U M.

REPORT

of

COMMITTEE ON EXAMINATION

This is to certify that we the undersigned, as a Committee of the Graduate School, have given Ernest George Roth final oral examination for the degree of Master of Science. We recommend that the degree of Master of Science be conferred upon the candidate.

Minneapolis, Minnesota

May 29 1917

J. Alexander
Chairman

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REPORT

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Ernest George Roth for the degree of Master of Science. They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science.

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THE CHARACTER OF THE PEAT SOILS OF ANOKA COUNTY

By

Ernest G. Roth

A THESIS

Submitted to the Graduate School of the University of Minnesota in partial fulfillment of the requirements

For the Degree

of

Master of Science.

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INTRODUCTION

Minnesota has between three and five million acres of peat lands[1], more than any other state in the Union. While the greater part of this occurs in very large swamps and muskegs in the northern counties, bogs are numerous in the central and southern counties, except in the southeastern and southwestern corners. In no other county in the southern half of the state does peat land appear to form such a large proportion of the surface as in Anoka. There, close to the excellent markets of the Twin Cities, are found enormous acreages of this soil which cannot profitably be farmed by ordinary methods. It was to define more precisely the extent of the peat areas in this county, to classify them according to their general character, and to attempt a rough summing up of the agricultural outlook of these lands, that the investigation reported in this paper was arranged between the Minneapolis Civic and Commerce Association and the Minnesota Agricultural Experiment Station.

The Bureau of Soils of the United States Department of Agriculture, as represented by Mr. W. G. Smith and the Division of Soils of the University of Minnesota, as represented by Mr. G. H. Nesom and the author, in the summer of 1916 made a soil survey of Anoka, the exploration of the peat areas located by Mr. Smith being left to the author, who took numerous samples for later analyses. During the summer he conducted field experiments on a tract of peat land which a preliminary investigation had indicated to be typical of the larger bogs of the county. During the following winter and spring greenhouse experiments were conducted with soil from the experimental tract.

[1] Alway, F.J. -The Future of the Peat Areas of Minnesota, a paper read before the All-Minnesota Development Assoc. at Hibbing, Minn., June 9, 1916.

The results of this work, when viewed in the light of investigations carried out elsewhere, chiefly in Germany, Sweden and Austria, permit of conclusions as to the general solution of the problem of the reclamation of the peat lands of Anoka County.

HISTORICAL REVIEW

Weber defines moors or peat lands as those lands on which there is a peat layer at least eight inches in thickness after allowing for the shrinkage incidental to drainage. "Peat is formed from the residues of dead plants through the exclusion of air and in the presence of water by means of a peculiar chemical process not yet fully explained in its details which one designates, for brevity, as peat formation. In contrast to the processes of decay which constitutes complete decomposition of the residues of plants no microörganisms take part in the peat formation" as stated by Bersch[1].

EARLY USE OF PEAT LAND[2] - No record of the early use of peat lands for agricultural purposes has been found, although some of the better drained grass-covered bogs were probably used as meadows and pastures. Their first use as arable fields was based upon the employment of the Fen System[3] in the 16th century. Near the large cities of Holland the peat was covered with 5 or 6 inches of sand to which was applied a heavy dressing of compost, street sweepings and other city refuse, which was mixed with the sand by plowing.

Somewhat later the Burning System[4] developed as the peat areas remote from a city could not employ the Fen system. The bogs were drained and then the loose surface material burned off, after which

[1]Bersch, Wm. - Handbuch der Moorkultur, Second Edition, 1912, p. 11.

[2]Alway, F. J. - The Future of the Peat Areas of Minnesota, a paper read before the All-Minnesota Development Association at Hibbing, Minnesota, June 9, 1916.

[3]Von Seelhorst, Conrad - Handbuch der Moorkultur, Second Edition, 1914, p. 245.

[4]Ibid, p. 270.

crops of oats and buckwheat were seeded. The first crop obtained by this method was usually quite satisfactory, but after this the crops declined so rapidly that at the end of 4 or 5 years they were not worth gathering.

RECLAMATION OF PEAT LANDS IN GERMANY - Rimpau[1] who owned a large tract of peat land, which had a sandy substratum, devised the method of draining these lands by open ditches, leveling the peat between them and then covering the surface with 4 to 6 inches of sand taken from the bottom of the ditches. He was careful not to mix this with the peat during cultivation. In addition to the sand he used potash salts and some phosphates as fertilizers. This method proved eminently successful on the high-lime, well decomposed peats, such as his own. However, it was found a complete failure on the great Hanoverian bogs and, in 1876, the first peat experiment station in the world was founded on these bogs near Bremen. Here was developed the so-called North German System[2], which consisted in lowering the water-level to about 3 feet below the surface, adding lime or ground limestone, potash and phosphate fertilizers, and then in order to supply nitrogen, either a nitrogen fertilizer was added or a leguminous crop was grown and plowed under. The kinds and amounts of the different fertilizers depended upon the character of the particular bog. Later investigations have shown that differences in climatic conditions make the actual soil conditions different, so that it has become recognized as necessary to establish experimental fields on each type of peat in the different climatic regions in order to determine the proper system of field procedure.

[1]Von Massenbach, Karl Freiheern, Praktische Anleitung zur Rimpauschen Moordammkultur. 3rd Ed., 1904, pp. 4-39

[2]Bersch, Wm., Handbuch der Moorkultur, 1914, p. 183.

Up to the outbreak of the present war Germany had reclaimed about 500,000 acres or 10 per cent of her peat lands for farming purposes. A large number of the present prisoners of war are employed in reclaiming these peat areas, turning them into meadows, pastures and cultivated areas.

RECLAMATION OF BOGS IN SWEDEN[1] - Sweden possesses twice as much peat land as Germany. In 1886, after the successful work of the Bremen Station in Germany had become recognized, the Swedish Peat Land Cultivation Society, composed of farmers who owned peat land, was formed. The government contributes to the support of this society, which has established an experimental station at Jönköping and two experimental farms, the one at Flahult and the other at Torestorp. Nearly two thousand bogs, either wholly or in part, have been reclaimed by members of this society.

LOCATION OF OTHER PEAT EXPERIMENTAL STATIONS AND FARMS - Germany now has two stations and numerous experimental fields, while Austria, Norway, Finland and Russia proper all have established peat experimental stations.

CROPS ON PEAT LANDS[2].- The results obtained during the past 30 years from European peat experiment stations show that peat soils have the ability to produce satisfactory crops of forage plants, small grains and all our ordinary vegetables with the single ex-

[1]Von Feilitzen, Hjalmar - Über die chemische Analyse des Moorbodens ber der Bewertung fur Kulturzwecke, in Verhandlungen Der Zweiten Internationalen Agrogeologenkonferenz, 1911, pp. 160 to 167.

[2]Bersch, William - Handbuch der Moorkultur, 1914, p. 238.

ception of asparagus, when suitable cultivation and proper fertilization are employed as well as when climatic conditions are favorable.

DRAINAGE OF PEAT LANDS - Satisfactory drainage in the case of peat lands is that which holds the water far enough below the surface to prevent water logging and make it possible for men and horses to work upon it, and yet does not lower it so far that crops suffer from drouth. In regions of heavy rainfall, such as those with an annual precipitation of 60 to 80 inches there is no danger from drouth, but in regions, such as Minnesota, a depth of 3 feet for cultivated crops, 30 inches for pasture, and 20 inches for hay, permits the highest yields. The most favorable depth depends upon the crop in question.

HANDLING OF SHALLOW AND DEEP PEAT - In many places in Minnesota there are considerable areas that are covered with shallow peat, only 8 to 15 inches deep, which, at least within a few years after being brought under cultivation, may be treated the same as mineral soils. The soil of the deep peat areas where the layer has a thickness of 3 feet or more must be handled by methods distinctly different from those applicable to mineral soils, they requiring special treatment as to drainage, fertilization and cultivation. In the case of the areas with a layer of peat greater than 12 inches and less than 3 feet in depth part of the soils may be treated as shallow peats and the other as deep peats[1].

DANGER OF SUMMER FROSTS - Peat lands are especially subject to frosts in both Europe and America, as is shown by the following table.

[1] Alway, F.J. - Some Limitations on the Cultivation of Peat Lands in Minnesota, Journal of American Peat Society, vol. 9, 1916, p. 67.

Frequency of frosts on peat land experimental farms at Flahult and Torestorp, Sweden and at Grand Rapids, Minnesota.

Month	At Flahult:	At Torestorp		At Grand Rapids	
	Peat Soil	Peat soil	Sand hill in bog	Peat Soil	Mineral soil
May	14 days	13 days	9 days		
June	3 "	5 "	1 "	4 days	0 days
July	0 "	1 "	0 "	1 "	0 "
August	1 "	3 "	2 "	5 "	1 "
September	8 "	10 "	7 "	8 "	4 "

ROLLING PEAT LANDS[1] - In Germany, Austria and Sweden it has been found essential on cultivated peat lands as well as in the meadows and pastures to use heavy rollers of at least 2,500 pounds to the yard. They compact the surface, furnish a firm seed-bed, and aid in capillary elevation of the water and in off-setting the effects of drouth. The capillarity is much more limited than in mineral soils.

PEAT EXPERIMENTAL WORK IN AMERICA - Very little experimental work has been done on peat lands in the United States and Canada, due chiefly to the large acreage of easily cultivatable and readily available mineral soils. This era, however, is past, while high prices of land, and the increased food shortages are beginning to draw attention to our large acreages of peat.

Illinois, Wisconsin and Iowa have done some work on peats. Illinois[2] carried on experiments on two peat fields, the one at Tampico for 3 years and the other at Momence for 10 years, both with corn as a crop. These trials showed a very great deficiency in the element of potassium, with lime having a beneficial effect. It was concluded that potassium alone needed to be added.

[1] Bersch, Wm. - Die Pflege unsere Moorkultur in Kreigenzeiten, in Zeitschrift für Moorkultur und Torfverwer ung, 1914, pp. 175-182

[2] Illinois Bulletin 157, Cyril G. Hopkins, J. H. Readhimer and O.S. Fisher, 1912.

Wisconsin[1] carried out one year trials on peat lands on fields in cooperation with farmers and on experimental fields in Marinette and Waukesha counties. In these both potash and phosphorus proved beneficial.

The Iowa station[2] has confined its attention to the shallow peat soils. In field trials at Somers, Iowa, on peat 10 to 26 inches deep, and at Eagle Grove, on peat 8 to 12 inches deep, and at Ontario, on well drained shallow peat, neither potash nor phosphate fertilizers gave increased yields and it was concluded that the peat soils of Iowa do not need fertilizers, but only better drainage and cultivation. No experiments were made on deep peat.

Peat experiments were begun in Minnesota at Grand Rapids in 1914. The results for that year are reported by Chapman[3]. Further studies on Minnesota peat have been reported by Hungerford[4], Harmer[5] and Clapp[6].

[1]Wisconsin Bulletin 205 - Development of Marsh Lands, by A. R. Whitson, and F. J. Sievers, 1911.

[2]Iowa Bulletin 157 - Iowa's Peat and Alkali Soils, by W. H. Stevenson and P. E. Brown.

[3]Chapman, James E. - A Study of the Fertilizer Requirements of a High Moor, Thesis, University of Minnesota, June, 1915.

[4]Hungerford, DeForest - Chemical Composition of Some Minnesota Peat Lands, Jour. of American Peat Society, vol. 9, 1916, pp. 24-81.

[5]Harmer, Paul M. - A Study of the Chemical Constituents of Thirty-seven peat bogs of Southern Minnesota, Thesis, University of Minnesota, June, 1915.

[6]Clapp, F. C. - Productivity of Certain Peat Soils as Related to their Chemical Composition, Thesis, University of Minnesota, June, 1916.

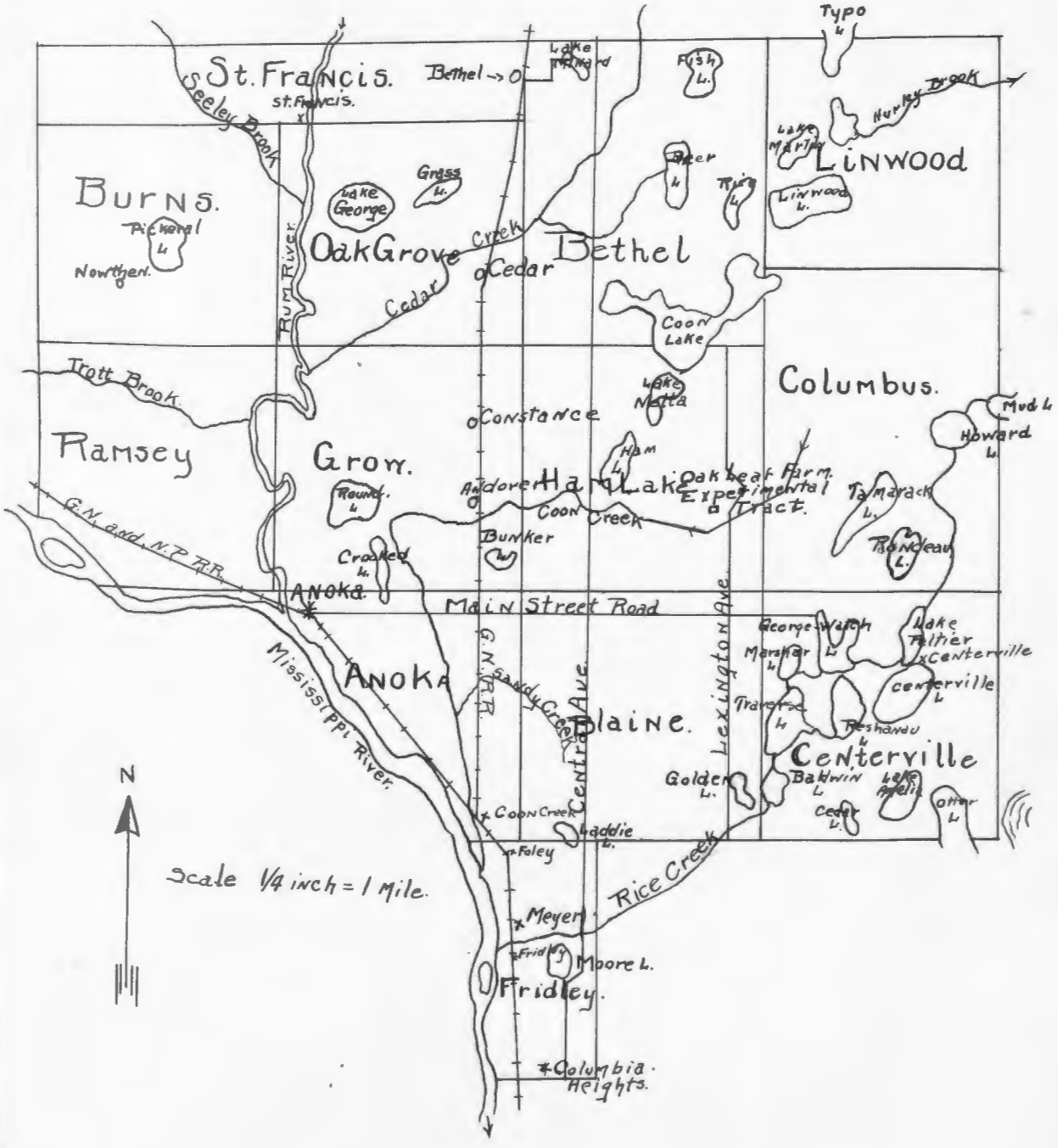
GEOLOGY, GEOGRAPHY AND HISTORY OF ANOKA COUNTY.

Anoka was organized as a county in 1857 with the village of the same name as the county seat. The county lies in the eastern part of Minnesota, a few miles north of the cities of St. Paul and Minneapolis, with the Mississippi River as its western boundary. It has an area of 445 square miles, of which 425 is land, the rest consisting of small lakes. As shown by the recent soil survey of the county, about 31 per cent, or 143 square miles, is occupied by deep peat. (See County map in Fig. 1).

Anoka village has a population of 3,000. The only other centers of population are St. Francis, Bethel, Centerville, Coon Creek, Andover, Cedar and Nowthen, none having more than 200 inhabitants.

GEOLOGY - Outcrops of the formations underlying the drift are found only in Fridley township. This consists of Trenton limestone of Silurian age. This Palaeozoic limestone is about 10 feet thick, with the top about 40 to 50 feet above the Mississippi River. Below the limestone at its northern exposure 2 or 3 feet of the underlying St. Peter sandstone are to be seen. These constitute the most northerly exposures of the Trenton and St. Peter formations found in Minnesota.

The whole of the county has been traversed by at least three ice sheets, the Kansan and two of later age, known as those of the Red Drift and the Late Gray Drift, At Dayton, in the southwest corner of the county, there is to be seen red till overlain by blue till and yellow drift. The red till is characterized by the pebbles and boulders of the Lake Superior district, brought down by ice currents flowing southward from the region of Lake Superior, and is probably of Early Wisconsin age. The blue till, or grey



Anoka County.

Fig. 1 - Map of County, showing the prominent geographical features.

drift, containing limestone fragments and cretaceous shale, was brought down by ice currents from the region of Lake Winnipeg and the Red River Valley, flowing south and southeast, and is of Late Wisconsin age. Exposures of this occur in the Centerville district.

