baudette soils on the well-drained areas adjacent to streams and on the well-drained ridges and "islands" scattered over the county at a distance from natural drainage ways. The natural drainage is in all places thorough, both by reason of an undulating surface and a porous soil through which water readily moves. The soil is subject to drought during dry spells, the more damaging effects being on the areas of deeper sand where the sand is particularly loose and porous and especially low in content of silt or clay. The areas in Myhre and Hiwood Townships are, as a whole, of the deeper sand. The depth of the sand areas in T. 158 N., R. 34 W. ranges from 4 to 15 feet but is in most places 6 or 8 feet. In general these areas have a higher water table than those in Hiwood and Myhre Townships. There has been no artificial drainage, and the headwaters of North Branch Rapid River furnish a very inadequate outlet. This higher water table is reflected in the denser stands as well as the mixed character of the timber growth. Crops on these areas are not so subject to drought as on areas in Myhre and Hiwood Townships.

The characteristic tree growth in fairly pure stands on the deeper, sandier areas of Hiwood loamy fine sand is jack pine with scattered Norway pines. On the areas of shallower sand, jack and Norway pines are larger but in very few places are in pure stands, being mixed with poplar, birch, and balm-of-Gilead. The timber stands on Hiwood loamy fine sand are rather sparse, and the underbrush is commonly scant. The consequent ease of clearing led to considerable settlement on the areas of this soil, first on those accessible to the streams, then on those close to the railroad, and later on those made accessible by the present county-road system. Rough computations show Hiwood loamy fine sand to rank second to Taylor very fine sandy loam in density of settlement. As a whole, however, the farms are not so well improved as those on the Taylor soil and are not so accessible to local markets. The average size of clearings ranges from 15 to 50 or more acres.

The only recent land transfers involve unimproved or very slightly improved acreages of this soil 25 or 30 miles from the railroad. The

price ranged from $3 to $6 an acre. Farms accessible to markets and with 20 or 30 acres of improved crop land command higher prices, though no recent transfers have occurred on which to base an estimate.

FAUNCE SAND

Faunce sand has a surface layer of leaf litter and mold from 2 to 3 inches thick. Immediately beneath this layer the soil is colored dark by a small content of organic matter. This thin layer of dark-colored sandy humus soil grades into a layer of light-gray sand, less than 1 inch thick, which is underlain by grayish-yellow loose sand or coarse sand which becomes more yellowish or brownish with increasing depth, owing largely to stain on the individual sand grains. This sand is poorly assorted and, although it consists largely of quartz, there are many grains of other minerals, including feldspars and ferromagnesian minerals. The sand grains are rounded or subangular in shape.

This soil is mostly free from bowlders, but a few are exposed in places and in a few areas, principally in the southwestern part of Park Township, in section 18 of Norris Township, and in parts of Beaver Dam Township, the surface is very bowldery in spots. The bowlder-free areas consist generally of loose and porous sand throughout; the soil which carries bowlders contains, in places, pockets of gravel, silt, and clay which increase the moisture-retaining capacity of the soil. In places the plowed surface soil is somewhat coherent and has a light sandy clay texture. The layer below the leaf litter is in places colored dark by organic matter to a depth of 3 or 4 inches. The light-gray layer is not so well developed as in Hiwood loamy fine sand and is absent in many places.

This soil, as a whole, is generally slightly or medium acid to a depth of 3 feet and below a depth of 5 feet is neutral or slightly alkaline in reaction.

Faunce sand covers an area of about 45 square miles in the county. Two-thirds of this area is mapped in Clover Dale, Myhre, Norris, Park, Eugene, Beaver Dam, Lakewood, and Prosper Townships. None of the soil is mapped in 16 of the 35 townships south of Lake of the Woods. One small area is mapped on Garden Island.

This soil occupies well-elevated sandy plains and ridges. The run-off is moderate, but the internal drainage through the porous loose sand is excessive, making the soil in the bowlder-free areas the most droughty soil in the county. Many of the areas of more mixed texture are fairly retentive of moisture except during long periods of dry weather.

The forest growth on Faunce sand is predominantly coniferous, jack pines being by far the dominant and most characteristic trees. (Pl. 2, A.) The hardwoods present, mainly poplar and birch, are seen only in very scattered small stands, and spruce and tamarack are incidental, occurring mostly around the lower borders of the areas. Norway pine composed a considerable part of the original forest, but nearly all of these trees have been destroyed by logging operations and frequent burning of the slashings. The timber stands on this soil are not dense, and there is only a scant growth of underbrush. Clearing is much easier and less expensive than on the heavier

soils where the growth is thicker. This ease of clearing encouraged settlement on the soil, and at present it ranks third in number of clearings. Individual clearings range from 15 to 50 acres in extent. According to local information, the area on Garden Island was cultivated by the Indians.

Farms of this soil are not, as a whole, so well improved as farms on Hiwood loamy fine sand and are much less improved than those on Taylor very fine sandy loam. The few recent transfers indicate a price ranging from $6 to $10 an acre for unimproved tracts 15 miles from the railroad and of $15 an acre for acreages slightly improved and more accessible.

MARQUETTE GRAVELLY SANDY LOAM

Marquette gravelly sandy loam consists of the following layers: (1) A surface covering of leaf litter and mold, from 2 to 4 inches thick; (2) a layer of light grayish-yellow loose gravelly sand or loamy sand about 10 inches thick, below which is (3) a layer of brown or reddish-brown gravelly sandy loam, from 3 to 6 inches thick, in which coarse gravel is embedded in a soil mass more coherent and heavier textured than in layers above or below; and (4) loose, coarse sand and gravel of the variegated color of the various minerals which compose it but being, as a mass, of a grayish or light brownish-gray shade. Limestone pebbles or lime-coated pebbles are a considerable part of this substratum layer and occur in varying small quantities in the soil above.

Marquette gravelly sandy loam occurs in characteristic old beach ridges from 5 to 20 feet above adjacent more level areas. Except in a few places bowlders are not present. Because of the varied texture and composition of the sands and gravels, the soil weathered from them is more or less variable in texture, with pockets of clayey sand in an otherwise loose, porous sandy gravelly soil. The heavier-textured brownish soil layer results largely from the weathering of clay-forming minerals in the parent materials and the concentration of the clay particles in the layer. This layer is not everywhere clearly defined. It is best developed where the parent material was composed most largely of clay-forming minerals and where soil-forming agencies have proceeded without interruption for the longest periods of time. In areas where gravel is less abundant and the sand is better assorted the soil resembles Faunce sand. In association with Faunce sand Marquette gravelly sandy loam occurs on small, slightly defined ridges or on slopes between areas of Faunce sand and peat or other lower lands.

Marquette gravelly sandy loam occupies a total area of nearly 20 square miles in the county. It is mapped in 12 of the 35 townships south of Lake of the Woods. About one-half the area mapped is in Lakewood, Prosper, Park, Norris, and Clover Dale Townships. The larger, more continuous beach ridges have a definite trend, commonly from northwest to southeast. The longest of these beach lines in the county runs from Chilgren Township southeastward into Spooner Township, a distance of about 25 miles. It is not continuous, being broken where streams cut through in their courses to the lake.

The characteristic forest growth of jack pine ranges from a moderately thick sapling growth to a thinner growth of trees from 25

to 30 feet tall. Here and there is a taller Norway pine. Poplar and birch compose most of the hardwood growth. Underbrush is very scant. The ease of clearing, together with the well-elevated, dry locations has made the areas of this soil popular sites for the homesteaders' farm buildings. Outside of use for garden patches, little of the soil is cultivated.

There have been no recent transfers on which to base an estimate of the market value of Marquette gravelly sandy loam cleared for farming. Wooded areas have sold at prices ranging from $12.50 to $28.50 an acre.

GUDRID FINE SANDY LOAM

Gudrid fine sandy loam comprises the following soil layers from the surface downward: (1) A covering of leaf litter and mold from 2 to 4 inches thick; (2) a layer of grayish or pale yellowish-gray loamy fine sand, 16 or 18 inches thick, in which black humus stains are noticeable to the depth to which grass roots have penetrated; (3) gray or light yellowish-gray heavy fine sandy clay or silty clay, somewhat plastic when wet and finely granular when dry, which is apparently a geologic deposit distinct from the overlying sand. The subsoil material is rich in lime below an average depth of 24 inches; the second sandy layer ranges from medium acid to slightly alkaline in reaction. Few bowlders are exposed on the surface, and the soil is remarkably free from gravel and coarse sand. Many exposures in road cuts show distinct lamination in the lower part of the subsoil and in the substratum. The absence of glacial till serves in part to distinguish this soil from McDougald fine sandy loam.