A large part of the surface of the county is now occupied by a sandy soil derived from the glacialMississippi River, and transported to its present position by the prevailing westerly winds, while just east of the present Mississippi River are terraces of sandy and gravelly soil partly the direct deposit of the river and partly remaining after the wind had carried much of the original sand to the eastward.

DRAINAGE - The Rum River, the outlet of Lake Mille Lacs, passes through the western part of the county, flowing southward to its junction with the Mississippi River at the village of Anoka. Tributaries to the Rum River from the west are Trott Brook from the central western part of the county and Seely Brook from the northwest. Cedar Creek, from the east, joins the Rum River near the center of the county. The eastern part of the county is drained by Rice and Coon Creeks, each of which forms the outlet of a chain of lakes and joins the Mississippi River southeast of Anoka. The former drains the east central portion of the county and the latter, the southeast part.

LAKES - Anoka is richly supplied with lakes, forty-one being entirely or partly in the county. Of these, the two chains of lakes along Rice and Coon Creeks, cover the largest area. Coon Lake is the largest body of water, being about four miles long from northeast to southwest. Several of the Centerville lakes are used in connection with the St. Paul water supply. This

cluster of lakes is about seven miles long and the Coon Creek chain about eighteen miles. Other lakes of considerable size in the County are George, Bunker, Round, Crooked, Howard and Otter. Most of these are well stocked with fish and in the autumn afford hunting for ducks and geese. To some extent they are used as summer resorts.

TOPOGRAPHY - The greater portion of the county is an approximately level plain of sand and gravel, belonging to the modified drift. This contains a large number of peat areas, which are from 5 to 15 feet below the general surface. In the eastern half of Centerville Township we find the Gray till, which is level or only slightly undulating. In the southeastern part of Fridley Township moranic till rises in irregular hills 200 feet above the Mississippi. In Ramsey, Burns and St. Francis moranic till gives the surface a rolling contour.

The highest land of the county, about 1000 feet above the sea, is found in sections 24 and 25 in Fridley Township. High elevations are found also in St. Francis and Burns, but the greater portion of the county is nearly level and about 900 feet above the sea level, the mean elevation being 910 feet above the sea level.

ABORIGINES - Anoka, named after the Dakota Indian word meaning "on both sides", or the Chippewa word meaning "to work", early was known as a bloody battle ground for the Sioux and Chippewas. A large Sioux village was located in and around the peat marshes of Centerville Township. This tribe, consisting of about 3000 people, finding plenty of food in the marshes and numerous lakes of this district. Fish, ducks and geese were plentiful, while deer abounded on the surrounding highland. The wild rice of the

marshes not only fed the ducks and geese, but also furnished an excellent food for the Indians, who, every fall, gathered a harvest of the seed. The favorable conditions of this region attracted other tribes, notably the Chippewas, Outanouas and Hurons, who often attacked the Sioux at Centerville. The position was easy to defend, however, owing to the numerous lakes and the wet boggy condition of the soil, and the Sioux easily repulsed every attack. French trappers and traders later came to this locality, and still later a French settlement was established here. The French intermarried with the Indians, and a few of their descendants still reside in the district.

EARLY SETTLEMENT - Anoka, located at the mouth of the Rum River, early became an Indian trading post, the Indians bringing furs from all over the district. The first permanent settlement was made in 1849, north of the present site of Anoka on the Rum. Settlers, seeing that the crops could be grown quickly and in abundance on the light soils of the county, flocked in. Corn, potatoes, wheat and oats were the chief crops grown, while garden produce found a ready market in the Twin Cities, a few miles to the south.

Land values were early given over to speculation, the lands were soldfar above their real value, hugh loans were floated, funds being secured from eastern firms, or even from European corporations, all of these being secured by little or no actual values. The result was that in the panic of 1857 many of the settlers of the county were ruined and forced to leave. To add to this the grasshoppers destroyed all of the crops, leaving the people with neither food nor money. This gave the county a setback from

which it only slowly recovered.

Lumbering was an early industry, sawmills being built at Anoka in 1854, and later at Coon Creek, all of the county being wooded except a small strip along the Mississippi River. Pine, black and bur oak, ironwood, elm, hackberry, poplar, balsam, basswood, sugar and silver maple , boxelder and wild plum were the chief upland trees, while tamarack abounded in the swamps.

In 1855 flour mills were started which at first had wheat shipped from points in other parts of the state and from Iowa, but later secured enough from the farmers of the county. Ginsing was found in the woods near Anoka, the collection of which soon became a thriving industry of the locality.

LATER CHANGES IN FARMING.- The early crops grown were corn, potatoes, wheat, oats and rye. In 1859, the high wool prices started the sheep raising industry, which remained prominent for many years. In 1886, Reuel Hall built at Anoka the largest starch factory in the United States, and potato growing soon grew profitable and the crops and acreage went up rapidly, so as to make this the chief industry of the county, a position which it still holds. The potatoes of Anoka County have become famous throughout the country for their excellent table qualities.

DRAINING THE MARSH LANDS - In 1884 the first public ditch in the county was dug. Two years later ditches were dug in the eastern part of the county. No extensive ditching was done until Mr. James T. Elwell bought about 50,000 acres of land in Ham Lake, Columbus and Blaine Townships and dug about 200 miles of ditches. From that time ditching has been extensively carried on throughout

the county. Mr. Elwell also built the road between Ham and Golden lakes, which cut through the heart of the peat marshes of this district. Stock farms were started and dairying became an added source of income to the Anoka County farmers.

Fuller data on the history, geology and geography may be found in the foot-note publications.

[1]Upham, Warren - Geological and Natural History of Minnesota.

[2]Hall, C. W. - Geography and Geology of Minnesota.

[3]Upham, Warren, - Minnesota in Three Centuries.

[4]Goodrich, Albert M - History of Anoka County.

[5]Goodrich, Albert M. - Early Trails and Settlements at Centerville, Minnesota.

EXTENT OF PEAT LANDS.

Of the 445 square miles in the county, water occupies 20 and peat soil 150, of which about 140 is deep. In "deep peat" are included all of the areas in which the peat has a depth of 18 inches or more. By townships the distribution of the peat is shown in Table I.

The peat is chiefly located in Columbus, Blaine, Ham Lake, Bethel and Centerville townships, where from 50 to 66 per cent of the total land is covered with it. It lies from 5 to 15 feet below the level of the surrounding upland, and, in general, in each bog the surface is lower in the center, frequently containing a body of water in this position. In many cases the bog represents the location of an old lake, in which marl deposits, from 6 inches to 8 feet thick, are found. Many sandy islands are scattered throughout the peat areas, so the depth of the peat varies greatly from place to place in most of the county.

Two chief peat systems are found in the eastern part of the county, the one being in the Coon Creek drainage basin and the other in the Rice Creek basin. The Coon Creek peats range in depth from 3 to 11 feet, the average being about 6.5 feet, and are more uniform in depth than those of the Rice Creek basin. Further their peats are more fibrous, and not as well decomposed, and do not possess the lime content of the Rice Creek peats.

The Rice Creek peat marshes are located in the vicinity of the numerous lakes of the Centerville district and commonly are underlaid by marl deposits. The peat of these is fairly well decomposed and, as a rule, possesses a high lime content. In depth these bogs range from shallow areas to those of over 15 feet.

Table I - Distribution of peat lands by townships.

Township	Area in square miles			Percentage of total area	
	Total	Deep peat*	Shallow peat*	Deep peat*	Shallow peat*
Fridley	16.00	1.0	.25	6.33	1.57
Anoka	25.00	4.0	.00	16.00	.00
Ramsey	32.00	4.0	1.00	12.50	3.12
Burns	36.00	6.0	1.00	16.66	2.76
St. Francis	24.75	2.0	.50	8.10	2.02
Oak Grove	36.00	4.0	.50	11.11	1.40
Grow	36.00	6.0	.75	16.66	1.97
Blaine	36.00	18.0	1.50	50.00	5.20
Ham Lake	36.00	18.0	.50	50.00	1.40
Bethel	47.25	18.0	1.00	38.07	2.11
Linwood	36.00	17.0	1.00	48.60	1.40
Columbus	48.00	32.5	1.50	66.70	3.12
Centerville	36.00	12.0	1.00	33.33	2.76

*Approximate

Many old lake beds are completely covered with peat, while in others a small lake remains in the center of a great bog which is too soft to traverse, and which is covered with rushes and wild rice.

Cedar Creek drains another group of peat marshes underlaid chiefly by marl deposits, and has bogs from 2 to over 15 feet in depth. Trott Brook, on the west side of the Rum River and emptying into the Rum, drains a small group of marshes, which have a marl or clay subsoil. Seely Brook, north of Trott Brook, drains peat areas with a sandy subsoil and peat of a similar character to that of the marshes of Coon Creek.

DEPTHS OF THE PEAT

Maps 1 to 3 show the depths of the peat on the different bogs. There is a great variation in the depth in the same bog due to the numerous islands and the undulating surface of the old lake bed. In making the survey for depth and substratum characteristics, soundings were made on the north-south section lines at 200 yard intervals. On the small bogs the depth was determined and the substratum examined at the center of each area. All samplings were made by means of a Davis peat sampler, this being pushed into the peat until the substratum was reached, the depth recorded, the sampling device opened, pushed in a little farther, thus securing a sample of the substratum. Then a notation was made as to the location, vegetation, utilization and any peculiar characteristics of the peat. Extensions only up to 15 feet were carried and so wherever the peat was deeper than 15 feet the depth is recorded as 180+ inches. Wherever marl was located the sampler was used to collect a sample for later analysis in the laboratory.

Maps 1 to 3 give the exact depths as recorded in the field, while Maps 4 to 6 show in colors the various areas of different depths. The shallow type, colored brownish-red, includes all peat ranging in depth from 1 inch to 18 inches and is designated as "shallow peat". The "intermediate peat", colored red on the maps, includes the areas ranging in depth from 18 to 36 inches and is found chiefly at the margin of the deeper peat or in the center of the bogs of shallower peat. The "deep peat", indicated by yellow, ranges in depth from 36 to 120 inches and includes the largest peat areas in the county, totaling 105 out of the total

153 square miles of peat in Anoka. The "very deep peat", shown on the map by a deep green color, exceeds 120 inches in depth and covers 23 square miles. Table II on the following page gives the area of each of the four classes of peat soil in the different townships.

Table II - Distribution of peat of various depths.

Township	Total peat area Square miles*	0-18 inches Square miles*	18-36 inches Square miles*	36-120 inches Square miles*	Over 120 inches Square miles*
Fridley	1.25	.25	.12	.75	.12
Anoka	4.00	.00	.50	2.50	1.00
Ramsey	5.00	1.00	1.00	3.00	.00
Burns	7.00	1.00	1.50	3.00	1.50
St. Francis	2.50	.50	.75	.50	.75
Oak Grove	4.50	.50	.50	3.25	.25
Grow	6.75	.75	.50	5.25	.25
Blaine	19.50	1.50	2.00	16.00	1.00
Ham Lake	18.50	.50	2.00	15.00	1.00
Bethel	17.00	1.00	.00	12.00	6.00
Linwood	18.00	1.00	.25	15.50	1.25
Columbus	34.00	1.50	3.00	23.50	6.00
Centerville	13.00	1.00	2.50	5.00	4.50
Total	153.00	9.50	14.62	105.25	23.62

*Approximate

Depths of peat in inches.

Map 1.


BETHEL
LINWOOD
Linwood Lake
Coon Lake
HAM LAKE


SAINT FRANCIS
BURNS
OAK GROVE
RAMSEY
GROW
Lake George
Round Lake
Mississippi River

Map 3.

Depth of Peat Areas, in Colors.

Map 4.


LINWOOD
LINWOOD
BE
COLUMBUS
LAKE
CO
Lake


SAINT FRANCIS
OAK GROVE
BURNS
GROW
RAMSEY
Lake
Mississippi River

Map 6

NATURAL VEGETATION

According to their natural vegetation the peat lands of Anoka may be divided into seven classes, as shown in Maps 7 to 9 and in Table III, namely: 1, tamarack (Plate I, Fig. 1); 2, willow and poplar brush (Plate I, Fig. 2); 3, rushes (Plate I, Fig. 3); 4, wire-grass (Plate II, Fig. 1); 5, other sedges (Plate II, Fig. 2); 6, cranberry; 7, redtop (Plate II, Fig. 3). The present vegetation depends partly upon the natural and partly upon the artificial drainage of the area, but also partly upon the character of the substratum. Flags, reeds, rushes, wild rice, mosses and algae grow in the shallow water or along the water's edge, wire-grass where the water comes just to the surface, and cranberries thrive in very lime-deficient bogs that have standing water part of the year. Sedge grasses are found on the bogs free of surface water for the greater part of the year, while redtop grows only on those bogs which are still drier. Tamarack is found on both deep and shallow peats, and on wet as well as on comparatively dry areas, but the larger trees are confined to the black, well decomposed type, commonly called "muck". Usually the drainage is very poor in the tamarack swamps. Brush and willows usually are found on burned-over areas of peat.

Table III shows the area of each type of vegetation in the county. There are approximately 39 square miles of sedge grasses, 42 of wire-grass, 39 of redtop, 9 of willow and poplar brush, 3? of tamarack, and 0.5 of the wire-grass-cranberry association.

The maps show that the bogs of the central part of the county are largely covered by wire-grass and sedges, with tamarack and

redtop growing on the edges. The peat areas west of the Rum River are largely covered with redtop and tamarack. Large areas of rushes and reeds are found around the lakes and in the wet centers of the bogs.

Some of the weeds commonly found on these peat marshes are: common smart-weed (Polygonumus hydropiper), wool grass (Scirpus cyperinus), swamp dock (Rumex britannica), butter and eggs (Lineria vulgaris), tumbling pigweed (Amaranthus graecizans), ragweed (Ambrosia artmisiifolia), rough five-finger (Potentilla monspeliensis), evening prinrose (Oenothera biennis), small flowered agalinis (Agalinis paupercula), blue vervain (Verbena hastata), plantains (Plantago major and Plantago rugelii), wild aster (Aster sp.), lambs' quarters (Chenopodium album), yarrow (Achillea millefolium), golden-rod (Solidago sp.), swamp milkweed (Asclepias incarnata), wild mint (Mentha canadensis), cattail rushes (Typha latifolia), great American bulrush (Scirpus sp.), tall reed grass (Phragmites comminis), and large blue flag (Iris versicolor). Of these the smartweeds and docks are the most injurious to cultivated crops.

Vegetation of the Peat Areas.

Map 7.


LINWOOD
Linwood
COLUMBUS
lake


SAINT FRANCIS
George
OAK GROVE
RAMSEY
GROVE
Round Lake
Mississippi River

Map 9.

Plate I

Fig. 1 - Tamarack growth on deep peat marsh.

Fig. 2 - Brush of poplar, willow and elder on burned-over peat area.

Fig. 3 - Cattail rushes on a low, wet marsh.

Plate II.

Fig. 1 - Wire-grass marsh showing a curing shed in the background.

Fig. 2 - Sedge grass marsh.

Fig. 3 - Redtop grass, used extensively for hay.

Plate III

Fig. 1 - Tall reed grass found on wet peat area.

Fig. 2 - Low reeds and rushes commonly found in low wet peat areas.

Plate IV

Vegetation samples taken from peat areas in Anoka.

1 - A small fine found sedge grass.
2 - Wire-grass.
3 - Flat sedge grass.
4 - Tall reed grass.
5 - Forked beard grass.
6 - Blue joint, commonly called redtop
7 - American great bulrush
8 - Wool grass
9 - Cattail.

Table III - Distribution of vegetation on the peat areas, in square miles.

Township	Total peat	Sedge grass	Wire grass	Red top	Tamarack	Cranberry	Brush	Rushes
Fridley	1.25	.25	.12	.62	.06	.0	.06	.12
Anoka	4.00	2.50	.06	.75	.62	.0	0	.06
Ramsey	5.00	1.00	.75	3.18	.06	0	0	.50
Burns	7.00	1.00	.00	2.50	1.50	0	1.00	1.00
St. Francis	2.50	.05	.00	2.00	.31	0	.06	.06
Oak Grove	4.50	.25	.37	2.62	1.63	0	0	.12
Grow	6.75	3.00	.00	3.00	.50	0	0	.25
Blaine	19.50	8.00	2.00	8.00	.50	0	0	1.00
Ham Lake	18.50	9.00	2.50	5.00	1.25	.25	.25	.25
Bethel	19.00	3.00	5.00	4.00	5.75	.25	.25	.75
Linwood	18.00	4.00	7.75	1.00	4.50	0	0	.75
Columbus	34.00	3.00	23.00	2.00	4.00	0	0	2.00
Centerville	13.00	3.50	1.00	4.00	2.50	0	0	2.00
	153.00	38.55	42.53	38.67	23.18	.50	1.62	8.76

PRESENT UTILIZATION

At the time of the exploration of the peat areas a record was made of the present use of the different marshes, and on Maps 10, 11 and 12, and in Table IV are shown the proportions under cultivation, used for hay, wiregrass production and pasture, as well as those covered by tamaracks or lying as entirely waste areas. Those areas used for hay and pasturage are considered in the tables and maps as hay land.

LAND IN CULTIVATION.- Only 5 fields on the peat areas of the county have been brought under the plow, and of these, which form but little more than one-thousanth part of the peat acreage of Anoka, only one produced a crop in 1916. In the northwest corner of the southwest quarter of Section 25, Ham Lake, Mr. F. A. Griswold plowed about 10 acres late in 1916 in preparation for seeding in 1917. Mr. G. Borg, whose farm is located in the NW¼ of the SE¼ of Section 11, Anoka Township, similarly prepared about 10 acres. On the Oak Leaf Farm, Section 24 of Ham Lake, two fields, one of 50 acres and the other of 30, were broken late in 1915. The former was so wet that no crop was put on it in 1916 while the latter, except for the 5 acre tract used by the Minnesota Experiment Station for field experiments and dealt with in a separate section of this thesis, flax and millet were sown. These two crops proved failures due, in part at least, to the inadequate drainage of the field.

The fifth and last field, the only one producing a crop, accordingly acquires an unusual interest. It belongs to a Mr. Brunell, is located on the NE¼ of the NW¼ of Section 29 of Ham Lake, being adjacent to the Lexington Avenue Road and contains about 5 acres. A large ditch (Coon Creek dredged) passes through it, thus

insuring an opportunity for drainage. The peat on most of it is 5 feet deep, but on part of it the depth is less. The surrounding upland soil consists of Merrimac loamy fine sand. The bog had been broken in 1915 and seeded to flax, but as an August frost ruined the crop the rank growth of straw was allowed to remain on the surface until plowed under in the spring of 1916. A liberal supply of stable manure was applied before planting the corn. High winds in 1916 and in former years had carried much sand onto the field, a matter that may have some bearing upon the yield of corn in 1916. The corn made a satisfactory growth and gave as good a yield of fully matured grain as the adjacent fields on mineral soil. (Illustration of cornfield in Plate V., Fig. 1), p. 50.

Whether the surface of this field of peat had been burned off shortly before it was plowed is not known. In origin and chemical composition (Chemical Analysis, Sample 40) the soil is similar to that on the Oak Leaf Farm, where the plot experiments were conducted and with which greenhouse trials were made. Accordingly we should expect that it would be adequately supplied with lime, to have the nitrogen in a rather readily available form, and to carry sufficient available potash to insure one or more fair crops. The phosphate supply we should expect to be the limiting factor, but, for this constituent, the corn would have that collected by the flax during the previous season and that supplied in the manure as well as what it could itself collect. Further, if the land had been burned previous to breaking much would have been left in the ash. So, all things considered, the good yield of corn is not so surprising.

Table V - Present utilization of the peat land.

Township	Total peat: acres	Cultivated: acres	Hay: acres	Waste: acres	Tamarack: acres	Pasture: acres	Wire-gras: acres
Fridley	800	0	400	160	80	160	0
Anoka	2560	20	1680	320	400	120	0
Ramsey	3200	0	1880	960	40	320	0
Burns	4480	0	1440	1920	960	160	0
St. Francis	1600	0	1040	320	240	0	0
Oak Grove	2880	0	1760	160	720	0	320
Grow	4320	0	3360	320	320	320	0
Blaine	12480	0	10560	640	320	320	640
Ham Lake	11840	80	9080	640	960	640	640
Bethel	12160	0	2560	3200	3840	640	1920
Linwood	11520	0	3520	320	2880	0	5800
Columbus	21760	0	2560	4480	2560	640	12160
Centerville	8320	0	4160	1920	1600	640	0
Total	97920	100	39600	15360	14720	3960	21480

Present utilization of the peat areas.

Map 10.


LINWOOD
LINWOOD
COLUMBUS
HAMSLAKE


SAINT FRANCIS
OAK GROVE
BURNS
GROVE
RAMSEY
Mississippi River

Map 12.

HAY-LAND - The sedge grasses, redtop (or browntop), and some of the fine wire-grass are cut for hay, which is used locally as feed for cattle, horses and sheep or is sold on the market as Midland hay. This is usually baled and shipped by rail to the Twin Cities, but it is often hauled into the cities without baling, especially from Fridley and Blaine townships. There it sells for $10.00 to $13.00 per ton, depending upon the quality. The redtop is considered the best hay, and, if most of the hay consists of redtop, it is sold for Upland hay at from $13.00 to $14.00 per ton.

This is cut yearly, haying usually commencing about the first of August and lasting until the grass is killed by frost. The grass is cut with a mower, raked into windrows, bunched, then hauled to the stack with a sweep-rake or wagon, and stacked either by hand or with a haystacker. The stacks vary in size from two to thirty tons, and in shape are round or elongated. When the ground is frozen and covered with snow the hay is hauled away. Frequently it is baled in the field and then hauled to the nearest railway station. The grasses are easily cured, and the hay is ready for the mow after lying in the sun for one day. The most salable hay is that which is put up the best - that in a covered mow or in well-built stacks. Stacks with defective tops allow the water to enter and lessen the feeding and market values.

The yields of hay vary from 1 to 2 tons per acre, and, on the average, it can be placed on the city market, baled, at a cost for labor alone of about $7.00 per ton. This cost will be higher where the field is far from market or railway station.

Nearly half of the total peat acreage of the county is at present used for hay or is in a condition in which it can readily

be used for this. The estimated acreage in the fall of 1916 was 67 square miles utilized for hay purposes, the largest areas being in Blaine, Ham Lake and Centerville townships. Table IV shows the acreage in the various townships.

WIRE-GRASS FOR CARPET MAKING - The Crex Carpet Company own or rent practically all of the wire grass bogs in the county and from these every year all of the clean wire-grass is carefully cut, cured, housed and shipped to St. Paul. These bogs, which are shown by a brick red color on the maps, represent the areas where the vegetation is largely wire-grass. All this was at once time covered by wire-grass and cut for the carpet industry, but later township ditches were dug, the water drained off and redtop and other grasses began to crowd out the wire-grass and mix with it to such an extent that the purity of it was so reduced as to render it valueless for carpet purposes. By a legislative act, passed in 1915, a private individual or a company is permitted to close the ditches on their own property. By so doing the Crex Company can now control the water level and, as a result the wire-grass is gradually being reinstated over the entire wire-grass region. At present about half, or 12.5 of the 25 square miles, of the wire-grass area is actually cut for carpet grass, while the remainder either is cut for hay, which is of a poor grade, or is simply cut and allowed to rot on the ground, the object of this being to get rid of the redtop and undesirable sedges.

The most favorable conditions for the wire-grass are peat soil and the water-level at the surface all of the year. The Crex Company have ditches with which they control the water level and keep it at this level most of the year. During harvest time, however,

they drain the water to a foot or 18 inches below the surface, thus allowing teams and machinery to work on the marshes. The harvesting usually begins about the first of August and continues until the first killing frost. The wire-grass is cut with reapers, picked up and tied into bundles either by hand or with a machine and then hauled into covered sheds where it may cure properly. During the winter it is hauled to the station and shipped by rail to St. Paul, to be manufactured into carpets, rugs, mats and similar products. The wire-grass, when properly cured, is very tough and pliable and when woven into carpets is attractive, durable and useful. Most of the wire-grass is harvested in Linwood and Columbus townships.

PASTURE - More and more of the peat land is being fenced off every year for pasture. Frequently after the fence is put around the bog it is discovered that the peat marsh is too wet for a pasture and then it is used for hay. In all such cases the field is recorded as hayland. In many cases the smaller bogs are fenced in and used for hay, as the cattle prefer the upland pasturage for grazing purposes. The marsh, when sufficiently drained, provides pasturage, and when yearly cut for hay furnishes in the spring a tender succulent feed for the cattle. In the neutral bogs it is practicable to start clover and tame grasses. One handicap in pasturing the drained marsh is that during the hot weather the cattle wade in ditches and soon cause obstructions that interfere with the drainage.

It is estimated that about 6 square miles of these peat lands are used primarily for pasturage purposes, although much more is fenced. Farmers, pasturing stock for hire during the summer, charge $1.50 per head, this providing for pasturage from May 1 to

October 1 or October 15.

TAMARACK - Approximately 25 square miles are covered with tamarack swamps, these being largely in Bethel, Linwood, Columbus, Centerville and Ham Lake, although some are found in each of the other townships. These trees are used for fire-wood, building timbers, fence posts and other purposes. On some of the tamarack swamps the trees are so dwarfed that these areas could properly be designated as waste.

WASTE LAND - This class, represented by areas scattered throughout the various townships, embraces the areas that are too wet to be at present utilized for any purpose. It is estimated that these cover 24 square miles, much of this being covered with rushes, flags and reeds. With improved drainage a large proportion of it could be utilized for hay or wire-grass. The largest areas of this waste land are located in Columbus, Bethel and Centerville.

Maps 10 to 12 show in colors the present utilization of the peat lands, while Table IV gives, in square miles, the area in each township. In Table V I have made an estimate of the crop returns from the various classes of bogs. The average net return, after allowing for labor, is a little less than $1.00 per acre, a sum which does not justify a very high valuation.

Plate V, Fig. 2 shows a wire-grass shed in the background, such as is commonly used for curing the grass before shipping, while Fig. 3 on the same plate shows a characteristic redtop field near Centerville with the hay in 2 to 3 ton stacks.

Table V - Estimated annual production of the whole peat acreage.

Product	Acreage	Yield per acre: Tons	Annual net value: per acre	Total net value
Hay	40,000	1½	$1.00	$40,000.00
Wire-grass	20,000	1	2.00	40,000.00
Pasturage	4,000		.50	2,000.00
Tamarack	15,000		.25	3,750.00
Waste	15,000		0	0.00
Total	94,000			85,750.00

Plate V.

Fig. 1 - Shocked corn on 5 acre cultivated tract of peat land on farm owned by Mr. Brunell.

Fig. 2 - Wire-grass shed in background, used for curing wire-grass for carpet manufacture..

Fig. 3 - 2 to 3 ton stacks of redtop hay on a bog near Centerville.

MINERAL SUBSTRATUM

- The mineral soils of the county owe their origin directly or indirectly to glacial action, being derived from either the Gray or the Red Drift. The Miami soils, located in the Fridley and Centerville districts, are derived largely from the till or boulder clay of the Gray Drift, while the Gloucester soils are similarly derived from the Red Drift, being confined chiefly to St. Francis, Burns, Oak Grove, Grow and Ramsey. The outwash plains that remained undisturbed and the wind deposited sands form level areas of Merrimac soils. The alluvial deposits along the Mississippi give rise to the Waukesha and Buckner soils.

The Miami soils, usually containing more than 25 per cent of limestone material, form much of the substratum of the peat areas of the high-lime, muckier peat soils of the Centerville and Fridley districts, while the Gloucester and Merrimac soils form the substratum of the more fibrous and less decomposed bogs of the county.

The substratum of the marshes varies with the different localities, and as a rule with the type of soil found on the upland surrounding the bogs. Thus, in the Centerville district, where the upland is a Miami loam we find the substratum of the peat either largely boulder clay or a marl which in its turn is underlaid by boulder clay. Part of this area is covered with a light colored sand as is found in the substratum of the Coon Creek districts. In Bethel, St. Francis, Oak Grove and Ramsey townships also clay and marl deposits are found. Marl deposits are shown on the substratum maps 13 to 15 in light green color, while clay is shown in red. Anoka County has 17 square miles of marl, and 13 square miles of

Substratum of Peat Areas.

Map 13


BETHEL
LINWOOD
Linwood Ldg.
Coon Lake
COLUMBUS
Rod gravel
Substratum


SAINT FRANCIS
Lake George
OAK GROVE
BURNS
RAMSEY
GROW
Round Lake
Mississippi River

Map 15.

clay substratum under the peat areas.

Yellow sandy substratum, shown in Maps 13 to 15 by a yellow color, covers the larger part of the area, and is found chiefly under the shallow peat areas of the county. The area of each type of substratum for all of the townships is given in Table VI and is shown with colors on Maps 13 to 15. The total acreage of yellow sandy substratum in the county is 109 square miles.

In most of the peat areas west of the Rum River and in small areas in Grow, Anoka and Fridley townships a black sand forms the substratum. This is of a more loamy texture than the yellow sand. The total area of this type of substratum is 13 square miles and is shown in black on Maps 13 to 15.

Table VI shows the location and acreage of each type of substratum in each township.

Table VI - Peat areas classified according to the character of the substratum.

Township	Marl Square miles	Clay Square miles	Yellow sand Square miles	Black sand Square miles
Fridley	0	.25	1.0	0.0
Anoka	.5	.0	2.75	0.75
Ramsey	2.0	.5	.0	2.5
Burns	.75	.0	.0	6.25
St. Francis	.15	.875	.5	1.0
Oak Grove	.5	1.5	2.0	0.5
Grow	.06	.125	4.56	2.0
Blaine	.5	.125	18.67	0
Ham Lake	.0	.125	18.37	0
Bethel	5.0	5.0	9.0	0
Linwood	.75	.75	16.5	0
Columbus	3.0	2.0	29.0	0
Centerville	4.0	2.5	6.5	0
Totals	17.18	13.75	109.06	13.0

CHEMICAL COMPOSITION

METHOD OF SAMPLING - In taking a sample from a field the bog was carefully looked over to find a uniform and representative area which was still, as nearly as possible, in its virgin state. A composite of five samples from this area was then made, each sample being at least ten paces from any of the other four. The samples were taken by means of a flattened spade, so as to represent the surface eight inch section. Blocks 8 inches square were cut out for each sample, the five blocks placed on a canvas sheet, chopped up finely with the spade and with a large knife, and thoroughly mixed by hand. From this mixture a 5 to 10 pound sample was taken, placed in a small sack, tagged with a record number and shipped to the Experiment Station.

THE ANALYSES - In each of the samples the ash, volatile matter, soluble ash, insoluble matter, lime (CaO), nitrogen and degree of acidity were determined. All determinations were made in duplicate and the data reported are the means of concordant duplicates.

The nitrogen content of the organic or volatile matter is also reported. In so far as the character of the peat is concerned this should have more significance than the proportion of nitrogen in the peat itself. An addition of sand or clay to the peat, and the subsequent mixing of the two would lower the nitrogen content of the mixture, but not of the volatile portion. Such mixtures result in nature from the washing or blowing down of the higher lying mineral soil.

METHODS OF ANALYSES

PREPARATION OF THE SAMPLE FOR ANALYSIS - Each sample was air-dried, ground in a feed mill so that all of it would pass through a 2 mm. sieve, thoroughly mixed and placed in a covered glass container. From this container a 15 to 20 gram sample was taken by means of a sampling tube, placed in a small tin can provided with a tight-fitting cover, dried in a water oven for 24 hours at a temperature of about 100° C, covered and allowed to cool in a desiccator. It was then ready for the chemical analyses, starting with the ash determination.

ACIDITY - For acidity the Truog test was used. A one-gram sample was placed in a 300 cc Erlenmeyer flask, 100 cc distilled water added, the mixture boiled for five minutes, or until the peat ceased to stick to the sides of the flask. Then 10 cc. of aqueous suspension of zinc sulphide in calcium chloride was added, the mixture brought to the boiling point and boiled for one minute. A strip of filter paper, moistened with two drops of a 10 per cent solution of lead acetate was then at once placed over the mouth of the flask and the boiling continued for 2 minutes. The test paper was then removed, dried, compared with a standard and the degree of acidity recorded.

VOLATILE MATTER AND ASH - Five grams of the dried peat were accurately weighed out into a quartz dish, the weighing being done as quickly as possible to avoid the taking up of an appreciable amount of moisture from the air. The organic matter was then partly burned off over a Bunsen burner and the ignition completed in an electric muffle. The quartz dish and the contents were allowed to cool in a desiccator for an hour before being weighed. The loss

represents the volatile matter, the residue being recorded as "ash".

INSOLUBLE MATTER AND SOLUBLE ASH - By means of a jet of water from a wash-bottle the ash was carefully transferred from the quartz dish to a 4 inch porcelain evaporating dish. The ash, covered with water, was treated with 15 cc. of concentrated hydrochloric acid and 10 cc. of conc. nitric acid. After standing covered with a watch glass for 10 minutes the mixture was evaporated to dryness on a steam bath in order to dehydrate the silica, the dry residue treated with the same aqua regia mixture and again evaporated to dryness on the steam bath. When entirely dry 20 cc. of conc. hydrochloric acid and about 100 cc of water was added, the mixture filtered through a 9 cm. filter paper and washed free of chlorides and ignited in the muffle in the original quartz dish until free from carbon, cooled and weighed. The weight of the residue gives the insoluble matter, and the loss represents the soluble ash.

The filtrate from the insoluble matter containing the soluble salts was made up to 500 cc with distilled water, designated as "Solution A", and saved for other analyses.