Gudrid fine sandy loam comprises an area of about 17 square miles in the county and occurs in 19 of the 35 townships south of Lake of the Woods. About half the total acreage is mapped in Gudrid, McDougald, Spooner, and Swiftwater Townships. Areas occur principally on well-drained uplands adjacent to the main stream channels. In this position the soil is closely associated with Taylor very fine sandy loam and Baudette very fine sandy loam. In places the covering of fine sand is deeper than typical, and the soil approaches in character Hiwood loamy fine sand and is associated with it. Where the content of coarser till sand and gravel increases in the lower heavy layer and a more variable texture makes the line of separation less distinct and abrupt between the sand and the heavier layer, Gudrid fine sandy loam is associated with and approaches the character of Rulien fine sandy loam and McDougald fine sandy loam. Usually in such places the soil occupies positions adjacent to or on burned-over peat lands, where drainage is poorer than typical.

Most of this soil is at present covered with a second growth of balm-of-Gilead, aspen, and birch, with smaller numbers of elm, soft maple, ash, balsam fir, spruce, and Norway pine. Clumps of jack pine occur in places on the deeper sand areas. When undisturbed by fire or logging this timber growth is thick and there is considerable underbrush, and clearing for cultivation has usually been laborious. Settlement for farming was encouraged by the fact that the soil was accessible by the streams and later by the roads and the railroad. At present this soil is comparatively well settled.

The state of improvement and accessibility influence greatly the market value of this soil. The only transfer noted recently, in November, 1924, involved a tract of 80 acres, very accessible, well cleared, and moderately well improved. The price was $37.50 an acre.

M'DOUGALD FINE SANDY LOAM

McDougald fine sandy loam, where not recently and severely burned over, consists of the following soil layers: (1) A covering of leaf litter and mold or peaty material from 2 to 6 inches thick; (2) a layer of grayish or light yellowish-brown loamy fine sand from 12 to 24 inches thick; and (3) grayish or light yellowish-gray heavy sandy clay or silty clay rich in lime and of finely granular structure when dry but plastic when wet. The two upper layers are generally neutral or slightly acid in reaction and less commonly show a strongly acid condition. The variable quantities of gravel present seem to be more a part of the third layer than of the upper soil layers. Bowlders are exposed on the surface and in the soil. McDougald fine sandy loam differs from Rulien fine sandy loam chiefly in having a deeper sandy surface covering over the heavier till substratum common to both soils. The material at and below a depth of 20 inches is, on the average, a little more friable in the McDougald than in the Rulien soil.

Perhaps one-fourth of the area of McDougald fine sandy loam occurs on fairly well-drained uplands showing little or no evidence of a former covering of true peat. In such positions the soil shows a range of characteristics. In places light sandy loam extends to a depth of 3 feet, and to that depth the soil resembles Hiwood loamy fine sand. In other places in association with Baudette very fine sandy loam the surface soil is finer textured, ranging to loamy very fine sand. In still other places, the soil is uniform in texture, free from gravel and bowlders, and resembles Gudrid fine sandy loam. The areas mapped as McDougald fine sandy loam in the southern half of the northwest angle were not thoroughly examined in the course of the survey and probably include, as outlined, considerable areas of other soils, such as Chilgren clay loam and peat, shallow phase.

McDougald fine sandy loam typically occupies low islands in the peat bogs, intermediate areas between well-drained uplands and bogs, and areas once covered with peat but now burned over. Many areas, such as the one in section 12 of Myhre Township, are associated with higher areas of Hiwood loamy fine sand and lower-lying areas of Chilgren clay loam. The soil is mapped in all but two of the 35 townships south of Lake of the Woods, in the northwest angle, and on Garden Island. Large areas of this soil are in McDougald, Walhalla, Beaver Dam, Potamo, and Keil Townships.

The natural drainage of McDougald fine sandy loam ranges from poor to good. The most poorly drained parts are areas which are distinctly burned-over bog and in which the two upper soil layers are generally shallower or heavier textured than typical. The best-drained areas are on the higher positions and resemble Hiwood loamy fine sand.

The most typical timber cover of McDougald fine sandy loam is a second growth of poplar or aspen, with some birch, balm-of-Gilead, elm, alder, and ash mixed with a minor stand of conifers, such as balsam fir, spruce, white pine, jack pine, and Norway pine. Where the soil is better drained and similar to Hiwood loamy fine sand jack pine makes up a larger proportion of the growth and the underbrush is less dense.

The greater part of the McDougald fine sandy loam in the mainland part of the county occurs in the more accessible locations, and for that reason the soil is well settled. Clearing this soil is not so laborious as on Taylor very fine sandy loam but is more difficult than on the Hiwood and Faunce soils.

The few transfers of land of this kind made in the years 1924 and 1925 were at prices ranging from $3 to $35 an acre, depending on the accessibility and state of improvement for farming or on the quantity and quality of marketable timber.

McDougald fine sandy loam, stony phase.—A stony phase of McDougald fine sandy loam is indicated on the soil map by crosslines. The phase differs from the typical soil in the greater number of large bowlders which occur on the surface and throughout the soil mass. In places there are also rounded outcrops of granite bedrock, in association with which the soil mantle is generally thin. The bowlders are entirely or nearly all of crystalline rock, mostly granite. Over most of the soil they are so numerous as to practically preclude cultivation, and the land can be used only for forestry or pasture. The natural vegetation is diversified and probably includes all the species of trees common to the region, but poplar is at present dominant. Only 3 square miles of this soil are mapped, all in the northwest angle and on Oak Island.

RULIEN FINE SANDY LOAM

Rulien fine sandy loam consists of the following layers from the surface downward: (1) A covering, from 2 to 6 inches thick, of leaf litter and mold or, in places, of peat; (2) light yellowish-gray or gray loamy fine sand or fine sand from 8 to 14 inches thick; (3) a layer of dark dull-gray silty clay, more plastic when wet and a little more coarsely granular when dry than the underlying layer; (4) more friable light grayish-yellow silty clay loam, finely granular when dry and moderately plastic when wet. This layer is rich in lime; the layers above vary from medium acid to alkaline in reaction. The amounts of drift sand and gravel are rather large in the lower layer and commonly increase with depth in the unweathered till. The two upper layers, as a rule, contain only small quantities of the coarser gravel particles. Bowlders are exposed on the surface and occur in the soil.

Where this soil has the deeper sandy surface layers, the third layer is in many places missing. In another variation there is a finer-textured surface soil, approaching loamy very fine sand. Such an area is in section 13 of Chilgren Township. Again, a thin layer of black soil may occur immediately under the leaf mold, and the loamy fine sand below may also be darkened to some extent. This is common where the grass cover is more dense than usual. The areas

in section 30 of Lakewood Township and in sections 19 and 30 of Victory Township show such variations. In section 30 of Prosper Township the area of this soil is more bowldery than typical, with a coarse surface soil of loamy sand texture and underlying layers of sandier texture than is typical.

About one-half of this soil mapped in the county occurs in the townships of Rulien, Chilgren, Keil, Lakewood, Prosper, Victory, and T. 158 N., R. 35 W. No areas are shown in Beaver Dam, Gudrid, Noyes, and Hiwood Townships. Areas were formerly covered with peat. Until this peat was removed by burning, the mineral substratum was kept moist or saturated by the surface water absorbed and held by this peat covering. With the removal of the peat, drainage conditions improved, but the level or very gently undulating surface and the heavy-textured substratum layers favor poor natural drainage. About one-sixth of the area of this soil is moderately well drained, however, by reason of a deeper sandy surface soil and a more elevated position than typical. The area occurring in section 4 of Myhre Township is an example.

The present forest is chiefly a second growth of poplar, balm-of-Gilead, birch, ash, and elm, with balsam fir and spruce as the main conifers, though there are also some white and Norway pines. The growth of underbrush is in most places very dense, and the clearing of the soil for farming is laborious. Where a 2-foot or 3-foot layer of peat covered the soil and burning was especially severe, much of the timber and brush, even the roots, was destroyed, saving considerable labor in clearing. Fair-sized clearings and settlements have been made on the more accessible areas of the soil.

No transfers of land of this kind occurred during the years 1924 and 1925, but it is held at about the same figure as McDougald fine sandy loam.

RULIEN SANDY LOAM

Rulien sandy loam, like Rulien fine sandy loam, occurs in areas formerly covered with peat. The surface material is variable, depending on the completeness of the destruction of the peat and the time elapsed since the burning. Where burning has been complete, the present surface soil, to a depth varying between 6 and 8 inches, is grayish-brown sand or coarse sand. Below this is a layer, 10 or 12 inches thick, of sand and gravel, which contains much lime, either as fragments of limestone or as disseminated fine material. The substratum is gravelly sandy clay, very rich in lime. Stones and bowlders are present on the surface and through the soil mass in many areas. Hummocks and small areas of peat, which escaped burning, are common.

In some areas of this soil a surface layer of leaf litter and mold has accumulated. Some of the areas of Rulien sandy loam are adjacent to areas of Marquette gravelly sandy loam. Other areas are associated with Rulien fine sandy loam, from which soil Rulien sandy loam differs in being coarser textured, gravelly, and distinctly richer in lime in the upper layers. In an area north of Pitt, occurring in association with Rulien fine sandy loam, the sandy surface covering is a little thicker, extending to a depth ranging from 18 to 24 inches,

and the lower part of the subsoil is more porous and contains less lime than is typical of this soil.

The forest cover on this soil is composed chiefly of hardwoods, such as poplar, balm-of-Gilead, ash, and elm, mixed with balsam fir, spruce, and tamarack, and some small rather dense stands of young jack pine on the drier areas. The underbrush, which consists chiefly of small birch and alder, is dense.

There is no record of the sale of any of this soil, and it is difficult to arrive at its value.

SPOONER VERY FINE SANDY LOAM

Spooner very fine sandy loam comprises the following soil layers from the surface downward: (1) A 3 or 4 inch layer of leaf litter and mold or, in places, of peat; (2) a layer, about 8 inches thick, of grayish loamy very fine sand; (3) a layer about 8 inches thick of light grayish-yellow very fine sandy loam mottled gray and rust brown; (4) a substratum of very light-gray heavier very fine sandy clay or silty clay, mottled with yellow and rust brown. When moist this layer is smooth and plastic and when dry it is finely granular. The first two layers contain no appreciable quantities of lime, the third layer contains variable quantities, and the fourth layer is highly calcareous. These different soil layers are alike in being smooth textured and free from stone and gravel to a depth of 46 or more inches.

Spooner very fine sandy loam occurs on positions intermediate between peat-covered areas and higher well-drained mineral soils. A few areas consist of the mineral substrata of burned-over peat bogs. The surface is very gently sloping or level, and natural drainage is fair or poor. The structure and texture of the soil, more particularly of the three upper layers, favor well-regulated internal drainage but not sufficiently to allow any great excess of water on the more level areas to be carried far downward. Spooner very fine sandy loam is commonly associated with slightly higher-lying better-drained areas of Baudette very fine sandy loam and Gudrid fine sandy loam, and in common with these soils is composed of stone-free, smooth-textured material differing in poorer oxidation, owing to poorer drainage, and more mottled and grayish in color. This soil also differs from Baudette very fine sandy loam in that the heavier soil layer lies at a depth of about 20 inches, and from Gudrid fine sandy loam in having finer-textured upper soil layers.

Included with Spooner very fine sandy loam is a soil which differs mainly in that the heavier-textured lower soil layer is not present or, if present, is very thin and occurs at no definite depth below the surface. This soil occurs in positions similar to those occupied by the typical Spooner soil but is practically all in poorly drained areas which are distinctly burned-over peat bogs. Spooner very fine sandy loam is mapped in small scattered areas in the mainland part of the county. About one-half of the total area of the lighter-textured phase is mapped in Gudrid and Swiftwater Townships.

The forest growth on Spooner very fine sandy loam is chiefly second-growth poplar, balm-of-Gilead, and ash. Balsam fir, spruce, tamarack, cedar, and an occasional white or Norway pine make up

a small mixture of conifers. The underbrush growth is dense, particularly in the more poorly drained areas, where alder and small birch are abundant.

Clearing for farming has been laborious on most of this soil, but occurring as it does in the more accessible and well-settled parts of the county, a fair percentage of it has been improved for cropping.

No land transfers of areas of this soil have recently occurred, and no accurate estimate of prices can be made.

WILDWOOD SILTY CLAY

Wildwood silty clay consists mostly of the mineral substratum of former shallow peat bogs, from which the peat covering has been burned. Where the soil has been cultivated since the last burning, the ash and any organic-matter residue have been mixed with the upper layer of mineral soil. Where there has been no cultivation, these residues constitute the surface material, except that the ash may have largely disappeared after some years and that litter from trees and shrubs may have contributed to the unburned organic matter. On areas which have never been covered by a layer of true peat and have not been severely burned over, there is a layer of forest litter and mold 4 or 5 inches thick on the surface.

The mineral soil layers of Wildwood silty clay, from the surface downward, are as follows: (1) A layer of very dark grayish-brown silty clay, about 4 inches thick, plastic and smooth when wet, and when dry breaking into fine, rather hard subangular granules; (2) a layer of dark-gray silty clay, ranging from 6 to 10 inches in thickness, plastic when wet and medium or coarsely granular when dry; (3) gray or olive-gray silty clay or clay, 12 or 14 inches thick, plastic and granular as is the layer above but differing from it in a lighter-gray color and a slightly higher lime content; (4) a substratum of gray or olive-gray clay with white streaks or splotchings of lime and a few rust-brown and yellow stains, moderately plastic when wet and finely or coarsely granular when dry, but more friable than the two soil layers above because of its high lime content. The granules formed are characteristically angular in shape. The amounts of drift sand, gravel, and bowlders vary. In most places the bowlders occur on the surface, rather than embedded in the soil. In few places are they present in sufficient quantities to make cultivation difficult, and a part of the soil is remarkably free from stones. The fourth or lower soil layer is very rich in lime. The second and third layers contain a small quantity of lime, commonly increasing with depth; the upper or dark soil layer is neutral or slightly alkaline in reaction.

In the most poorly drained areas of this soil the second layer, which is gradational between the surface layer and the third layer, is absent. In sections 12, 13, and 14 of Lakewood Township areas of this soil have a 6 or 8 inch covering of peat, no soil layer corresponding to the second layer described above, and lower layers which are sandier and more mixed than typical. In other places, such as in section 29 of Lakewood Township, there is a 2 or 3 inch surface layer of very fine or fine sand which under cultivation is mixed with the silty clay to form a more tractable soil than typical. This variation occurs usually in association with Rulien fine sandy loam. In gen-

eral, Wildwood silty clay on the northwest angle and on Oak Island is more silty and more friable throughout than the soil of the large area just west of Baudette. In areas associated with Chilgren clay loam there is in places a thin gray surface layer of very fine sand or silt loam. Where this layer is 3 or more inches thick the soil is classed with Chilgren clay loam. Parts of the Wildwood silty clay are entirely or almost entirely free from stone and bowlders and have a more uniformly textured soil throughout than is typical. Such areas occur in Gudrid, Wheeler, Baudette, Wabanica, and Swiftwater Townships.

Most of this soil is mapped in Lakewood, Prosper, Wheeler, Baudette, Gudrid, Spooner, Zippel, Boone, and Swiftwater Townships, on the mainland, and on the northwest angle and Oak Island. The soil occupies flat or very gently undulating areas. Its elevation is intermediate between that of the higher-lying soils, such as the Taylor and Baudette soils, and the lower-lying peat-covered areas. Drainage is imperfect throughout.

The forest growth on Wildwood silty clay is dense. The principal hardwoods are poplar, elm, birch, and ash, and conifers such as spruce and balsam fir grow in scattered stands. The underbrush of alder and other shrubs is in places dense, and the ground floor is well covered with grasses where the tree vegetation is not too thick.

Clearing for farming has been laborious. Where fires have burned off the peat and the trees and brush, thus aiding clearing, large areas, such as those near Baudette, are at present cultivated, and settlement is well established. Elsewhere settlement on this soil is sparse. The soil is utilized mainly for hay.