LIME (CaO) - 100 cc of Solution A, made strongly ammoniacal with ammonium hydroxide, boiled and, while boiling, 10 cc. of a saturated solution of ammonium oxalate was added, the boiling continued for 5 minutes and the mixture allowed to stand over night. It was then filtered through a 9 cm. filter paper and washed free of oxalates with warm water, testing for the removal of the oxalate by a weak permanganate solution. The filter was then punctured and the precipitate washed into a beaker with hot water, and dissolved with a 1 to 5 sulphuric acid solution, the filter also being wash-

ed with the H_2SO_4 solution. 10 cc. of conc. H_2SO_4 was added, the solution brought to boiling and titrated against a standard solution of potassium permanganate.

NITROGEN - This was determined by the modified Gunning method, using 1 gram of peat dried at 100° C. for each analysis.

Maps 16 to 18 give the location from which were taken the peat samples for analysis. The numbers on the map are the same as the numbers used in the tables. Two numbers, the one above and the other below a dash indicate that there were two samples taken at the same place, the number below the dash being that of the deeper sample taken. The number shown in red indicates that the sample was a marl.

THE CHEMICAL DATA

The analyses are reported in Tables VII to XIX in which the samples are grouped by townships. Following each table is a statement of the source of the samples, sufficiently definite to permit of their duplication or the detailed study on the spot of the relation of the vegetation, etc. to the chemical composition.

The character of the substratum was recorded at each sampling and if it appeared other than a sand it was tested with dilute hydrochloric acid. If considerable effervescence resulted a sample was taken for later analysis, the results being reported in Table XXII.

Maps showing location and numbers of samples taken for chemical analysis

Map 16


BETHEL
LINWOOD
COLUMBUS
BLAINE
CENTERVILLE


SAINT FRANCIS
BURNS
OAK GROVE
GROW
RAMSEY
Lake George
Round Lake
Mississippi River
108
107
101
100
99
98
97
96
95
94
93
92
91
90
89
88
87
86
85
104

Map 18.

FRIDLEY TOWNSHIP

The peat lands of Fridley Township cover about 1.25 square miles, which is a total acreage of about 800 acres. Of this 16 acres consist of the shallow type which is found chiefly along the banks of Rice Creek and the edges of the chief bog. The chief tract is at the southern end of the larger bogs in the townships north of Fridley. The peat of this area varies in depth from 4 to 11 feet. It has 3 main ditches running through it which drain off the water fairly well, so that hay can be made during the drier part of the haying season. The vegetation consists chiefly of redtop and sedges which are used for hay. The yield varies from one and a half to two tons per acre. Bog shoes are used on the horses during wet weather or when the bog is in a soft condition. About two-thirds of this bog was cut in 1916, furnishing 800 tons of hay.

The peat area around Moore Lake has about 250 acres, of which 100 is used for hay, while the remainder, which lies around the lake, is low, soft, covered with cattail rushes and forms simply waste land. This has a neutral peat, and is underlain with marl, the peat ranging from 2 to 11 feet. The hay, consisting of redtop and sedges, averages from one to one and a half tons per acre.

Smaller peat areas, ranging from 2 to 15 acres, scattered over the township, are usually shallow and used for either hay or pasture, but are sometimes left as waste land on account of their poor drainage.

The shallow peat areas, that is those with 18 inches or less of peat, which are found along Rice Creek and in some of the smaller bogs, are used for hay or are cultivated, being handled just like mineral soils.

The analyses of the samples from this township (Table VII) show them to vary in acidity from medium to very slight, but all have a rather high lime content, this varying from 1.94 to 3.50 per cent. This in all is so high that the application of ground limestone will be unnecessary. The ash content is fairly high in all as is also the nitrogen.

Table VII - Composition of Fridley peats.

Thesis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of ash soluble	Ash	Insoluble matter	Soluble ash	Nitrogen
	Inches	Ft.-Ins.		P.ct.	P.ct.	P. ct.	P.ct.	P. ct.	P.ct.	P. ct.
1	0-8"	11'2"	Medium	1.98	3.7	41	17.6	10.4	7.2	3.04
2	0-8"	5'2"	"	1.94	3.6	16	32.1	26.8	5.3	2.48
3	0-8"	8'0"	"	2.48	3.4	35	22.5	14.5	8.0	2.93
4	8-16"	8'0"	V.slight	2.53	3.5	57	25.3	10.9	14.4	2.66
5	0-8"	6'6"	Medium	1.97	4.0	31	22.8	15.6	7.2	3.11
6	0-8"	8'0"	Slight	3.50	4.1	32	27.5	17.7	9.8	3.08
7	8-16"	8'0"	V.slight	4.13	3.7	34	18.5	12.2	6.3	3.01
8	0-8"	4'8"	Slight	3.19	3.4	50	26.8	13.1	13.7	2.50
9	8-16"	4'8"	Slight	2.90	3.9	11	20.6	17.3	3.3	3.02

SAMPLE 1 - Taken from Moore Lake bed, which is used partly for hay, the remainder being too wet. The vegetation consists of redtop and rushes. The substratum is sandy.

SAMPLE 2 - Taken from the center of a small bog south of Meyer station. Vegetation rushes and willows. The bog is used for pasture.

SAMPLES 3 to 9 - All taken from the large bog in Fridley township. Consist of fairly well decomposed peat. Vegetation redtop, used chiefly for hay. The drainage is poor.

Table VII gives the chemical analyses of these samples, while Map 16 shows their source.

ANOKA TOWNSHIP

In this township the peat covers about 4 square miles, the bogs being drained by Coon Creek and constituting part of the extensive marshes that extend down from Coon Creek drainage basin. Sandy Creek, which is tributary to Coon Creek, drains part of these lands. These bogs, with tamarack on the edges, but covered with sedges and redtop for the most part, are used to a large extent for hay. The location of the vegetation is illustrated by Map 7 and its utilization by Map 10. A few small peat areas, scattered throughout the township, are either ignored by the farmers or are used for hay or pasture. Frequently these small areas are too wet to be of any value. Hay which is cut yearly on these marshes yields from 1 to 2 tons per acre.

Ditches have been dug through all the larger peat areas, but have either not been dug deeply enough or been allowed to fill up with dirt and vegetation, so as to make them inefficient. To make them of most service as hayfields these bogs require better drainage. As is shown by Map 4 the peat ranges in depth from shallow to very deep, the deeper areas, as a rule, being covered with tamarack.

Table VIII - Composition of Anoka peats.

Thesis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of soluble ash	Ash	Insoluble matter	Soluble ash	Nitrogen
	Inches	Ft-Ins		P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P. ct.
10	0-8"	6'8"	Neutral	3.08	3.6	32	20.3	13.8	6.5	2.89
11	0-16"	6'8"	"	3.55	3.0	38	25.5	15.7	9.8	2.28
12	0-8"	7'6"	"	3.01	3.5	30	18.5	13.1	5.4	2.92
13	0-8"	3'6"	Medium	2.58	3.4	30	27.0	16.4	10.6	2.64
14	0-8"	3'0"	Strong	1.24	4.9	12	51.2	44.3	6.9	2.30
15	0-8"	7'6"	Slight	3.21	3.9	36	24.6	15.6	9.0	2.96
16	8-16"	7'6"	Medium	2.99	3.6	44	19.3	10.8	8.5	2.95
17	0-8"	6'8"	V.slight	3.94	3.9	32	30.3	20.4	9.9	2.78
18	0-8"	4'8"	Slight	1.70	3.2	31	14.3	9.9	4.4	2.71
19	0-8"	8'6"	Neutral	4.51	3.2	43	22.7	12.8	9.9	2.43
20	0-8"	10'6"	V.slight	2.83	4.0	45	14.5	8.0	6.5	3.46
21	0-8"	5'2"	Slight	3.51	3.9	38	21.2	13.1	8.1	3.13

SAMPLE 10.- Taken half a mile south of Foley. Vegetation consists of redtop, wire-grass and other sedges, used for hay, averaging about 1.5 tons per acre. This was found to be neutral, high in lime, well decomposed and with a medium content of nitrogen.

SAMPLE 11 - Formed the second 8 inches corresponding to the above sample and shows the same characteristics as the latter.

SAMPLE 12 - Taken 50 rods north of 11. Vegetation consists of redtop and sedges, used for hay. 500 stacks, or approximately 1000 tons of hay were on the bog. The peat is fairly well decomposed and drier than on other parts of the same bog.

SAMPLE 13 - Taken half a mile east of Foley. Fairly well decomposed. Covered with redtop and sedge grass, all being used for hay. The marsh here is poorly drained and bog shoes have to be used on the horses. It shows a medium acidity but has sufficient lime to not require the application of limestone.

SAMPLE 14 - Taken in a pasture just north of Lake Laddie. It is strongly acid, low in lime, high in mineral matter and medium in nitrogen content. An application of limestone would be beneficial when this is brought under cultivation. It is covered with a sparse growth of wild onion and smartweed. It has poor drainage.

SAMPLES 15 and 16 - Surface 8 inches and second 8 inches respectively, taken in a newly plowed peat area in the SE corner of SW¼ of 11. The peat is well drained and the peat well decomposed, it formerly being a tamarack bed. It is slightly acid, but rather high in lime and with a fair nitrogen content.

SAMPLE 17 - Taken in Sec. 15 near Sandy Creek. The bog is well drained, and all used for hay. The peat is very slightly acid, but high in lime, well decomposed and of fair nitrogen con-

tent.

SAMPLE 18 - Taken in Section 1, from an area too wet for utilization, poorly drained with vegetation consisting of wire-grass and other sedges. Of slight acidity and low in lime and nitrogen.

SAMPLE 19 - Taken half a mile east of Coon Creek on Main Street road, on an old tamarack bed, with peat 8 feet deep and a marly subs stratum, which is 5 feet deep. Used for hay. Neutral in reaction, high in lime, and well decomposed.

SAMPLE 20 - Taken just east of Coon Creek on the Main Street road. The bog is used partly for hay, but part is too wet for any use. All covered by sedges. Of very slight acidity, fairly high in lime, and high in nitrogen.

SAMPLE 21 - Taken in SW¼ of Sec. 18 of Blaine Twp. Shows slight acidity, is high in lime and nitrogen. This bog is well drained, partly tiled and used for hay, averaging 1.5 tons per acre. 500 stacks were put up in 1916. Vegetation consists of redtop and sedges.

BLAINE TOWNSHIP

Approximately 20 square miles or 55 per cent of Blaine is covered with peat, which ranges in depth from 6 inch areas is the southwestern corner to those 11 feet deep. These bogs were at one time part of the great wire-grass marsh, but drainage has caused redtop and other sedges to invade them so that now they are used for hay or pasture. The substratum is everywhere a yellow sand with the exception of a small area in Rice Creek bottoms in the southeastern corner. Several ditches drain this area into Coon Creek or Rice Creek, but they are too shallow to be adequate.

Table IX Composition of Blaine peats.

Thesis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of ash soluble	Ash	Insoluble matter	Soluble ash	Nitrogen	Phosphates P_2O_5
	Inches	Ft-Ins		P.ct.	P. ct.	P.ct.	P.ct.	P. ct.	P.ct.	P. ct.	P. ct.
21	0-8"	5'2"	Slight	3.51	3.9	38	24.2	15.1	8.1	3.13	
22	0-8"	6'2"	"	1.42	3.4	22	17.5	13.6	3.9	2.86	
23	0-8"	2'6"	"	2.14	2.9	24	31.5	23.9	7.6	2.56	
24	0-8"	2'2"	"	1.61	3.8	12	49.4	43.5	5.9	1.92	
25	0-8"	6'2"	V.slight	1.78	3.6	21	20.1	15.7	4.4	2.91	
26	0-8"	6'3"	"	1.67	4.0	13	29.8	25.8	4.0	2.84	
27	0-8"	12'2"	"	4.76	3.7	42	23.9	13.9	10.0	3.27	
28	0-8"	4'8"	Neutral	3.91	3.7	38	21.5	13.2	8.3	3.06	
29	0-8"	4'8"	"	4.66	3.2	45	22.5	12.2	10.3	2.49	
124	0-8"	2'6"	V.slight	1.36	4.6	13	23.46	19.44	4.02	3.11	.19
125	8-16"	2'6"	"	1.60	3.3	13	27.43	23.94	3.49	2.54	.15
126	0-8"	4'0"	Slight	1.02	3.3	30	12.99	9.02	3.97	2.93	.18
127	8-16"	4'0"	"	1.38	3.1	21	12.60	9.93	2.67	2.71	.19
128	0-8"	5'3"	Strong	.88	3.6	6	51.21	47.17	3.04	1.82	.25

SAMPLE 21 - Taken in northwest corner of Sec. 18. A well drained peat, used extensively for hay. It is slightly acid, high in lime, ash and nitrogen.

SAMPLE 22 - Taken 500 yards west of Blaine church and 1 rod north of Main Street road. It is covered with grass which is cut for the carpet company. Of slight acidity, low in lime, ash and nitrogen.

SAMPLE 23 - From Sec. 16. Sedges used for hay, averaging 1.5 ton per acre. Medium in lime. High in ash and low in nitrogen.

SAMPLE 24 - From the northwest corner of SW¼ Sec. 24. Vegetation consists of wire-grass, other sedges and rushes, used partly for hay, but partly forming waste land. Of slight acidity, rather low in lime, high in ash and nitrogen.

SAMPLE 25 - From Sec. 12, on Main Street road, covered with sedges and rushes. Soil too soft to utilize. Of very slight acidity, low in lime, medium in ash and low in nitrogen.

SAMPLE 26 - From Sec. 16 on Lexington Avenue road and Line road crossing. Vegetation wire-grass and other sedges used for hay. Very slightly acid and low in lime.

SAMPLE 27 - Taken in Sec. 36, 12 rods east of Lexington Avenue road and 2 rods south of Branch road. Sedges used for pasture. Well drained and well decomposed and with marly substratum. Of very slight acidity, high in lime and nitrogen.

SAMPLE 28 - Taken in southeast ¼ of Sec. 36. Sedges used for hay. Has a clay substratum. Neutral in reaction, high in lime and nitrogen.

SAMPLE 29 - From southeast corner of SE¼, Sec. 36, 2 rods

from Ramsey County line. Covered with tamarack. Neutral in reaction, well decomposed, high in lime and of medium nitrogen content.

SAMPLE 124 - Taken near Peebles' place, 250 yards north of south boundary and 150 yards east of east and west boundary of SE¼ of NE¼ - 12-31-23.

SAMPLE 125 - Second 8 inches of Sample 124.

SAMPLE 126 - Peebles' peat. Taken 150 yards south of east and west center line and south center line of SE¼ of Sec. 11-31-23.

SAMPLE 127 - Second 8 inches of Sample 126.

SAMPLE 128 - Peebles' peat taken 150 yards west of intersection of north and south ditch and east and west ditch on north center of SE¼, Sec. 11-31-23. Taken in shallow peat in pasture.

HAM LAKE TOWNSHIP

Peat covers about half of Ham Lake Township. It is quite uniform in depth, ranging from 3 to 8 feet, with an average of about 6 feet for the entire township. The substratum is everywhere a yellow sand. There are several ditches in the township but, the area being nearly level, the flow of water in these is sluggish. Coon Creek drains the marshes, all of which at one time were covered with wire-grass, but, due to the ditching, other sedges and redtop have now largely replaced this. Some tamarack swamps are found. Blueberries are found at the edge of most of the marshes and cranberries occur on some of the more acid bogs.

Chemically the peats differ widely, the extremes being shown on the one hand by the strongly acid, low lime samples, 35 and 46, both with less than 0.70 per cent CaO, and on the other by the practically neutral samples, 30 and 38, which contain over 4.0 per cent CaO. Both the latter are from areas originally covered with tamarack and both have a high nitrogen content in the organic matter, viz. 3.3 and 3.4. Of the first pair Sample 35 is from a cranberry, sphagnum, wire-grass bog and shows a low percentage of nitrogen in both the whole sample and in the volatile portion, while the other, Sample 46, is from a tamarack swamp and shows a nitrogen content similar to that of the first pair.

Table X Composition of Ham Lake peats.