Two transfers of land of this kind in 1925 indicate a value between $3 and $5 an acre for unimproved lands and of $22 an acre for improved, more accessible tracts.

CHILGREN CLAY LOAM

Chilgren clay loam comprises the following soil layers from the surface downward: (1) A covering of leaf litter and mold, in places mixed with peat, ashes, or peaty residue, of variable thickness depending largely on the severity of recent fires; (2) dark grayish-brown or very dark grayish-brown clay loam, 4 or 5 inches thick, moderately plastic when wet and breaking into fine granules when dry; (3) dark-gray silty clay, 8 or 10 inches thick, plastic when wet and finely granular when dry; and (4) dark-gray or dark olive-gray silty clay containing small quantities of lime concretions or lime-coated pebbles and sand grains. This material is somewhat plastic when wet but is more friable than the layer above it because of its high lime content. The soil layers above contain no lime or only small quantities. Bowlders are commonly present on the surface, though not, in most places, in sufficient numbers to make cultivation difficult. Bowlders embedded in the soil are generally less common than those on the surface.

About two-thirds of this soil mapped in Lake of the Woods County occurs in Lakewood, Prosper, Rapid River, Chilgren, Spooner, Swiftwater, and McDougald Townships, and in T. 158 N., R. 30 W. and T. 158 N., R. 35 W. Small areas are mapped in the

northwest angle and on Flag Island. As mapped, Chilgren clay loam occurs both on slightly elevated and low positions. The soil on the gentle slopes where surface drainage is fair differs from the Taylor soils mainly in that the surface soil is heavier and that the light-gray layer is thinner or entirely absent. The soil occurs mostly in positions intermediate between lower-lying peat lands and higher well-drained mineral soils, and the flat or very gently undulating surface of these areas is most typical of this soil. In sections 8 and 18 of Zippel Township and in Spooner Township along Baudette River the soil occupies moderately well-drained upland positions fringing the stream ways.

As a whole Chilgren clay loam has been developed under slightly better drainage conditions than Wildwood silty clay. It differs from the Wildwood soil mainly in having a lighter-colored surface soil. In some places a thin surface layer, below the leaf mold, is nearly black, owing to the humus content, but the material is not darkened to a depth sufficient to class it with the Wildwood soil. In areas associated with Rulien fine sandy loam a sandy surface layer, 2 or 3 inches thick, is present, in many places. Areas in sections 17 and 18 of Prosper Township are of this kind.

The number of bowlders on this soil is variable. Only a small proportion of the total area is so bowldery as to be difficult to cultivate. Bowldery areas occur in the northern half of Lakewood Township and in sections 17, 18, and 20 of Prosper Township. These areas have extremely variable-textured subsoils, which, however, in few places are lighter than sandy clay.

The hardwood forest growth on Chilgren clay loam is dense, and there are some conifers, mostly balsam fir, white pine, and spruce. Balm-of-Gilead and poplar are the most abundant hardwoods, and elm, ash, and birch are seen in smaller numbers. The underbrush is of variable density, being most dense on the more poorly drained areas.

Clearing for farming has been laborious, and little headway has been made except on the more accessible, better-drained areas or where fires have aided clearing.

Transfers of this soil in 1924 and 1925 show prices of $3, $8, $15, and $25 an acre. This indicates the range of values at that time of both unimproved and improved areas of this soil.

POTAMO LOAMY SAND

Potamo loamy sand has a surface layer of leaf mold and humus soil, from 2 to 4 inches thick, which is underlain by light grayish-yellow or grayish-yellow loose sand about 10 inches thick. In the soil immediately beneath the humus there are a few black stains of organic matter from the decayed grass roots. Below a depth ranging from 16 to 20 inches, the sand is coarser in texture and variable in color, with rust-brown, gray, and yellow mottles. Thin, clayey sand pockets or layers are numerous. The surface soil and upper part of the subsoil are pervious, but because of a high water table the subsoil is usually moist or water-logged below a depth of 2 feet. The soil material to a depth of 3 or 4 feet is slightly or strongly acid, and below this depth to the calcareous drift the material is neutral or

slightly alkaline. The soil is typically bowlder free, only small areas showing bowlders exposed on the surface.

Two-thirds of this soil mapped in the county occurs in Clover Dale, Potamo, Park, Norris, Eugene, and Beaver Dam Townships. Areas are largely associated with Faunce sand occupying with respect to that soil, poorly drained, low-lying, flat areas. Two small areas in Myhre Township and one just west of Faunce are gravelly and bowldery. Mottling of the subsoil and the presence of more pockets and layers of clayey sand constitute the essential differences, aside from drainage, between Potamo loamy sand and Faunce sand. Potamo loamy sand is also associated with Rulien fine sandy loam and McDougald fine sandy loam, but it differs in having a deeper coarser-textured sand layer. Most areas of Potamo loamy sand show evidence of having been covered formerly with peat.

The forest growth on this soil varies with drainage conditions and length of time since burning. A small, scattered stand of jack pine is present on the drier areas; thicker stands of poplar, with some mixture of balsam fir, spruce, and hardwoods, such as elm, ash, and birch, are more typical. The underbrush is of alder and small birch in scattered clumps, and the grass growth is thin but well distributed, as a rule.

Clearing for cultivation has been fairly easy, and the better-drained areas are in many places farmed to some extent.

Two transfers of this soil in 1924 and 1925 indicate a value of $30 an acre for an improved area and $6 an acre for an unimproved area.

PEAT

In 1925 about 64 per cent of the total area of Lake of the Woods County was covered with peat. This peat, which consists almost entirely of plant remains, varies from brown, coarse, fibrous material to black, finely divided material, depending for its characteristics on the species of plants from which it has been formed and on the degree of disintegration and oxidation which has taken place. In the Lake of the Woods County reconnaissance survey no differentiation based on these physical differences in the peat was attempted, although profiles of a number of different organic soils were recognized. The thickness of the peat layer is also extremely variable, but an attempt was made to classify the peat areas on the basis of depth, areas in which the peat was 3 or more feet thick being separated from areas in which it was less than 3 feet thick. The shallow areas were mapped as peat, shallow phase. Five or six feet is the average depth of the peat over the areas mapped as typical peat.

The deepest peat deposits are around Winter Road Lake, along the south line of Hiwood Township, in sections 27 and 28, T. 157 N., R. 35 W., in sections 2, 3, 4, 11, and 13, T. 157 N., R. 34 W., in the southern part of Gudrid Township, in the southeastern part of Spooner Township, in Boone Township, and in the northwestern part of Wabanica Township. Over these areas the deposits range from 6 to 15 feet in thickness, and in a few places are thicker. The plant remains making up the upper layers of the deep peat are generally brown and fibrous or woody and contain little mineral matter.

Around Winter Road Lake much of the peat is of the firmer sedge type. This sedge peat is usually found near the surface of the

deposit where tree growth has been sparse or absent and the grass and sedge growth abundant. On large areas of deep peat fires have destroyed tree growth and thus indirectly encouraged the grass stands, until now such areas appear as open grasslands with scattered fire-killed dwarf black spruce and tamarack. (Pl. 2, B.) In such areas, however, very little grass or sedge peat is developed at the surface, and the deposit is largely of the woody type. In the following areas the peat bogs are of this character: Chilgren Township, section 18; Myhre Township, sections 19 and 30; Noyes Township, section 22 and northern half of the township; Eugene Township, northwest quarter of township; Norris Township, northeast quarter of township; Clover Dale Township, sections 17 and 18; Hiwood Township, practically all areas in the township; Beaver Dam Township, section 36 and the northern part of township; Rapid River Township, sections 21, 22, 23, 24, and southern tier of sections; Boone Township, southern tier of sections; Meadowland Township, section 18; T. 157 N., R. 33 W., southern tier of sections; T. 158 N., R. 34 W., southwestern one-fourth of township; T. 157 N., R. 35 W., sections 21, 22, 27, 28, and 33; T. 158 N., R. 35 W., northwestern one-fourth of township; and small areas in Meadowland, Victory, and Pioneer Townships. The rest of the deep peat areas support stands of tamarack and black spruce. Most of the older tamarack trees are dead or nearly dead, owing, probably, to the ravages of the sawfly. Black spruce seems hardy, though most of it is dwarfed. The shrubs of the undergrowth are chiefly myrtle-leaf willow, tag alder or low birch, and small poplar. The ground cover is variable. In places it is almost entirely a thick mat of Sphagnum moss; elsewhere there is much leatherleaf, Labrador-tea, low-bush cranberry, snowberry, dwarf Kalmia, pitcher plant, crowberry, Cassandra, cotton grass, and other sedges and grasses.