Thesis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of ash soluble	Ash	Insoluble matter	Soluble ash	Nitrogen	Phosphates P_2O_5
	Inches	Ft-Ins		P.ct.	P. ct.	P.ct.	P.ct.	P. ct.	P.ct.	P. ct.	P. ct.
30	0-8"	4'8"	V.slight	4.09	3.3	49	19.3	9.9	9.4	2.66	
31	0-8"	4'2"	Slight	2.51	3.5	47	12.6	6.9	5.7	2.96	
32	0-8"	4'6"	V.slight	3.62	3.0	35	20.5	13.4	7.1	2.38	
33	0-8"	9'0"	Medium	2.12	3.8	44	16.9	9.5	7.4	3.17	
34	0-8"	5'6"	"	2.35	3.4	49	15.2	7.9	7.3	2.88	
35	0-8"	3'2"	Strong	.63	1.2	21	10.9	8.6	2.3	1.12	
36	0-8"	4'6"	V.slight	3.50	2.9	46	16.1	8.6	7.5	2.48	
37	0-8"	4'8"	Medium	1.25	3.9	23	22.4	15.1	7.3	3.04	
38	0-8"	8'6"	Neutral	4.48	3.4	61	24.9	9.6	15.3	2.56	
39	0-8"	3'6"	"	2.74	3.8	35	22.3	14.5	7.8	2.94	
40	0-8"	5'8"	Slight	2.25	3.6	30	21.9	15.2	6.7	2.80	
41	0-8"	4'8"	Medium	1.85	4.1	18	32.8	26.9	5.9	2.77	
42	0-8"	3'6"	V.slight	2.28	3.3	36	19.9	12.8	7.1	2.70	
43	0-8"	4'8"	"	3.97	3.7	40	27.8	16.7	11.1	2.70	
44	0-8"	6'4"	Medium	1.09	3.0	23	14.1	10.8	3.3	2.73	
45	0-8"	3'8"	Neutral	1.96	4.5	16	32.0	26.7	5.3	3.06	
46	0-8"	4'0"	Strong	.61	3.2	13	13.0	11.3	1.7	2.70	
47	0-8"	3'2"	Neutral	1.72	4.0	17	38.8	32.2	6.6	2.48	
48	0-8"	12'6"	Slight	2.14	3.7	44	13.0	7.2	5.7	3.26	
117	0-8"	7'6"	V.slight	1.76	3.7	37	15.38	9.57	5.8	3.22	.46
118	8-16"	7'6"	"	1.67	3.8	53	13.71	8.46	7.25	3.34	.39
119	0-8"	9'8"	"	1.83	3.8	27	14.33	10.46	3.87	3.30	.38
120	8-16"	6'8"	Neutral	2.11	3.7	41	14.29	8.42	5.87	3.42	.38
121	0-8"	5'6"	Slight	1.76	3.6	32	18.23	12.37	5.87	3.08	.38
122	8-16"	5'6"	"	1.73	2.6	38	13.60	8.32	5.28	2.30	.25
123	0-8"	4'0"	V.slight	2.86	2.9	19	42.69	34.49	8.2	2.29	.16

SAMPLE 30 - Taken one and a half miles east of Bunker Lake; covered by brush and tamaracks.

SAMPLE 31 - Taken 400 rods north of preceding from a redtop meadow.

SAMPLE 32 - From 1 mile north and 2 miles east of Andover in a redtop meadow. The average yield of hay is about 1.5 tons per acre.

SAMPLE 33 - Taken from a red-top meadow 2 miles east of Constance. There is a marly substratum.

SAMPLE 34 - From a tamarack swamp one mile southeast of Constance.

SAMPLE 35 - Taken from a cranberry bog one mile northwest of Free Mission Church. Besides the cranberries there occurs sphagnum moss and wire-grass.

SAMPLE 36 - Taken from redtop and sedge meadow half a mile west of preceding. At the time of sampling the hay had been put into 250 stacks each of 2 to 4 tons.

SAMPLE 37 - Taken from wire-grass and sedge pasture in Sec. 14.

SAMPLE 38 - Taken from redtop and sedge meadow. It has a clay loam substratum. Originally it formed a tamarack swamp, but now it produces about 1.5 tons of hay per acre.

SAMPLE 39 - Taken from a tract of sedge-covered waste.

SAMPLE 40 - Taken from the field in corn in Sec. 36, about 4 rods north of Coon Creek bridge on the Lexington road. The stalks were 6 feet high and the ears well filled on past 8 feet 8 inches deep.

SAMPLE 41 - Taken from a sedge-covered waste area on the east center line of Sec. 27.

SAMPLE 42 - Taken from a Carex wire-grass field, 4 rods east and

10 rods south of the Northwest corner of the NE¼ of Sec. 29.

SAMPLE 44 - Taken in a Carex wire-grass field, 2 rods south and 2 rods west of the northwest corner of the NE¼, Sec. 28.

SAMPLE 45 - Taken in the northwest corner of the SW¼ of Sec. 8. The vegetation consisting of wire-grass and other sedges and rushes is used partly as hay, but part of the area is waste land.

SAMPLE 46 - Taken from the tamarack swamp in Sec. 14. The peat is black and well decomposed, although low in lime and strongly acid.

SAMPLE 47 - Taken at the north end of Lexington Avenue, where it turns west toward the Oak Leaf Farm. In pasture, redtop, sedges and grasses.

SAMPLE 48 - Taken in southeast corner of SE¼ Sec. 2. Redtop grass, used for hay.

SAMPLE 117 - Taken west of Oak Leaf Farm house, 75 rods southwest of a turn in the road. Field plowed for cultivation.

SAMPLE 118 - Second 8 inches of Sample 117.

SAMPLE 119 - Taken west of Dayton's house, 500 yards southwest of turn in road, near experimental field, 50 yards east of west ditch.

SAMPLE 120 - Second 8 inches of Sample 119.

SAMPLE 121 - First 8 inches at Dayton's house, east of house 300 yards south of end of road on burned area west of northeast and southwest ditch.

SAMPLE 122 - Second 8 inches of 121.

SAMPLE 123 - Taken in SE¼ of Sec. 27 on 160 owned by H. M. Titterud.

BETHEL TOWNSHIP

In Bethel the bogs cover approximately 19 square miles and in depth range from shallow to very deep. There are two chief drainage basins, Coon Creek and Cedar Creek. Several ditches run into Coon Lake, but a large proportion of the marshes around this lake are still too wet to be used as meadows. Due to the inadequate ditching there are still many waste areas.

The substratum consists of a marly clay in the Cedar Creek basin, and of a yellow sand in the Coon Creek basin. The vegetation consists of tamarack, wire-grass, other sedges, redtop and rushes. Areas of each were sampled, as shown in Table XI The bogs at present serve as hay or wire-grass meadows.

Chemically the bogs show the same variations as those in Ham Lake. The bogs of this township vary from very strongly acid to neutral (Table XI), from .56 to 4.03 per cent CaO, from 1.8 to 20.9 per cent soluble matter and from 1.95 to 3.19 per cent nitrogen, showing as wide a variation as there is in the county.

Table XI - Composition of Bethel peats

The-sis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of ash soluble	Ash	Insoluble matter	Soluble ash	Nitrogen
	Inches	Ft. Ins.		P.ct.	P. ct.	P.ct.	P.ct.	P. ct.	P.ct.	P. ct.
49	0-8"	7'4"	Slight	2.20	3.7	38	19.1	12.5	6.6	3.05
50	0-8"	10'9"	V.slight	4.03	3.0	69	30.3	4.4	20.9	1.95
51	0-8"	8'6"	V.strong	.56	3.2	14	12.8	11.0	1.8	2.80
52	0-8"	6'6"	Neutral	3.22	3.6	40	20.9	12.5	8.5	2.87
53	0-8"	8'6"	V.slight	2.68	3.5	42	15.7	9.0	6.7	2.99
54	0-8"	6'4"	"	2.26	3.6	43	11.4	6.5	4.9	3.19
55	0-8"	4'6"	Medium	2.07	2.3	27	13.7	10.0	3.7	2.00

SAMPLE 49 - Taken from a sedge and redtop meadow on Cedar Creek, half a mile south of Cedar. A well decomposed peat with a marl-substratum. The center of the bog is too wet to permit of cutting.

SAMPLE 50 - Taken from an open tamarack swamp pasture one mile south of Bethel. The substratum consists of clay.

SAMPLE 51 - Taken one mile north of the Swedish church and three-fourths of a mile southwest of Rice arm of Coon Creek from a cranberry-sphagnum bog with a scattered growth of small tamaracks, now simply a waste tract. Chemically it is somewhat similar to the two low-lime peats from Ham Lake township, resembling Sample 35 in vegetation in part and Sample 46 in nitrogen content and partly in vegetation.

SAMPLE 52 - Taken from a good sedge and redtop meadow three and a half miles north of the Free Mission church, the average yield of hay approaching 2 tons per acre. The substratum consists of marly clay.

SAMPLE 53 - Taken from a dense tamarack fringe surrounding the bog from which 51 was taken. It has a marl substratum. It differs radically in composition from 51, carrying over 4 times as much lime.

SAMPLE 54 - Taken from a Carex wire-grass meadow one mile west of center of Rice Lake. It was formerly a tamarack swamp.

SAMPLE 55 - Taken from a poorly drained brush swamp, one and a half miles west of the center of Fish Lake, and three-fourths of a mile south of the Isanti County line.

LINWOOD TOWNSHIP

Linwood has a peat area of 18 square miles, or 50 per cent of its surface. This area is over-grown with wire-grass, other sedges and redtop in the proportions given in Table III and as shown on Map 8. The substratum is largely yellow sand, with the exception of a few square miles around Typo Lake. These bogs are used as meadows or for carpet grass. The drainage conditions are poor.

The chemical analyses of these marshes are reported in Table XII. The samples vary from very slight to strong acidity, and from a lime content of 1.44 to one of 2.32 per cent, which is decidedly low, compared with the peats from the other townships.

Table XII Composition of Linwood peats

The-sis No.	Section sampled: Inches	Depth: Ft-Ins	Acidity	Lime: CaO: P.ct	N in organic matter: P. ct.	Proportion of ash soluble: P.ct.	Ash: P.ct	Insoluble matter: P. ct.	Soluble ash: P.ct.	Nitrogen: P. ct.
56	0-8"	5'4"	V. slight	1.75	3.2	37	13.1	8.2	4.9	2.76
57	0-8"	10'6"	"	2.32	3.3	33	18.0	11.9	6.1	2.73
58	0-8"	11'6"	Slight	1.62	4.0	16	27.9	23.4	4.5	2.87
59	0-8"	4'2"	"	2.22	3.4	47	12.6	6.9	5.7	2.96
60	0-8"	6'2"	Medium	1.44	4.0	32	15.1	10.3	4.8	3.43
61	0-8"	7'8"	Strong	1.24	3.1	26	13.5	9.9	2.6	2.72

SAMPLE 56 - Taken one mile east of the south side of Fish Lake. Vegetation consists of sedges and especially wire-grass. These are used for hay and give an average yield of 1.5 tons per acre.

SAMPLE 57 - Taken one mile southwest of Typo Lake from a red-top meadow, with a marlish clay substratum.

SAMPLE 58 - Taken a quarter of a mile south of Long Lake from a wire-grass swamp too wet to cut.

SAMPLE 59 - Taken two miles east of Little Tamarack Lake. The covering of wire-grass, used for carpet manufacture, averages one ton per acre.

SAMPLE 60 - Taken four miles west of Wyoming and 3 miles east of Rice Lake, from the heart of a wire-grass swamp. At the time of sampling the wire-grass was being cut for the Crex Carpet Company, and averaged 1.5 tons per acre.

SAMPLE 61 - Taken one mile west of Sample 60 from a tamarack swamp with wire-grass in the open places.

COLUMBUS TOWNSHIP

The largest area of peat in the county is found in this township, 34 of its 48 square miles of surface being peat covered. Of this 23 square miles are in wire-grass marshes and the remainder in sedges and tamarack.

The depth of the bogs in this township is quite uniform, averaging from 6 to 7 feet, although many in places are 11 and 12 feet. The substratum is mainly of yellow sand, except in the southeast corner, where it is formed by marl and clay. The drainage is on the whole poor and immense areas of waste land occur.

The chemical composition of these samples is given in Table XIII. In acidity, lime content, ash, solubility of ash and soluble matter they vary from one extreme to the other.

Table XIII - Composition of Columbus peats.

Thesis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of ash soluble	Ash	Insoluble matter	Soluble ash	Nitrogen
	Inches	Ft-Ins		P.ct.	P. ct.	P.ct.	P.ct.	P. ct.	P.ct.	P. ct.
62	0-8"	5'2"	Neutral	3.89	3.5	64	35.2	12.4	22.8	2.96
63	0-8"	6'4"	Strong	1.37	3.9	32	13.0	8.8	4.2	3.38
64	0-8"	6'8"	V.slight	2.00	3.8	37	13.0	8.1	4.9	3.30
65	0-8"	6'6"	Neutral	1.90	3.5	40	13.5	8.3	5.2	3.04
66	0-8"	3'6"	V.slight	1.43	3.9	32	15.3	10.4	4.9	3.30
67	0-8"	4'8"	Slight	1.42	3.4	30	14.5	10.2	4.3	2.94
68	0-8"	4'8"	Medium	2.49	3.9	45	15.6	8.5	7.1	2.23
69	0-8"	11'6"	V.slight	4.00	2.8	54	14.6	6.7	7.9	2.23
70	0-8"	15'6"	Neutral	5.05	2.6	53	18.3	8.5	9.8	2.16
71	0-8"	8'6"	V.slight	2.11	3.2	41	13.2	7.7	5.5	2.74
72	0-8"	11'0"	Neutral	4.87	3.0	68	14.7	4.4	9.7	2.58
73	0-8"	8'6"	Neutral	4.83	3.7	40	23.8	14.3	9.5	2.85

SAMPLE 62 - Taken 2 miles south and 2 miles west of Wyoming, on the edge of a wire-grass marsh, covered with tamarack and brush.

SAMPLE 63 - Taken a quarter of a mile southwest of Little Coon Lake from a wire-grass marsh. The vegetation consists of mixed wire-grass and redtop and is used as meadow.

SAMPLE 64 - Half a mile north of District School No. 68. Vegetation consists of wire-grass, which is cut for the Crex Carpet Company.

SAMPLE 65 - From the northwest corner of NE¼ of Sec. 18, Twp. 32. Vegetation and use the same as the preceding.

SAMPLE 66 - 440 yards south of Camp 3 House on section line. Vegetation and use the same as the preceding.

SAMPLE 67 - From center of section line on the west side of Section 30. Vegetation and use the same as the preceding.

SAMPLE 68 - Taken in the northwest corner of SW¼ of NW¼ of Sec. 32, one rod north of the ditch and 2 rods west of the road. The vegetation consists of sedges and is used as meadow.

SAMPLE 69 - Taken 40 rods north and 12 rods west of southeast corner of SE¼ of Sec. 13. It is covered by a dense growth of tamaracks.

SAMPLE 70 - Taken 20 rods east and 2 rods south of northwest corner of NE¼ of Sec. 22. Vegetation consists of dense growth of tamarack. The substratum consists of a calcareous clay.

SAMPLE 71 - Taken 120 rods east of the southwest corner of SW¼ of Sec. 9, Centerville township, covered by tamaracks mixed with brush.

SAMPLE 72 - Taken on northeast corner of NE¼ of Section 33 in a dense growth of tamaracks. It has a marl substratum.

SAMPLE 73 - Taken 4 rods north and 15 rods east of southwest corner of SE¼, Sec. 35. Vegetation consists of mixture of wild rice, bull rushes and tamaracks.

CENTERVILLE TOWNSHIP

The bogs in this township cover about 13 square miles, are large and underlaid with a clay or marly substratum. They are, in general, better decomposed, or of a more mucky nature, than those in the other townships. Drainage has not been carried out very extensively. So a large number of the marshes are too wet for utilization. The whole area is drained by Rice Creek which is shallow and sluggish, running through large marshes. The peat, as a rule, is deep. The numerous lakes of this township are usually situated near the center of peat areas, the edges of which are over-grown with flags, wild rice and rushes. Redtop and sedges, which form the chief vegetation, are utilized as hay. Tamarack which occurs extensively is used for posts and building material.

The analyses are reported in Table XIV.

It will be seen that the peats from this township vary in lime content and acidity from very low to very high, with a fairly high ash content, with great variations in solubility of the ash and in the nitrogen. As a good illustration of the variation in composition within even the same marsh, we may refer to the data, given in the table on samples 83 and 84. The former from near the edge of a small bog and 84 from its center. The one is very strongly acid, while the other is only slightly acid.

In lime content they differ markedly.

Table XIV - Composition of Centerville peats.

Thesis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of ash soluble	Ash	Insoluble matter	Soluble ash	Nitrogen
	Inches	Ft.-In.		P.ct.	P. ct.	P.ct.	P.ct.	P.ct.	P.ct.	P. ct.
74	0-8"	8'6"	Neutral	4.73	2.9	56	18.5	8.1	10.4	2.38
75	0-8"	8'2"	V.slight	3.58	3.6	44	17.2	9.6	7.6	2.99
76	0-8"	2'6"	Slight	1.29	4.3	6	58.6	54.8	3.8	1.78
77	0-8"	4'8"	V.slight	3.35	3.2	47	16.5	8.8	7.7	2.63
78	0-8"	3'6"	Neutral	2.99	3.4	21	23.6	14.5	9.1	2.65
79	0-8"	15'6"	V.slight	1.98	3.3	42	11.3	6.5	4.8	2.96
80	0-8"	11'0"	V.slight	2.29	3.2	32	21.2	14.4	6.8	2.59
81	0-8"	11'6"	Neutral	1.59	4.2	19	29.9	24.1	5.8	3.05
82	0-8"	10'6"	V.slight	1.04	2.6	42	8.0	4.6	3.4	2.47
83	0-8"	8'6"	V.slight	.93	2.6	19	12.9	10.4	2.5	2.25
84	0-8"	10'0"	slight	2.73	3.9	30	22.4	15.7	6.7	3.09

SAMPLE 74 - Taken 120 rods east of the southwest corner of the SW¼ of Sec. 9 on a bog covered with a dense tamarack growth on the shore of George Patch Lake. Some willow and poplar brush are found along the edge of the swamp.

SAMPLE 75 - Taken 400 rods from the southwest corner of Lake Traverse, 25 rods east of the State road and 2 rods south of Branch road. Dense tamarack growth. Substratum marly clay.

SAMPLE 76 - Taken on the shore of Lake Traverse, 40 rods east and 20 rods south of the northwest corner of the NW¼ of Sec. 30. Vegetation consists chiefly of sedges used as meadow.

SAMPLE 77 - Taken 12 rods south of the northwest corner of the NW¼ Sec. 32. Sedges cut for hay, averaging 1 ton per acre.

SAMPLE 78 - Taken 2 rods west and 10 rods north of the southeast corner of the SE¼, Sec. 28. Coarse and fine sedges, used for hay, averaging 1.5 tons per acre.

SAMPLE 79 - Taken in the southeast corner of the SW¼ of Sec. 33. This is in the bed of the old Cedar Lake. The peat is soft and well decomposed. Covered with sedges and rushes and forming only waste land.

SAMPLE 80 - Taken at the northeast corner of the SW¼ of SW¼, Sec. 26. Sedges cut for hay.

SAMPLE 81 - Taken in southeast corner of NW¼ of SE¼, Sec. 35. Part of bed of old Lake Amelia, covered with bull rushes, flags and sedges. Too soft for use. Soil being well decomposed and soft is covered by a crust-like sod which is dangerous to walk upon. Substratum a marly clay.

SAMPLE 82 - Taken at the upper end of old Lake Amelia. Covered by rushes and sedges, with a fringe of tamarack and forming

waste land.

SAMPLE 83 - Taken 10 rods north and 6 rods west of northeast corner of SE¼, Sec. 35. The vegetation consists of wire-grass and other sedges and is used for pasture. The substratum consists of a reddish gravel.

SAMPLE 84 - Taken 15 rods east and 8 rods south of northwest corner of SE¼ of Sec. 36. Sedge grasses cut as hay yield about a ton per acre.

GROW TOWNSHIP

The peat areas in Grow cover about 7 square miles, drained by 2 creeks into the Rum River. In depth the peat varies from shallow to very deep, the substratum under part being yellow sand and under the rest clay or marl. The vegetation consists of sedges, redtop, rushes and tamarack.

These peats all appear well supplied with lime and in general are quite uniform.

Table XV - Composition of Grow peats

Thesis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of ash soluble	Ash	Insoluble matter	Soluble ash	Nitrogen
	Inches	Ft.-Ins.		P.ct.	P. ct.	P.ct.	P.ct.	P. ct.	P.ct.	P.ct.
85	0-8"	12'6"	Neutral	2.78	3.8	34	22.4	14.8	7.6	2.99
86	0-8"	6'7"	Slight	4.16	3.4	33	23.6	15.7	7.9	2.65
87	0-8"	2'6"	"	2.22	3.7	29	23.5	16.6	6.9	2.81
88	0-8"	6'8"	Slight	2.57	3.1	33	21.7	14.4	7.3	2.47
89	0-8"	7'6"	Slight	1.95	3.5	16	29.9	25.2	4.7	2.51
90	0-8"	3'2"	"	2.44	3.8	43	37.3	21.1	16.2	2.38

SAMPLE 85 - Taken from southeast corner of NW¼, Sec. 4, Anoka Twp. It is an old tamarack swamp, now occupied by a sedge meadow, that yields about 1 ton of hay per acre.

SAMPLE 86 - From the northeast corner of the NW¼ of Sec. 28. Waste land occupied by tamarack, elder, willows, dogwood and sedge.

SAMPLE 87 - From the sedge and redtop meadow on the northeast corner of NW¼, Sec. 22, 6 rods east of the ditch.

SAMPLE 88 - Taken in the southwest corner of NE¼ of NE¼, Sec. 15. Vegetation consists of tamarack and brush, but on part these have been removed and the land used as meadow.

SAMPLE 89 - From a sedge meadow on the northeast corner of NE¼, Sec. 16. It was formerly a tamarack swamp.

SAMPLE 90 - From a well drained sedge meadow on the NE¼ of Sec. 7, 10 rods west of the ditch.

RAMSEY TOWNSHIP

Ramsey has a peat area of about 2 square miles underlaid chiefly with black sand, marl or clay and occupied by sedges and redtop. Part of the area is very wet and overgrown with flags and rushes, while a few small areas of tamarack are found in the northern part of the township. Trott Brook drains most of the bogs which are used as meadows. A few isolated bogs are scattered throughout the township, usually too wet for any use.

All the samples are well supplied with lime and are high in nitrogen.

Table XVI - Composition of Ramsey peats.

Thesis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of ash soluble	Ash	Insoluble matter	Soluble ash	Nitrogen
	Inches	Ft-Ins		P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.
91	0-8"	4'8"	Slight	2.67	3.7	21	27.9	22.1	5.8	2.69
92	0-8"	6'4"	"	3.04	3.7	40	22.2	13.3	8.9	2.89
93	0-8"	3'8"	"	4.01	3.4	42	26.6	15.2	11.4	2.53
94	0-8"	8'2"	Vslight	3.34	3.8	48	18.0	8.6	9.4	3.17
95	0-8"	6'2"	"	2.85	3.6	46	32.0	17.1	14.9	2.45
96	0-8"	10'6"	neutral	1.85	3.2	19	25.5	20.5	5.0	2.45

SAMPLE 91 - Taken one mile northwest of Jackson Lake where the peat is 4 feet 8 inches deep with a sandy black subsoil. The yield of hay from the redtop and sedge meadows avarages 1.5 tons per acre. The peat is well decomposed.

SAMPLE 92 - Taken from a redtop meadow at Trott Brook, 4 miles west of the Rum River, where the peat is 6 feet deep and underlaid by marl.

SAMPLE 93 - Taken from the old lake bed north of Dayton station. This bog, which is low and not drained is very soft, and covered with flags and rushes, and is a waste, except the edges, which are used as meadow. The peat, 3 feet 8 inches deep, has a sandy substratum.

SAMPLE 94 - Taken from a redtop meadow at Trott Brook on the western boundary of the county. The peat is 8 feet deep with a marly subsoil.

SAMPLE 95 - Taken from an old tamarack swamp in the northwest corner of the township, that has been cleared and is now used as pasture and meadow. It is covered with redtop and sedges.

SAMPLE 96 - From a meadow, formerly a tamarack swamp, on the line north of the center of Sec. 4. The peat is 10 feet deep with a marly substratum.

The chemical analyses of these samples are shown in Table XVI. As a whole these peats rank high in lime content, ash and total ash soluble. The nitrogen content is uniform and rather medium in amount.

BURNS TOWNSHIP

Burns township, has approximately 7 square miles of peat land, drained by Trott and Seely Brooks into the Rum River. The larger bogs drain into Pickeral and Goose Lakes, are rather low and poorly drained. The ditching system, while quite extensive is not sufficient to properly carry off the water.

These marshes are underlaid with a black sandy substratum with some marl at the southern side of the township.

The common vegetation is redtop, 2.5 square miles, sedge grass 1, tamarack 1.5 and brush 1 square mile.

These marshes are used chiefly as meadows, but the larger areas are still waste owing to the wet condition and to the presence of tamarack and brush. There are only a very few of the small isolated bogs.

All of the samples are high in nitrogen and, except 99 and 103, high in lime. These two show only a slightly acid reaction and are on the doubtful line in so far as the lime supply is concerned.

Table XVII - Composition of Burns peats.

Thesis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of ash soluble	Ash	Insoluble Matter	Soluble ash	Nitrogen
	Inches	Ft-Ins		P.ct	P. ct.	P.ct.	P.ct	P. ct.	P.ct.	P. ct.
97	0-8"	10'6"	Neutral	2.70	3.2	54	11.3	5.2	6.1	2.95
98	0-8"	9'2"	Slight	4.11	3.2	41	23.9	13.1	10.8	2.46
99	0-8"	4'8"	V.slight	1.55	3.1	27	14.1	10.2	3.9	2.80
100	0-8"	9'2"	Neutral	2.51	3.8	50	13.2	6.5	6.7	3.26
101	0-8"	3'6"	"	2.45	3.1	35	13.6	8.8	4.8	2.70
102	0-8"	5'6"	"	2.95	4.5	60	23.6	9.9	13.7	3.51
103	0-8"	9'2"	Slight	1.54	3.4	17	27.5	22.7	4.8	2.53

SAMPLE 97 - Taken from the tamarack fringe of a redtop meadow, with an average yield of 1.5 tons of hay, 2 miles south of Nowthen. The bog is 10 feet deep with a marly substratum.

SAMPLE 98 - Taken from the tamarack swamp 1 mile west of Rum River and 1¼ miles north of the south township line. The peat is 9 feet deep, and has a black sandy substratum.

SAMPLE 99 - Taken half a mile southwest of Nowthen, where the peat was 4 feet deep, had a sandy substratum and was covered with redtop and wire-grass, used for hay. The drainage was good.

Sample 100 - Taken just north of Pickeral Lake. The peat was 9 feet deep with vegetation of wire-grass, other sedges and redtop, part being used for hay, part for pasture, but part being still a waste due to the poor drainage.

SAMPLE 101 - Taken in the large bog half a mile west of Goose Lake, all of which at once time was part of Goose Lake. The peat is well decomposed, has a marly substrarum and is covered with wire-grass and rushes. It is still a waste, except on the edges which are used as meadow.

SAMPLE 102 - Taken three-quarters of a mile west of Norris Lake from an area covered with sedges and tamarack, still chiefly waste land. The peat is poorly decomposed.

SAMPLE 103 - Taken 2 miles west of the Apostles'Mission Church, where the peat is 9 feet deep and grown over with tamarack and sedges. It is used as pasture.

OAK GROVE TOWNSHIP

All of the bogs of Oak Grove, covering approximately 4.5 square miles, are drained by Cedar Creek. The drainage is not good and only a few ditches have been dug, all emptying into Cedar Creek. A few small bogs in this township that have no outlet, are usually low, wet and not utilized. The bogs along Cedar Creek itself have a clay or marly substratum, while the others are underlain by a yellow sand. The vegetation is similar to that in Grow Township.

The samples collected here are similar in composition to those from Grow.

Table XVIII - . Composition of Oak Grove peats

Thesis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of ash soluble	Ash	Insoluble matter	Soluble ash	Nitrogen
	Inches	Ft. Ins.		P.ct.	P. ct.	P.ct.	P.ct.	P. ct.	P.ct.	P. ct.
104	0-8"	7'4"	Slight	2.54	4.1	48	16.3	8.5	7.8	3.46
105	0-8"	1'4"	Strong	1.74	3.8	23	48.4	37.2	11.2	1.99
106	0-8"	6'6"	V.slight	2.69	3.6	51	18.1	9.8	8.3	2.97

SAMPLE 104 - Taken half a mile north of the south township line one-half a mile east of the Rum River, near Cedar Creek. Peat was mucky and center of bog soft. Marl subsoil, redtop and sedge grass which was cut for hay. 140 stacks in this area averaging 1.5 ton per acre. Slight acidity, high lime, high solubility and nitrogen. Bog needs more adequate drainage.

SAMPLE 105 - Taken 1 mile west of Cedar, is shallow, well decomposed peat. Low lime, strong acidity. Too wet for use. Sedges and willows are the chief vegetation. Some of the bog is used for hay. Has inadequate drainage.

SAMPLE 106 - Taken 2 miles northeast of Lake George. Bog is wet, used for pasture, has wire-grass and sedge grass and also a tamarack fringe around the bog. Shows slight acidity, high lime, medium ash and soluble ash with high nitrogen content.

The chemical analyses of these samples is found in Table XVIII.

ST. FRANCIS TOWNSHIP

In St. Francis township peat covers only about 2.5 square miles. The area west of the Rum River is drained by Seely Brook, and that on the east by Cedar Creek. Drainage is extensive, except in the case of the few small, isolated bogs scattered throughout the township. The vegetation consists chiefly of redtop and tamarack with some brush areas.

Table XIX - Composition of St. Francis peats.

Thesis No.	Section sampled	Depth	Acidity	Lime CaO	N in organic matter	Proportion of soluble ash	Ash	Insoluble matter	Soluble ash	Nitrogen
	Inches	Ft.-In.		P.ct.	P. ct.	P.ct.	P.ct.	P. ct.	P.ct.	P. ct.
107	0-8"	1'6"	Slight	2.27	3.6	38	15.4	9.5	5.9	3.07
108	0-8"	15'6"	"	2.19	3.5	55	18.3	10.1	10.1	2.87

The two samples taken are both high in lime and nitrogen.

SAMPLE 107 - Taken 1 mile northwest of Bethel on the county line, where the peat is 18 inches deep and covered by a redtop meadow yielding 1 ton per acre. At the time the samples were taken there were 200 stacks of hay to be seen here, they averaging 2 tons per stack.

SAMPLE 108 - Taken 1 mile north of District School No. 18, near the Isanti County line. The bog, now a redtop meadow, was formerly a tamarack swamp. The average yield of hay is about 1.5 tons per acre.

RELATION OF COMPOSITION OF PEATS TO THEIR CONTENT OF LIME AND DEGREE OF ACIDITY

In Table XX the data are arranged to show the dependence of the acidity, nitrogen content, etc. upon the amount of lime. In Table XXI the data are rearranged to show the dependence of the various constituents upon the degree of acidity as determined by the Truog method.

The composition is shown also on Maps 19 to 39 on which the different constituents are shown separately, thus permitting to be seen whether the differences in composition are due to the geographical location.

Table xx - Chemical composition of the samples, arranged in order to show the relation of the lime to that of acidity, nitrogen content, etc.

The-sis No.	Lime (CaO)	Acidity	Nitrogen	Total ash soluble	Ash	Insoluble matter	Soluble matter	Nitrogen in volatile matter
	P.ct.		P. ct.	P.ct.	P.ct.	P. ct.	P.ct.	P. ct.
51	.56	V. strong	2.80	14	12.8	11.0	1.8	3.2
46	.61	Strong	2.76	13	13.0	11.3	1.7	3.2
35	.68	"	1.12	21	10.9	8.6	2.3	1.2
83	.93	V. strong	2.25	19	12.9	10.4	2.5	2.6
82	1.04	V. slight	2.47	42	8.0	4.6	3.4	2.6
44	1.09	Medium	2.73	23	14.1	10.8	3.3	3.0
14	1.24	Strong	2.30	12	51.2	44.3	6.9	4.9
61	1.24	"	2.72	26	13.5	9.9	3.6	3.1
37	1.25	Medium	3.04	32	22.4	15.1	7.3	3.9
76	1.29	Slight	1.78	6	58.6	54.8	3.8	4.3
63	1.37	Strong	3.38	32	13.0	8.8	4.2	3.9
22	1.42	Slight	2.86	22	17.5	13.6	3.9	3.4
67	1.42	"	2.94	30	14.5	10.2	4.3	3.4
56	1.43	V. slight	3.30	32	15.3	10.4	4.9	3.9
60	1.44	Medium	3.43	32	15.1	10.3	4.8	4.0
103	1.54	Slight	2.53	17	27.5	22.7	4.8	3.4
99	1.55	V. slight	2.80	27	14.1	10.2	3.9	3.1
81	1.59	Neutral	3.05	19	29.9	24.1	5.8	4.2
24	1.61	Slight	1.92	12	49.4	43.6	5.9	3.8
58	1.63	"	2.87	16	27.9	23.4	4.5	4.0
26	1.67	V. slight	2.84	13	29.8	25.8	4.0	4.0
18	1.70	Slight	2.71	31	14.3	9.9	4.4	3.2
47	1.72	Neutral	2.48	17	38.8	32.2	6.6	4.0
106	1.74	Strong	1.99	23	48.4	37.2	11.2	3.8
86	1.75	V. slight	2.76	37	12.1	8.2	4.9	3.2
25	1.78	"	2.91	21	20.1	15.7	4.4	3.6
41	1.85	Medium	2.77	18	32.8	26.9	5.9	4.1
96	1.85	Neutral	2.45	19	25.5	20.5	5.0	3.8
6	1.97	Medium	3.11	31	22.8	15.6	7.2	4.0
65	1.90	Neutral	3.04	40	18.5	8.3	5.2	3.5
2	1.94	Medium	2.48	16	32.1	26.8	5.3	3.6
89	1.95	V. slight	2.81	16	29.9	25.2	4.7	3.5
45	1.96	Neutral	3.06	18	32.0	26.7	5.3	4.5
1	1.98	Medium	3.04	41	17.6	10.4	7.2	3.7
79	1.98	V. slight	2.96	42	11.3	6.5	4.8	3.5
64	2.00	"	3.30	37	13.0	9.1	4.9	3.6
55	2.07	Medium	2.00	27	13.7	10.0	3.7	2.3
71	2.11	V. slight	2.74	41	13.2	7.7	5.5	3.2
33	2.12	Medium	3.17	44	16.9	9.5	7.4	3.8
23	2.14	Slight	2.56	24	31.5	23.9	7.6	2.9
48	2.14	"	3.25	44	13.0	7.3	5.7	3.7
108	2.19	"	2.87	55	18.3	8.2	10.1	3.6
49	2.20	"	3.05	38	19.1	12.5	6.6	3.7
59	2.22	"	2.96	47	12.6	6.9	5.7	3.4
87	2.22	V. slight	2.81	29	23.5	16.6	6.9	3.7
40	2.25	slight	2.80	30	21.9	15.2	6.7	3.6
54	2.26	V. slight	3.19	45	11.4	6.5	4.9	3.6
107	2.27	Slight	3.07	38	15.4	9.6	5.9	3.6
42	2.28	V. slight	2.70	36	19.9	12.8	7.1	3.3
80	2.28	"	2.59	32	21.2	14.4	6.8	3.2
57	2.32	"	2.73	33	18.0	11.9	6.1	3.3