The water table varies in depth with seasonal conditions. Near the ditches it is seldom if ever within 2 or 3 feet of the surface. Much of the area burned over in the 1910 forest fire was sufficiently well drained to permit clearing, and once cleared and the ditches kept in order drainage is sufficient for cropping in all but unusually wet seasons. Drainage is not yet sufficient for cropping most of the peat lands in the southern tier of townships, even if other conditions were favorable to agricultural use. Some large areas are undrained and others in the drainage districts along streams or at the head of streams are almost perpetually water-logged. Most of the following peat lands and other smaller acreages not listed are water-logged: South half of T. 157 N., R. 30 W. and T. 157 N., R. 34 W.; all in T. 158 N., R. 34 W. and T. 158 N., R. 35 W.; Meadowland Township; in T. 157 N., R. 35 W. at the head of Rapid River; southern parts of Beaver Dam and Norris Townships; and practically all the peat land of the northwest angle. A water-logged condition exists where streams, such as Silver Creek, Canfield Creek, Haners Run, and smaller unnamed streams, issue into and disappear in peat bogs. Practically none of these areas are floating bogs. The only floating bogs of consequence occur in the areas fringing the shore of Lake of the Woods.

A detailed examination of the various kinds of mineral substrata underlying the deep peat is of no practical agricultural significance

at the present time. In a general way it may be safely assumed that the soil is similar to the lower-lying soils mapped in the sections adjacent to the peat.

The peat over these areas has certain characteristics common to all peat, regardless of its depth or details of composition. It absorbs and retains high percentages of water, a fact which renders drainage improvement slow even with efficient discharge of ditch waters, which is almost everywhere obtained in the drainage system of this county. Peat has a low volume weight. It is subject to destruction by fire when drained and dried out.

The reaction of the peat is variable, both areally and vertically in the profile. It is not possible, from the data obtained, to make any accurate general statements as to the distribution of acid, neutral, and alkaline peats, or of high-lime or low-lime peats, but it is reasonable to assume that the peat associated with the calcareous mineral soils and that overlying calcareous substrata is limy, at least in the lower layers.

Little settlement has been made on the deep peat for farming purposes. Only about 100 acres of deep peat were observed in crops in 1925. Cultivated fields were on the better-drained, firmer, better-packed peats where little or no clearing was required.

Four transfers of deep peat lands in 1924 indicate a value between $3 and $6 an acre. Four other transfers in 1924 and 1925 evidently involved tracts with some standing timber and showed a range in price from $10 to $30 an acre.

Peat, shallow phase.—Peat less than 3 feet thick has been mapped as peat, shallow phase. Areas on which the covering of peat is less than 9 inches thick have been mapped with the soil type underlying the peat. About 456 square miles are mapped as shallow peat in Lake of the Woods County. This constitutes about 35 per cent of the total area of the county and nearly 55 per cent of the total area of the peat lands.

In its general physical characteristics shallow peat is similar to the deeper peat; in fact, much of the peat mapped as the shallow phase was no doubt, not many years ago, more than 3 feet thick. In places fires have reduced the thickness of the organic deposits, elsewhere shrinkage attendant upon drainage and consequent drying out of the peat has been responsible. As in the deeper peat, the underlying substratum is variable, but the variations are not indicated on the soil map. The composition of this substratum material is suggested, however, by the characteristics of the adjoining mineral soils as indicated on the map.

The shallow phase of peat shows the same variations in structure and color as the deep or typical peat. It possesses the same characteristics of low volume weight, combustibility, and capacity of absorbing and retaining high proportions of water. In general, the shallow peat is a little more disintegrated than the deep peat, and artificial drainage maintains it in a drier condition and has, over much of the mainland part of the county, lowered the water table down to or below the surface of the mineral substratum. The lower part of the peat and the underlying mineral material are almost always moist, but the peat itself is less frequently waterlogged than is the deep peat. The stream meadows and small

seeped areas show the highest water table. They are water-logged at an average depth of 2 or 3 feet and are sometimes flooded in wet seasons. Areas around the shore of Lake of the Woods in the northwest angle and on some of the islands are completely water-logged and at times are covered with water from the lake.

The general forest growth on the shallow phase of peat is, on the whole, distinctive. Tamarack and black spruce are the most abundant trees and are usually larger than on the deep peat. White cedar or arborvitae (*Thuja occidentalis*), although not the most abundant, is a characteristic tree and in most places is a good indication of the presence of shallow peat, especially where the underlying mineral material is calcareous. A scattering of poplar, birch, and balsam fir is in many places to be noted. Alder generally forms a denser underbrush on shallow peat than on deep peat. Aside from the greater density of growth, the character of the underbrush and forest floor is much the same as that of the deep peat. Open meadows are not so numerous nor so large as on the deep peat, except as they occur in stream bottoms.

Probably less than 1 per cent of the total area of shallow peat was being cropped at the time of the survey. Very few, if any, farms were being maintained on shallow peat alone, and there was at the time no considerable expansion of agriculture on the peat lands. Some areas were being burned, the peat being destroyed in preparation for cropping the mineral substratum. (Pl. 2, C.) The drier condition of the shallow peat, as compared to the deep peat, allows a more thorough destruction of the peat by fires. On practically all farms including areas of shallow peat, the farm crops are produced entirely or largely on the associated mineral soils.

About 10 transfers of unimproved shallow peat lands in 1924 and 1925 indicated a value ranging from $3 to $7 an acre.

MEADOW

Narrow strips of low first-bottom land along the main streams have been mapped as meadow. The soils of such areas are extremely variable and mixed. Shallow surface layers of peat or muck are present in most places, admixed with variable quantities of sand, silt, and clay. In many places this kind of material extends to a depth of 3 or 4 feet, and thin layers of mineral soil, generally of a sandy texture, occur at variable depths.

A total area of about 12 square miles, all in the 35 townships south of Lake of the Woods, is mapped as meadow. An area of about 2 square miles in the valley of Rapid River, where it is most deeply intrenched, is not covered with peat or muck but is a sandy soil somewhat similar in texture to or slightly heavier than Hiwood loamy fine sand. This area has a brownish or mottled surface soil containing moderate quantities of organic matter. Below a depth ranging from 12 to 16 inches a mottled slightly heavier subsoil occurs in most places.

The mineral bottom-land soils are composed of materials washed into the flood plain and redeposited by flood waters. Such first-bottom mineral soils are similar to the Griffin soils mapped elsewhere in northern Minnesota and northern Michigan. Meadow areas

are almost entirely of open grass vegetation, with a scattered alder growth in places. They afford good cuttings of wild hay, and a few small cropped fields were observed on the higher ridges.

BEACH SAND

Beach sand includes the narrow strips of sand which in places form the shore lines and off-shore bars around Lake of the Woods. This material is generally bare of vegetation or supports only a few scattered plants. Much of it is subject to inundation at times of high water in the lake.

ROCK OUTCROP

Rock outcrop includes the areas where bare bedrock, mostly granite, forms most of the surface. Very small areas on which there is a thin covering of peaty soil are included. Such areas support some vegetation, including jack pine, white pine, blueberries, and grasses. Most of the rock outcrop is on the islands in Lake of the Woods, notably Flag Island, and adds scenic attraction and interest to the region.

SOIL MANAGEMENT

Lake of the Woods County is a new field for agriculture. Its farmers are experimenting and striving to choose crops for which there is the most profitable market and to produce those crops which yield best on their land. The methods of cropping are not established for any one community nor, as a rule, even for any one farm. Stable manure is the only fertilizer used, and on many of the soils too little of that is applied.

As farming continues it seems inevitable that successful cropping will more and more require the addition of proper quantities of manure and the practice of crop rotation. Manuring necessitates the keeping of sufficient numbers of livestock to produce the needed amounts of manure. Crop rotation calls for a farm of a sufficient number of subdivided field acreages to carry out a definite system of rotating crops from one field to another. At the present time the majority of the farms are too small in crop acreage and are not sufficiently stocked for carrying out these practices. The first need, therefore, is the clearing and improving of the necessary crop acreages on each farm. As the region and soils (except the sandy soils) are particularly adapted to the tame-hay and roughage feed crops, the farms of this county give best promise for the general livestock or dairy type of farming, and it is these types of farming that are found to be the best for maintaining soil fertility.