Table XX - (Continued)

The-sis No.	Lime (CaO)	Acidity	Nitrogen	Total ash solu-ble	Ash	Insoluble matter	Soluble matter	Nitrogen in vola-tile matter
	P.ct.		P. ct.	P.ct.	P.ct.	P. ct.	P. ct.	P. ct.
34	2.35	Medium	2.88	49	15.2	7.9	7.9	3.4
90	2.44	V. slight	2.38	43	37.3	21.1	16.2	3.8
101	2.45	Neutral	2.70	35	13.6	8.8	4.8	3.1
3	2.48	Medium	2.93	35	22.5	14.5	8.0	3.4
68	2.49	"	3.23	45	15.6	8.5	7.1	3.9
100	2.51	Neutral	3.26	50	13.2	6.5	6.7	3.8
4	2.54	V. slight	2.66	57	25.3	10.9	14.4	3.5
104	2.54	Slight	3.46	48	16.3	8.5	7.8	4.1
88	2.57	"	2.47	33	21.7	14.4	7.3	3.1
13	2.58	Medium	2.64	30	27.0	16.4	10.6	3.4
31	2.59	Slight	2.96	47	12.6	6.9	5.7	3.5
91	2.67	"	2.69	21	27.9	22.1	5.8	3.7
53	2.68	V. slight	2.99	42	15.7	9.0	6.7	3.5
106	2.69	"	2.97	51	18.1	9.8	8.3	3.6
97	2.70	Neutral	2.95	54	11.3	5.2	6.1	3.2
84	2.73	Slight	3.09	30	22.4	15.7	6.7	3.9
39	2.74	Neutral	2.94	35	22.3	14.5	7.8	3.8
85	2.78	"	2.99	34	22.4	14.8	7.6	3.8
20	2.82	V. slight	3.46	45	14.5	8.0	6.5	4.0
95	2.85	"	2.45	46	32.0	17.1	14.9	3.6
9	2.90	Slight	3.02	11	20.6	17.3	3.3	3.9
102	2.95	Neutral	3.51	60	23.6	9.9	13.7	4.5
16	2.99	Medium	2.95	44	19.3	10.8	8.5	3.6
78	2.99	Neutral	2.65	21	23.6	14.5	9.1	3.4
12	3.01	"	2.92	30	18.5	13.1	5.4	3.5
92	3.04	Slight	2.89	40	22.2	13.3	8.9	3.7
10	3.08	"	2.89	32	20.3	13.8	6.5	3.6
8	3.19	"	2.50	50	26.8	13.1	13.7	3.4
15	3.21	"	2.96	36	24.6	15.6	9.0	3.9
52	3.22	Neutral	2.87	40	20.9	12.5	8.5	3.6
94	3.34	V. slight	3.17	48	18.0	9.4	8.6	3.8
77	3.35	"	2.63	47	16.5	8.8	7.7	3.2
6	3.50	Slight	3.08	32	27.5	17.7	9.8	4.1
36	3.50	V. slight	2.48	46	16.1	8.6	7.5	2.9
21	3.51	Slight	3.13	38	21.2	13.1	8.1	3.9
11	3.55	Neutral	2.28	38	25.5	15.7	9.8	3.0
75	3.58	V. slight	2.99	44	17.2	9.6	7.6	3.6
32	3.62	"	2.38	35	20.5	13.4	7.1	3.0
62	3.89	Neutral	2.96	64	35.2	12.4	22.8	3.5
28	3.91	"	3.05	38	21.5	13.2	8.3	3.7
17	3.94	V. slight	2.78	32	30.3	20.4	9.9	3.9
43	3.97	"	2.70	40	27.8	16.7	11.1	3.7
69	4.00	"	2.23	54	14.6	6.7	7.9	2.8
93	4.01	Slight	2.53	42	26.6	15.2	11.4	3.4
50	4.03	V. slight	1.95	69	30.3	9.4	20.9	3.0
30	4.09	"	2.66	49	19.3	9.9	9.4	3.3
98	4.11	Slight	2.46	41	23.9	13.1	10.8	3.2
7	4.13	V. slight	3.01	34	18.5	12.2	6.3	3.7
86	4.16	"	2.65	33	23.6	15.7	7.9	3.4
38	4.48	Neutral	2.56	61	24.9	9.6	15.3	3.4
19	4.51	"	2.43	43	22.7	12.8	9.9	3.2
29	4.66	"	2.49	45	22.5	12.2	10.3	3.2
74	4.73	"	2.38	56	18.5	8.1	10.4	2.9

Table XX - (Continued)

Thesis No.	Lime (CaO)	Acidity	Nitrogen	Total ash soluble	Ash	Insoluble matter	Soluble matter	Nitrogen in volatile matter
	P.ct.		P. ct.	P.ct.	P.ct.	P. ct.	P.ct.	P. ct.
74	4.76	V. slight	3.27	42	23.9	13.9	10.0	3.7
73	4.83	Neutral	2.85	40	23.8	14.3	9.5	3.7
72	4.87	"	2.58	68	14.1	4.4	9.7	3.0
70	5.05	"	2.16	53	18.3	8.5	9.8	2.6

Table XXI - Chemical composition showing the data rearranged to show the relation of the lime, etc. to the degree of acidity indicated by the Truog test.

The-sis No.	Acidity	Lime (CaO)	Nitrogen in volatile matter	Total ash solu-ble	Ash	Insoluble matter	Soluble matter	Nitrogen
		P.ct.	P. ct.	P.ct.	P.ct.	P. ct.	P. ct.	P. ct.
61	V. strong	.56	3.2	14	12.8	11.0	1.8	2.80
83	"	.93	2.6	19	12.9	10.4	2.5	2.25
45	Strong	.61	2.2	13	13.0	11.3	1.7	2.76
35	"	.63	1.2	21	10.9	8.6	2.3	1.12
14	"	1.24	4.9	12	51.2	44.3	6.9	2.30
61	"	1.84	3.1	26	13.5	9.9	2.6	2.72
63	"	1.37	3.9	32	13.0	8.8	4.2	3.38
105	"	1.74	3.8	33	48.4	37.2	11.2	1.99
44	Medium	1.09	3.0	23	14.1	10.8	3.3	2.73
37	"	1.25	3.9	32	22.4	16.1	7.3	3.04
60	"	1.44	4.0	32	15.1	10.3	4.8	3.43
41	"	1.85	4.1	18	32.8	26.9	5.9	2.77
5	"	1.97	4.0	31	22.9	15.6	7.2	3.11
2	"	1.94	3.6	16	32.1	26.8	5.3	2.48
1	"	1.98	3.7	41	17.6	10.4	7.2	3.04
56	"	2.07	2.3	27	13.7	10.0	3.7	2.00
33	"	2.12	3.8	44	16.9	9.8	7.4	3.17
34	"	2.36	3.4	49	15.2	7.9	7.3	2.88
3	"	2.48	3.4	35	22.5	14.5	8.0	2.93
68	"	2.49	3.9	45	15.6	8.5	7.1	3.23
15	"	2.68	3.4	30	27.0	16.4	10.6	3.64
16	"	2.99	3.6	44	19.3	10.8	8.5	2.95
76	Slight	1.29	4.3	6	58.6	54.8	3.8	1.78
22	"	1.42	3.4	22	17.8	13.6	3.9	2.86
67	"	1.42	3.4	30	14.5	10.2	4.3	2.83
103	"	1.54	3.4	17	27.5	22.7	4.8	2.83
24	"	1.61	3.8	12	49.4	43.5	5.9	1.92
56	"	1.63	4.0	16	27.9	23.4	4.5	2.87
18	"	1.70	3.2	31	14.3	9.9	4.4	2.71
23	"	2.14	3.9	24	31.8	23.9	7.6	2.56
48	"	2.14	3.7	44	13.0	7.2	5.7	3.26
108	"	2.19	3.5	55	18.3	8.2	10.1	2.97
49	"	2.20	3.7	38	19.1	13.5	5.6	3.08
59	"	2.28	3.4	47	12.6	6.9	5.7	2.96
40	"	2.26	3.6	30	31.9	15.2	5.7	2.80
107	"	2.27	3.6	36	15.4	9.2	6.9	3.07
104	"	2.54	4.1	48	16.3	8.5	7.8	3.46
88	"	2.57	3.1	33	21.7	14.4	7.3	2.47
31	"	2.61	3.5	47	12.6	6.9	5.7	2.96
91	"	2.67	3.7	21	27.9	22.1	5.8	2.69
84	"	2.73	3.9	30	22.4	15.7	6.7	3.09
9	"	2.90	3.9	11	20.6	17.3	3.3	3.02
93	"	3.04	3.7	40	22.2	13.3	8.9	2.89
10	"	3.08	3.6	32	20.3	13.8	6.5	2.89
8	"	3.19	3.4	50	26.8	13.1	13.7	2.50
15	"	3.21	3.9	36	24.6	15.6	9.0	2.96
6	"	3.80	4.1	38	27.5	17.7	9.8	3.08
21	"	3.81	3.9	38	21.2	13.1	8.1	3.13
93	"	4.01	3.4	42	26.6	15.2	11.4	2.52
98	"	4.11	3.2	41	23.9	13.1	10.8	2.46

Table XXI - (Continued)

Thesis No.	Acidity	Lime (CaO)	Nitrogen in volatile matter	Total ash soluble	Ash	Insoluble matter	Soluble matter	Nitrogen
		P.ct.	P. ct.	P.ct.	P.ct.	P.ct.	P.ct.	P. ct.
93	V. slight	1.04	3.6	42	8.0	4.6	3.4	3.47
66	"	1.43	3.9	32	15.3	10.4	4.9	3.30
99	"	1.55	3.1	27	14.1	10.2	3.9	3.89
26	"	1.67	4.0	13	29.8	25.9	4.0	3.84
56	"	1.75	3.2	37	13.1	8.2	4.9	2.76
25	"	1.78	3.6	21	20.1	15.7	4.4	2.91
89	"	1.95	2.5	16	29.9	25.2	4.7	2.51
79	"	1.98	3.3	42	11.3	6.5	4.8	2.96
64	"	2.00	3.8	37	12.0	8.1	4.9	3.30
71	"	2.11	3.2	41	13.2	7.7	5.5	2.74
87	"	2.22	3.7	29	23.6	16.6	6.9	2.81
54	"	2.26	3.6	43	11.4	6.5	4.9	3.19
42	"	2.28	3.3	36	19.9	12.8	7.1	2.70
80	"	2.28	3.2	32	21.2	14.4	6.8	2.59
57	"	2.32	3.3	33	18.0	11.9	6.1	2.73
90	"	2.44	3.8	43	37.3	21.1	16.2	2.38
4	"	2.54	3.5	57	25.3	10.9	14.4	2.66
53	"	2.68	3.5	42	15.7	9.0	6.7	2.99
106	"	2.69	3.6	51	18.1	9.8	8.3	2.97
20	"	2.82	4.0	45	14.5	8.0	6.5	3.46
95	"	2.85	3.6	46	32.0	17.1	14.9	2.45
94	"	3.34	3.8	48	18.0	9.4	8.6	3.17
77	"	3.35	3.2	47	16.5	8.8	7.7	2.63
36	"	3.50	2.9	46	16.1	8.6	7.5	2.48
75	"	3.58	3.6	44	17.2	9.6	7.6	2.99
32	"	3.62	3.0	35	20.5	13.4	7.1	2.38
17	"	3.94	3.9	32	30.3	20.4	9.9	2.78
43	"	3.97	3.7	40	27.8	16.7	11.1	2.70
69	"	4.00	2.8	54	14.6	6.7	7.9	2.23
50	"	4.03	3.0	69	30.3	9.4	20.9	1.95
30	"	4.09	3.3	49	19.3	9.9	9.4	2.66
7	"	4.13	3.7	34	18.5	12.2	6.3	3.01
86	"	4.16	3.4	33	23.6	15.7	7.9	2.65
27	"	4.76	3.7	42	23.9	13.9	10.0	3.27
81	Neutral	1.59	4.2	19	29.9	24.1	5.8	3.05
47	"	1.72	4.0	17	38.8	32.2	6.6	2.48
96	"	1.85	3.2	19	25.5	20.5	5.0	2.45
65	"	1.90	3.5	40	13.5	8.3	5.2	3.04
45	"	1.96	4.5	16	32.0	26.7	5.3	3.06
101	"	2.45	3.1	35	13.6	8.8	4.8	2.70
100	"	2.51	3.8	50	13.2	6.5	6.7	3.26
97	"	2.70	3.2	54	11.3	5.2	6.1	2.95
39	"	2.74	3.8	35	22.3	14.5	7.8	2.94
85	"	2.78	3.8	54	22.4	14.8	7.6	2.99
102	"	2.95	4.5	60	23.6	9.9	13.7	3.51
78	"	2.99	3.4	21	23.6	14.5	9.1	2.65
12	"	3.01	3.5	20	18.5	13.1	5.4	2.92
52	"	3.22	3.6	40	20.9	12.6	8.5	2.87
11	"	3.55	3.0	38	25.5	15.7	9.8	2.38
62	"	3.89	3.5	64	35.8	12.4	22.8	2.96
28	"	3.91	3.7	38	21.5	13.2	8.3	3.06
38	"	4.48	3.4	61	24.9	9.6	15.3	2.56

Table XXI (continued)

The-sis No.	Acidity	Lime (CaO)	Nitrogen in volatile matter	Total ash solu-ble	Ash	Insoluble matter	Soluble matter	Nitrogen
		P.ct.	P. ct.	P.ct.	P.ct.	P.ct.	P.ct.	P. ct.
19	Neutral	4.51	3.2	43	22.7	12.8	9.9	2.43
29	"	4.66	3.2	45	22.5	12.2	10.3	2.49
74	"	4.73	2.9	56	18.5	8.1	10.4	2.38
73	"	4.83	3.7	40	23.8	14.3	9.5	2.85
72	"	4.87	3.0	68	14.1	4.4	9.7	2.58
70	"	5.05	2.6	53	18.3	8.5	9.8	2.16

(Continued)

Table XXI/ The concordance of results obtained by increasing the number of samples used in making a composite.