There are now on the mineral soils in the county a number of farms developed to this stage and operated by men who are able to and do carry out methods of soil improvement and to finance the more profitable farming enterprises. It seems inevitable that the number of such farms will increase, provided general economic conditions in agriculture and local factors, such as taxation, favor such development in the future.

In determining the present practicability of settlement of any particular tract of land in the county, accessible location and adequate

drainage are paramount considerations. There are tracts of all the soil types that because of inaccessibility or inadequate drainage are not now desirable.

The soil types, as previously described in the report, can well be grouped for discussion of their uses and possibilities as follows:

Taylor very fine sandy loam and Baudette very fine sandy loam.	Heavy or medium, textured, well-drained soils.
Marquette gravelly sandy loam, Hiwood loamy fine sand, and Faunce sand.	Sandy well-drained soils.
Gudrid fine sandy loam, Rulien fine sandy loam, and McDougald fine sandy loam.	Fairly well-drained sandy soils with heavier-textured subsoils.
Spooner very fine sandy loam	Medium - textured soil with fair or poor drainage.
Potamo loamy sand	Very sandy soil with poor drainage.
Wildwood silty clay and Chilgren clay loam	Heavy soils and subsoils with poor or fair drainage.
Peat and peat, shallow phase	Organic soils.

Taylor very fine sandy loam is the best-settled soil type in the county. An estimate places the average number of farms to the square mile as 3.4 on the Taylor soil and 1.3 on the Baudette soil.[7] As an average, these farms are among the best improved in the county.

In addition to the unimproved timbered areas of these soils not now in farms, there are included with the farms areas to be cleared as more crop land is needed. A dense, thrifty second growth of poplar, balm-of-Gilead, birch, and conifers is found in most places on these soils, and clearing generally is hard, slow work. Over most of the Baudette soil and over about two-fifths of the area of Taylor soils there are very few, if any, bowlders and in no place were there enough to necessitate a great deal of labor for their removal.

Under cultivation these soils can be worked under a fair range of moisture conditions. A mellow, friable seed bed can usually be prepared and a good mulch maintained. The soil warms up in good time in the spring for spring-planted crops, though it is not so early as the sandier soils. Internal drainage is well regulated to support crops during both wet and dry seasons. Crops yield well under a wider range of seasonal growing conditions than on any other soil in the county. Corn and small grains alike produce well. Good yields of fodder or silage corn can usually be depended on, and in the more favorable seasons a matured corn crop is obtained. These soils seem particularly adapted to the tame hays (alfalfa, red clover, alsike, sweetclover, and timothy).

These soils contain abundant supplies of lime below a depth of 20 or 30 inches, and the soil material above is ordinarily "sweet" enough for the needs of most crops. Alfalfa and sweetclover, crops which especially require a sweet soil, have thus far in the majority of fields produced good stands without special treatments of lime or inocu-

[7] The figures for the average number of farms on each soil type are rough estimates made in the course of the survey. They can not be entirely accurate, since many farms are made up of more than one soil type, but they serve to indicate the agricultural rank of the various soils.

lation. Whether such treatment would give sufficient increases in yield to justify the expense is doubtful. Brush is usually burned off, and the ash residue is alkaline in reaction. Considerable labor is required in preparing the firm seed bed desirable for these crops. Newly broken ground in many places would not be sufficiently free from weeds for successful stands.

With proper manuring and the practice of rotation of crops these soils promise to be steadily productive of all the common farm crops grown in the region.

The Marquette, Hiwood, and Faunce soils ranked among the best-settled soil types at the time of the survey. Of the three, Hiwood loamy fine sand ranked first, with an estimated average number of two farms to the square mile. The Marquette and Faunce soils averaged about one and one-half farms to the square mile. These soils are perhaps easier to clear than any other soils in the county on which there has been no peat covering. Most of the clearings have been made in the second-growth jack pine, poplar, and birch which abounds on these soils. The scantiness of the growth makes the removal of underbrush easy, and there are only a few bowlders to remove on the average tract. The few tracts of the Faunce soils and still fewer tracts of the Hiwood and Marquette soils noted in the preceding descriptions of these soils as more bowldery than the average, would, of course, be harder and more expensive to clear. Also those areas of Hiwood soil known to be underlain at a depth of 3 or 4 feet by heavier soil usually bear a more thrifty timber growth of mixed conifers and hardwood, with a denser underbrush, and such areas would be more difficult to clear. However, practically none of these tracts would be so hard to clear as the average tract of Taylor or Baudette soils. The ease of clearing has been a contributing factor toward the present better settlement of these soils. The Marquette soils, when cleared, have been utilized chiefly as farmstead sites and small field or garden acreages. Occurring as they do in long, narrow, ridgelike areas few fields of any size can be laid out on them, and cropping is mainly on the lower-lying soils adjacent. These soils are, therefore, comparatively unimportant as improved farm land. The estimated cost of clearing these soils ranges from $10 to $30 an acre.

Under cultivation these sandy soils can be worked under a wide range of moisture conditions. Many small spots more clayey than typical are sticky if plowed when moist and clod more or less. Most of the seed beds on these soils, however, show little or no tendency to clod and are easy to handle under cultivation. As larger areas are opened up there is increasing danger of damage by wind erosion on the looser sandier phases of these soils, especially where topographic position exposes the areas to the wind. The Faunce soils are particularly subject to droughtiness, except in areas where the clay and silt content is greater than typical or the heavier-textured substratum is only 3 or 4 feet below the surface. The Hiwood soils are not quite so droughty, as a rule, and in many areas where the substratum at a depth of 3 or 4 feet is heavier textured or a water table is maintained reasonably near the root zone, crops can be well grown during the average dry periods. Crops on the deeper sand areas suffer during dry spells, however. In the Marquette soil vari-

able quantities of clay and silt, which give it a little better moisture-holding capacity than the Faunce soils, are admixed with the gravel. However, dry periods also show their effect on crops on this soil. Although crops on all three soils are known to be more or less affected by drought, they also are known to be earlier and more dependable in maturing, as these soils warm up early and can be worked into condition for planting in good time. This is a distinct advantage in some seasons.

The sands and gravels of these soils have a varied mineralogical composition and possess a greater natural fertility than sands composed entirely of quartz. Their lack of organic matter is apparent, however, and in continued successful cropping manuring in some form is necessary. It ordinarily is not possible to return as much crop residue as is returned on the heavier soils. Clover, alfalfa, and sweetclover stands are in many places difficult to obtain. Red-clover stands suffer more severely from drought and winterkilling on these sandy soils. Sweetclover is more hardy. These crops are more dependable seed producers on these than on the heavier soils, although in a good seed-maturing season the crops on the heavier soils produce a larger crop. If a firm seed bed is prepared and the soil is not too dry for good germination a good stand can usually be obtained. Liming, inoculation, and manuring may be advisable in most cases, and one or all of these treatments will in any case usually bring about marked improvement in the stand.

Hay meadows can be maintained free from weeds or grasses for longer periods than on the heavier soils. The main difficulty on these sandy soils seems to be in establishing a good stand. The growing of hay crops is essential for the maintenance of the soils in their best production. Continuously cropped to corn, small grains, and root crops the soils will not produce profitable yields, particularly without the use of manure.

These soils are better adapted to small grains, particularly rye, than to corn. Corn generally produces short stalks and only moderate quantities of fodder but will mature ears more frequently than on the heavier soils. Potatoes produce well and are of better quality than when grown on the heavier soils.

Dairy farming seems the most promising farming industry on farms on these soils, as their successful cropping calls for manuring and crop rotation. Excellent root-forage crops can be raised, and the corn fodder and silage necessary can be produced. For successful dairy farming alfalfa or clover should be grown. The success attending the proper treatment of similar sandy soils elsewhere makes it reasonable to expect that these crops can in time be grown. The more droughty of these sandy soils for the present at least and probably permanently should be maintained in timber.

The estimated settlement at the time of the survey on the Gudrid, Rulien, and McDougald soils was from one to one and one-half farms to the square mile. The Gudrid soil, which is of smaller total extent and narrower distribution, is the best settled of the group.

The unimproved tracts of these soils show considerable range in the density of timber and underbrush growth and in the number of bowlders. Of the three soils, the Gudrid is perhaps the easiest to clear and is practically free from bowlders. About one-fourth of the

area of the McDougald soil is similar, though a few bowlders are present. On the Rulien soils the growth of timber and underbrush is denser and bowlders are more numerous, some tracts being very bowldery. The cost of clearing the more favorable areas of these soils is variously estimated but probably ranges between $25 and $50 an acre.

Present drainage conditions on this group of soils range from poor to good, and on a certain part of their area drainage improvement is required. As an estimate, the greater part of the Gudrid soil and about one-fourth of the area of the McDougald soil are well drained. On the other hand in the areas of Gudrid and McDougald soils are some tracts of somewhat droughty deeper sandy soil than typical, which belong more to the sandy soil group in any discussion of their utilization and management. The following statements do not refer to these more sandy tracts nor to very poorly drained areas.

These soils can be worked under a rather wide range of moisture conditions. They show little tendency to clod after working when moist, except where the underlying heavier-textured soil crops out on the surface. They warm up in the spring a little earlier than the Taylor and Baudette soils but not so early as the sandier soils. Seed beds can be prepared and plantings made in good time, and crops usually mature on these soils a little ahead of crops grown on the Taylor and Baudette soils. Of the three series in this group, the Rulien soils produce the latest-maturing, rankest-growing crops. As small grains on Rulien fine sandy loam grow too rank and lodge, the soil is more suited to hay crops. This is not the case with the Gudrid or McDougald soils. On the other hand, successful stands of alfalfa and red clover are more often difficult to establish on the Gudrid and McDougald soils than on the Rulien soils, owing in part no doubt to the greater depth to lime carbonates (2½ or 3 feet) in the first two soils.

In practically all other respects soils of this group have the same crop adaptations and requirements in management as the Taylor and Baudette soils and are considered only a little less productive than those soils.

Spooner very fine sandy loam belongs to the group of soils including members of the Gudrid, Rulien, and McDougald series as far as clearing, utilization, crop adaption, and management are concerned and has the same range in present drainage conditions. About one-half the acreage of this soil requires drainage improvement for successful cropping. The estimated present settlement is about one or one and one-half farms to the square mile. The better-drained areas closely resemble Baudette very fine sandy loam. However, the typical acreages of the Spooner soil are a little more intractable, are later to warm up in the spring, and produce later-maturing, ranker crops than the Baudette, Gudrid, or McDougald soils.

On Potamo loamy sand the present settlement is estimated to be about one farm to every 2 square miles. The undeveloped tracts of this soil can be cleared, probably at a cost ranging from $10 to $30 an acre. The timber is in part jack pine and in part mixed hardwood, largely poplar. A moderately dense growth of underbrush is present, and on some rather large tracts underbrush is practically

the only growth. Except in a few bowldery areas, the soil contains few bowlders to interfere with cultivation.

Present drainage conditions of most of this soil make cropping possible only in the drier seasons, and in such seasons the rapid internal drainage is such that crops may suffer to some extent from drought unless the moisture can be conserved by thorough mulching or the water table is fairly high. Tracts of this soil which are sufficiently well drained for cropping in average seasons are therefore similar in their use and requirements to the better-drained sandier soils. The Potamo soil possesses little more natural productiveness and has little less tendency to droughtiness than Faunce sand. On breaking it from the virgin state there is usually a little more organic matter to be incorporated with the seed bed, but unless this material is conserved or replenished by manuring it will, after a few years of cropping, be depleted.

Crops on this soil usually show damage in both wet and extremely dry years, and farmers consider the soil less desirable than the better-drained sandy soils.

The Wildwood and Chilgren soils are the heaviest-textured soils in the county. Clearing of timbered areas is a task, as these soils support a dense stand of second-growth hardwoods and mixed conifers, with dense underbrush. Bowlders are present in considerable numbers on many tracts. On a few areas of Wildwood silty clay, however, few bowlders are in evidence.

These soils are perhaps harder and more costly to clear than any other in the county. The estimated cost of clearing ranges from $35 to $75 an acre. The greatest part of the crop land is located where fires left the areas comparatively easy to clear. The settlement in 1925 was estimated to be between three-fourths and one and one-fourth farms to the square mile. The Wildwood soils are a little more densely settled than the Chilgren.

Under cultivation these soils are rather intractable, especially following breaking. When plowed wet they clod badly, but when slightly moist they give a granular and well-pulverized seed bed. When dry they are more or less hard and brittle. They can be advantageously worked under only a narrow range of moisture conditions. Cultivating and plowing requires considerable draft power, particularly the first breaking.

These soils remain cold and wet later in the spring than any other soils in the county. Seed beds are later in being prepared and plantings are delayed, as a rule. Crops usually grow rank and mature late. Small grains are uncertain to mature, and corn seldom makes grain, though a good yield of fodder can be counted on. The Wildwood soil, particularly, has a tendency to produce too rank a growth of small grain, causing damage from lodging. Potatoes yield heavily in a favorable season. These soils are especially suited to hay crops, ordinarily producing the heaviest yields obtained in the county. Clover, alfalfa, and sweetclover are quick and generally establish a good stand and produce heavy growths. The greatest acreages of these soils are in hay crops. Although wet seasons are the most unfavorable for grain crops in dry years the soils bake and crack, resulting in drought damage to crops.

The natural fertility of these soils is higher and more durable than of other soils in the county. The Wildwood soil has a high organic-matter content to a depth ranging from 12 to 16 inches and for this reason is more fertile than the Chilgren soil. Both soils have a high lime content in the lower part of the subsoil. Their intractable physical characteristics are their chief drawback. Where a farm contains other soils more suited to cultivated crops it is probably best to keep these soils in hay and pasture lands.

Most of the cleared acreages of shallow peat are on farms including mineral soils as well. On such farms the shallow peat is usually maintained in hay and pasture. Few farms consisting entirely of shallow peat have been started or maintained. A rather large proportion of the shallow peat areas is at present unsuitable for settlement, because of inaccessible location and inadequate drainage. Other areas are accessible and adequately drained for present development. Many of the recent clearings in the county have been on lands naturally covered by shallow peat but so frequently or thoroughly overrun with fires as to leave only dead timber with loosened roots and the underbrush growth which followed the fire, together with the bowlders that may be exposed. Clearing costs in such areas are estimated to range from $5 to $30 an acre, as compared to $30 to $75 an acre for unburned tracts. In addition to the ease of clearing the ash residue of the peat has a marked fertilizing effect on the soil. These factors have led to the practice of intentionally firing such lands in clearing.

Opinion is divided among the farmers of the county as to the advisability of firing the peat. Although a layer of mucky peat usually remains on the burned tracts under the ash, the organic-matter supply is of course greatly diminished by burning. Unless other sources of organic matter are available it seems reasonable, therefore, that in the long run it is best to avoid the destruction of the entire layer of peat by fire. In some places the more immediate beneficial effects of the ash residue are apparent, but in some areas the ash residue is said to be so strongly alkaline as to be caustic and injurious to crops. No such cases of crop damage in Lake of the Woods County came under observation during the course of the survey. It was pointed out by some farmers that they have, on their farms, shallow peat tracts which are ordinarily higher yielding than the mineral soils. These tracts, although they may formerly have been similar to the present undeveloped shallow peat, did not come into their present state of production until they had been partly burned, had been manured, or had become better decomposed and more mucky, more firm, or sufficiently shallow to enable the underlying soil, with deep plowing, to be intermixed with the peat.

If a settler chooses to burn the peat, there are a few things to consider in choosing the tract. Probably the best possible choice of underlying mineral soil material is one with a sandy loam soil, 1 or 2 feet thick, over a heavier-textured calcareous subsoil. An underlying heavy silty clay will not form so desirable a surface soil for most crops. Areas in which bowlders beneath the peat are numerous should of course be avoided. In such areas the bowlders are not visible until after burning. The settler should also make sure that he can supply any additional drainage necessary to ade-

quately drain the lowered land surface resulting from the burning of the peat. In firing, even burning as free as possible from pits and unburned peat hummocks should be made. Once under crops, the management of the tract becomes a problem of handling the underlying soil and depends on the character of that soil.

Practically all the deep peat in the county is at the present time unused for farming. Only about 100 acres in the county were observed in crops, mostly small grain, oats, and barley. Only indifferent success was obtained.

The problem of the utilization of these northern peat lands is especially acute in Lake of the Woods and adjoining counties because of the large sums of money which have been expended on drainage projects. Their extensive use for farm crops seems remote. Under the best conditions agriculture on peat lands presents unusual difficulties as compared with that on mineral soils. In this northern region further limitations are imposed by the normally short growing season and the frost hazard throughout even the summer months. Other possibilities for utilization lie in the use of the peat lands for tame meadows and pasture, for forestry, or for industrial purposes. There are inherent difficulties in all these possibilities.

The agricultural experiment station of the University of Minnesota has been conducting experiments on peat bogs in the State for a number of years.[8] It has been found that drainage alone will not make peat lands productive; that chemical requirements of peat bogs are extremely variable; that proper maintenance of water-table levels is important; that compaction by heavy rollers or tractors is an important feature of peat-land cultivation; and that peat soils are especially liable to summer frosts. The hazards and difficulties of peat-bog agriculture are pointed out with particular emphasis upon the difference between ordinary mineral soils and peat and between different kinds of peat in their possibilities and requirements for agriculture.

SUMMARY

Lake of the Woods County is in the extreme northern part of Minnesota. The county is a flat plain, with a gentle general slope to the north and east and with only minor relief features to vary its level surface.

The elevations of the county range from 1,060 to about 1,300 feet above sea level, the minimum figure being the water level of Lake of the Woods.

All the county, except a small area in the western part which drains into Red River, is in the watershed of rivers and streams which flow into Lake of the Woods.

About nine-tenths of the county was naturally poorly drained, partly because of a lack of surface relief and lack of development of drainage ways and partly because of the high moisture-absorbing and moisture-retaining qualities of the peat which covered about 64 per cent of the area. An extensive system of ditches in the county artificially supplements the natural drainage.

[8] ALWAY, F. J. AGRICULTURAL VALUE AND RECLAMATION OF MINNESOTA PEAT SOILS. Minn. Agr. Expt. Sta. Bul. 188, 136 pp., illus. 1920.

Originally nearly all the lands were forested with conifers and hardwoods. Only a few small tracts of virgin forest remain. The uncultivated lands are at present largely occupied by second-growth timber and brush, by the stumps, windfalls, and slashings left following logging operations, or by fire-killed trees.

A large percentage of the population is distributed within a radius of 12 miles from the one railroad, the Canadian National. The principal towns of the county along the railroad are joined by a graded gravel highway, and the main feeder highways into the other parts of the county are usually maintained in good travel condition during the summer and fall seasons.

The agricultural development of the county is at present hindered by the lack of good market facilities. The shipping costs usually make the marketing of the bulkier farm products unprofitable, and almost all surpluses are sold locally. Potatoes, flax, wheat, and the cultivated hayseed crops are the principal crops shipped. Dairy and poultry products furnish a large part of the farm income. These products are either shipped or sold locally. Duluth is the principal outside market.

The climate is marked by rather long cold winters and short pleasant summers. The frost-free season is from 100 to 120 days long. Occasional light frost in July and August may damage the tender vegetation.

Agriculture in the county had gained little headway prior to 1910. In 1925, 16.2 per cent of the county was reported in farms.

The principal crops grown are timothy and clover (red and alsike), oats, wild hay, alfalfa, corn (mostly fodder and silage), potatoes, flax, rye, wheat, barley, and sweetclover. Good-quality vegetables, root crops, and small fruits are grown. The most dependable and ordinarily the highest yielding of these crops are the potatoes, root crops, clover and timothy seed, and hay crops. The present trend in farming is toward dairying.

The present farming population as a whole is handicapped by a lack of funds which necessitates slow expansion. The main agricultural problems of the county, aside from the greater problems connected with peat and sand-land utilization, are those of obtaining a better cash market for farm produce and adapting the farming activities in the meantime to the present marketing facilities. The cost of clearing, which in most cases is a handicap, is not so great on the average undeveloped land in this county as in much of the northern cut-over region, and with modern methods clearing can be done economically on considerable acreages.

The greater part of the county was covered by a surface layer of peat. With this layer holding large quantities of water, the underlying mineral soil has not been exposed to the aerial weathering agencies and shows comparatively little change from the parent-soil material. Taylor very fine sandy loam shows most distinctly the soil layers developed by weathering. The other soil types show varying degrees of differentiation into weathered soil layers.

About 64 per cent of the land in the county is at present covered with peat to such a depth that examination and classification of the underlying mineral material was precluded. This peat has been

divided into two classses, peat and peat, shallow phase, based on the thickness of the peat covering. In the shallow phase it ranges generally between 2 and 3 feet.

Drainage conditions vary in the mineral soil, but soils of fair or good natural drainage are a little greater in total acreage than those of poor or fair drainage. The mineral soils have a textural range from sand to silty clay or clay. The Taylor and Baudette soils are the well-drained soils of very fine sandy loam texture. The Marquette, Hiwood, and Faunce soils are well-drained or excessively drained sandy soils. The Gudrid, McDougald, and Rulien soils occur in positions of fair drainage. Spooner very fine sandy loam and Potamo loamy sand occur in positions of poor or fair drainage. The Wildwood and Chilgren soils are silty clay loams or silty clays occupying positions of poor or fair drainage.

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[PUBLIC RESOLUTION—No. 9]

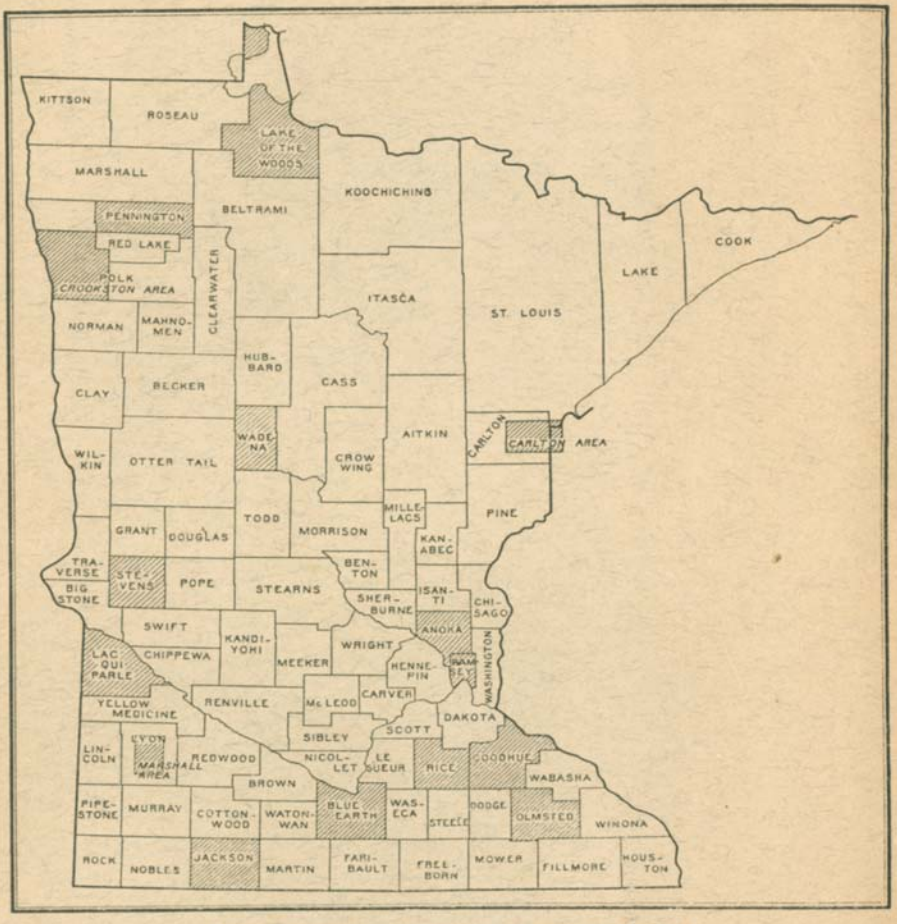
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Minnesota, shown by shading

U. S. GOVERNMENT PRINTING OFFICE: 1930

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