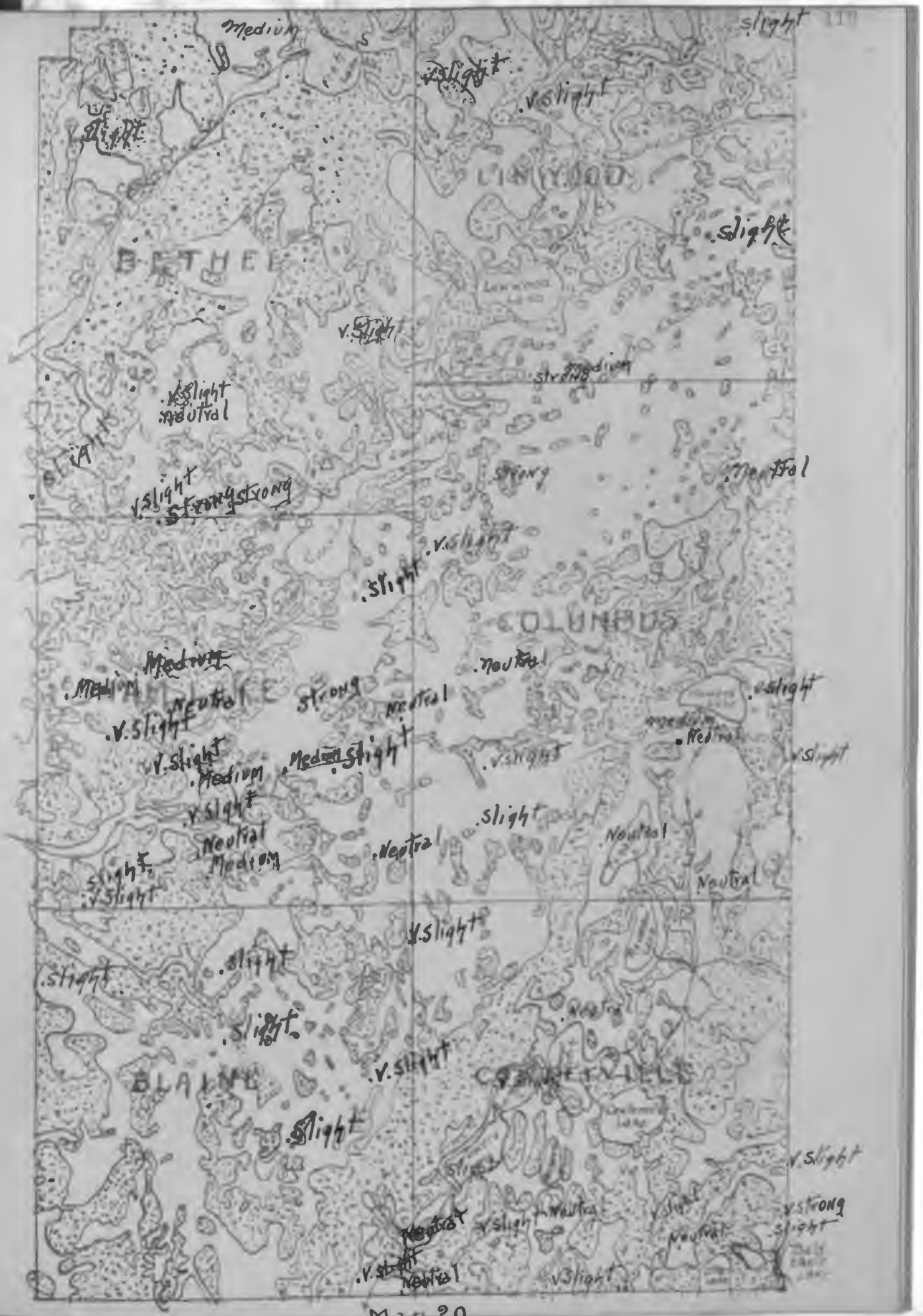
Thesis No.	Acidity	Lime (CaO)	Nitrogen in volatile matter	Total ash soluble	Ash	Insoluble matter	Soluble matter	Nitrogen
		P.ct.	P. ct.	P.ct.	P.ct.	P.ct.	P.ct.	P. ct.
				BY FIVES				
51-14	V. strong	.79	3.0	16	20.1	17.1	3.0	2.24
61-37	Strong	1.34	3.5	27	26.3	16.3	5.7	2.77
60- 1	Medium	1.83	3.7	27	24.1	17.9	6.1	2.96
56-68	"	2.30	3.4	40	16.8	10.1	6.9	2.84
13-67	Slight	1.94	3.6	28	27.4	21.1	6.2	2.63
103-23	"	1.72	3.5	20	30.1	24.7	5.4	2.52
48-40	"	2.22	3.6	43	16.9	10.0	6.9	2.99
107-91	"	2.51	3.6	37	18.8	12.3	6.3	3.93
84- 8	"	2.99	3.7	32	20.4	14.6	7.4	2.88
15-98	"	3.67	3.7	38	24.7	14.9	9.8	2.83
82-55	V. slight	1.89	3.3	30	16.0	11.8	4.2	2.83
25-71	"	1.96	3.5	31	17.5	12.5	4.1	2.91
89-57	"	2.27	3.4	34	18.8	12.4	6.3	2.81
90-20	"	2.63	3.7	47	22.2	11.7	10.4	2.89
95-75	"	2.32	3.4	46	19.9	10.7	9.2	2.74
32-50	"	3.91	3.3	46	26.7	13.3	11.4	2.21
30-81	"	3.74	3.6	31	23.0	15.3	7.9	2.93
47-101	Neutral	1.99	3.6	25	24.7	17.3	5.4	2.74
100-102	"	2.73	3.8	45	20.5	10.2	8.4	3.15
78-62	"	3.33	3.4	38	24.7	13.6	11.1	2.73
28-14	"	4.46	3.3	48	32.0	11.2	10.8	2.58
73-70	"	4.91	3.1	53	18.7	9.1	9.6	2.53
				BY TENS				
51-37	V. strong	1.06	3.2	31	23.2	16.7	4.3	2.80
60-68	Medium	2.06	3.2	33	20.4	14.0	6.5	2.90
13-23	Slight	1.83	3.5	24	29.7	22.9	6.8	2.67
48-91	"	2.26	3.6	40	17.8	11.1	6.6	3.46
85-98	"	3.33	3.7	35	22.5	14.7	8.6	2.85
82-71	V. slight	1.92	3.4	30	16.0	12.2	4.1	2.87
89-20	"	2.45	3.6	40	20.5	12.0	8.3	2.85
95-50	"	3.61	3.4	46	23.3	12.0	10.6	2.47
30-101	"	2.86	3.6	28	23.8	16.3	6.6	2.83
100-62	Neutral	3.08	3.5	42	22.6	11.9	9.7	2.94
28-70	"	4.68	3.2	50	20.3	10.1	10.2	2.55
				BY TWENTIES				
51-68	Strong	1.56	3.2	27	21.8	15.3	6.4	2.70
13-91	Slight	2.04	3.6	32	23.2	17.0	6.2	3.01
84-71	V. slight	2.62	3.5	32	19.6	13.9	6.3	2.86
89-50	"	3.03	3.5	43	21.9	13.0	9.3	2.66
30-70	Neutral	3.54	3.5	40	22.2	13.7	8.8	2.77
Total:								
Average:		2.56	3.4	38	21.7	14.2	7.2	2.80

The peat soils of Anoka County, on the whole, are high in lime, fairly high in ash and rather high in nitrogen. However, they vary greatly in composition from bog to bog, as is shown in Table XX.

Tables XX and XXI show that, while there are frequent exceptions, the more acid the peat has been found by the Truog test the smaller is the quantity of lime present and that the closer it approaches neutrality the higher is the lime content. These tables also show that the solubility of the ash increases with the increase in lime, and also that the percentage of nitrogen in the organic matter is not related to the lime content or the ash content of the peat, but is quite uniform throughout all of the analyses. The nitrogen content of the peat is not related to either the degree of acidity or the amount of lime present, but is dependent upon the amount of mineral matter in the soil; the higher the percentage of ash the lower is the total nitrogen content.

Showing the acidity of the peat areas.

Map 19


BETHEL
LINWOOD
COLUMBUS
BLAINE
Medium
Slight
V.Slight
Neutral
Strong
Map 20

Showing the acidity of the peat areas

Map 21

Percentage of lime (CaO) of the various peat areas

Map 22

Map 23


SAINT FRANCIS
OAK GROVE
BURNS
RAMSEY
GROW
Mississippi River

Map 24.

Percentage of ash content of the Anoka peats.

Map 25.

13.7
BETHEL
LINWOOD
12.4
COLUMBUS
13.0
13.5
16.9
20.5
13.0
32.8
21.9
14.1
19.9
24.9
Medium
22.4
12.6
19.3
14.5
14.1
15.6
58.6
27.2
31.5
29.8
49.4
23.6
22.9
32.5


SAINT FRANCIS
OAK GROVE
BURNS
GROW
RAMSEY
Mississippi River

Map 27.

Percent of ash soluble in aqua regia

Map 28.


LINWOOD
BETHEL
COLUMBUS
BLAINE
Linwood Lake
Comell Lake
Fish

MAP 29


SAINT FRANCIS
BURNS
OAK GROVE
RAMSEY
GROW
Mississippi River

Map 30.

Percentage of ash, insoluble in aqua regia

Map 31

Map 32


SAINT FRANCIS
BURNS
OAK GROVE
RAMSEY
GROW
Mississippi River

Map 33

Maps showing the proportion of ash soluble matter to nitrogen.

Map 34

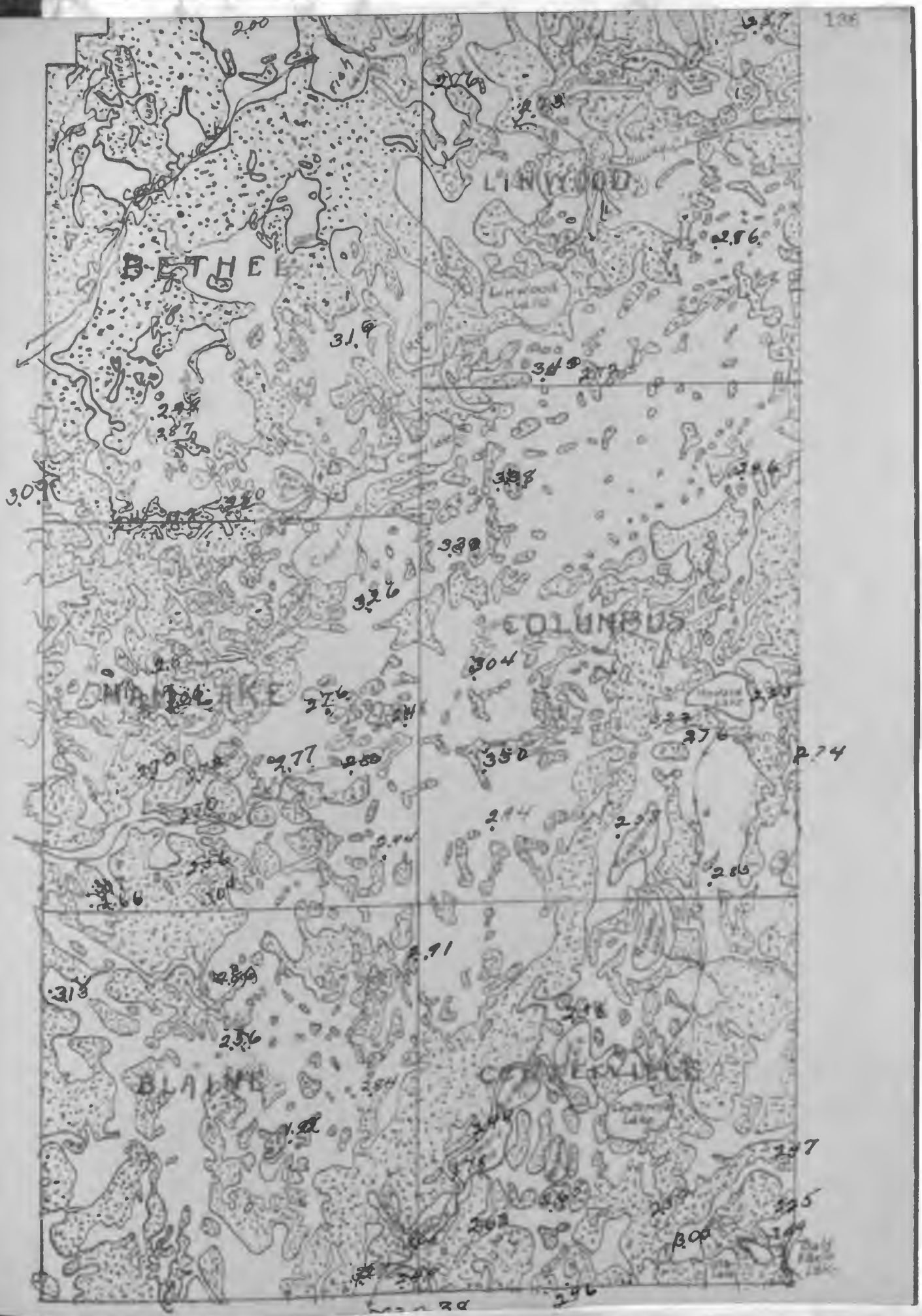

BETHEL
LINWOOD
COLUMBUS
BLAINE
CENTERVILLE


SAINT FRANCIS
BURNS
OAK GROVE
RAMSEY
GROW
Mississippi River

Map 36

Percentage of Nitrogen in different peat areas of Anoka.

Map 37.


BETHEL
LINWOOD
COLUMBUS
BLAINE


SAINT FRANCIS
BURNS
OAK GROVE
RAMSEY
GROW
Mississippi River

Map 59.

MARL DEPOSITS

The marl beds appear to be usually covered with well decomposed black peat, frequently supporting a growth of tamarack. This was not always the case, as some of the marl beds were overlain by a fibrous peat carrying sedges, redtop or rushes. These deposits ranged in depth from 6 inches to 7 feet, and in lime (CaO) content from 14.4 to 37.3 per cent, or as $CaCO_3$ from 25.9 to 66.6 per cent.

These marls were generally under 8 to 12 feet of peat and were underlain by clay. The location from which the marl samples were secured are shown on the maps in red.

As a few of the peat areas appear so low in lime as to require an application of this before they can be reclaimed these marl deposits may be used for this purpose. Part of them, being quite high in lime, are suitable for application as a soil amendment. Judging from the location of the marl beds found and the generally calcareous nature of the peats in all parts of the county it is probable that a detailed search might locate very many small deposits in all parts of the county. Those described here were found incident to sounding the bogs for the depth of the peat and without any attempt to locate the marl deposits of the county or to determine their area or depth.

Table XXII - Composition of marls.

Thesis No.	Depth below surface	Insoluble matter	Soluble matter	Lime (CaO)	Carbonate ($CaCO_3$)
	Feet	P. ct.	P. ct.	P. ct.	P. ct.
109	9	60.5	39.5	19.0	33.9
110	11	47.4	52.6	25.5	45.5
111	10	11.8	88.2	34.4	61.4
112	8	35.1	74.9	34.5	61.6
113	9	52.4	47.6	23.4	41.8
114	6	23.2	76.8	37.3	66.6
115	10	75.0	25.0	14.4	25.9
116	7	34.7	65.3	32.4	57.8

SAMPLE 109 - Taken from the northwest corner of the NW¼ of Sec. 36, Blaine Township. It was found under a well decomposed peat bearing sedges used for pasture. The peat (No. 27, Table IX) was rich in lime (4.76 per cent CaO) and nitrogen (3.27 per cent).

SAMPLE 110 - Taken from the northeast corner of the NW¼ of SW¼ of Sec. 26, Canterville. Covered with mucky peat and overgrown with sedges. It was overlain by 11 feet of black, well decomposed peat, which carried a sedge meadow (No. 80, Table XIV), which was very slightly acid, but carried 2.28 per cent CaO, only about half as much as 109.

SAMPLE 111 - Taken 15 rods east and 8 rods south of northwest corner of NE¼ of Sec. 36, Canterville. It is a white marl, covered by 10 feet of peat, overgrown with sedges, and containing 2.75 per cent CaO. (No. 84, Table XIV)

SAMPLE 112 - Taken half a mile east of Coon Creek on Main Street road. The bog is now a meadow, but was formerly a tamarack swamp. The peat (No. 19, Table VIII) carried 4.51 per cent CaO.

SAMPLE 113 - Taken 2 miles east of Constance. The peat was black and well decomposed, carrying only 2.12 per cent lime (No. 33, Table X). Sandy subsoil under marl, and bearing a redtop meadow.

SAMPLE 114 - Taken under a redtop meadow at Trott Brook, 4 miles east of Num River, the peat being 6 feet deep and the well decomposed surface layer containing 3.04 per cent CaO. The stratum of marl is 7 feet deep.

SAMPLE 115 - Taken 2 miles south of Nowthen from under an old tamarack swamp, now forming a redtop meadow. The peat is 10 feet deep, well decomposed and carries 2.70 per cent CaO (No. 97,

Table XVII).

SAMPLE 116 - Taken half a mile north of the south township line near Cedar Creek, half a mile east of the Rum River. The peat, which is occupied by a redtop and sedge meadow is well decomposed and carries 2.54 per cent CaO (No. 104, Table XVIII).

GREENHOUSE EXPERIMENTS

Blocks of peat soil from the surface eight inches of the experimental tract on the Oak Leaf Farm, were sacked and brought to the Experiment Station to be used in greenhouse experiments. Peat soil similarly taken from the Dibbell experimental tract, St. Louis County[1] and from a field on the Hartley Farm at Island in the same county were also used. The blocks were disintegrated so as to pass through a one-inch mesh sieve[2] and this fine material mixed by shoveling and rolling it on a large sheet. The same weight of this moist material was placed in each vegetation box, which consisted of a wooden box one foot square and ten inches deep on the inside. The boxes had been coated on the inside with pitch tar and to provide drainage had four holes bored in the bottom. From the thoroughly mixed peat a sample was taken to determine the percentage of moisture present, from which was calculated the amount of dry peat in each box.

The weight of each soil used in a box was such that when firmly packed it filled it to a depth of 8 inches, thus corresponding to the plowed layer in the field. Table XXIII gives the weight of dry and moist soil.

Thurston loam, taken from University Farm, was used as a basis of comparison.

The phosphate and lime, both separately and in combination, were added and then thoroughly mixed with the peat before packing it firmly into the box with a heavy tamper. The potassium sulphate and sodium nitrate were applied in solution to the surface after

[1] Clapp, W. S. - Northern Minnesota Peat Soils, Thesis, June, 1915, p. 57.

[2] Ibid, p. 10.

the box had been filled. Table XXIV shows the kinds and amount of fertilizer used in each box.

Before the seeds were planted the soil was watered with tap-water until seepage began and throughout the experiment it was moistened at frequent intervals.

The temperature of the greenhouse, heated by steam controlled by an electric thermostat, was kept at 70° F until January, after which it was lowered to 60° F. On some days these temperatures varied from 5° to 15°.

Medium red clover and barley, Minnesota No. 105, were seeded in the boxes. For the boxes of clover, plants were taken from a nearby field in which clover had been seeded with spring wheat in the preceding May. The plants were dug up with a spade and most of the soil adhering shaken off. The roots were then washed free from dirt with warm tap-water, the leaves trimmed off to the crown and the plants immediately placed in the soil. By this method clover plants with a good start were secured.

Previous work with clovers on peat soil in the same greenhouse had shown that if seed were planted in November the plants would not be sufficiently matured by the end of April to correspond to the first cutting for hay. Hence the transplanting method was tried. Each treatment was represented by duplicate boxes. By November 14 all the boxes had been filled and given such fertilizers as they were to have and on November 16 the barley was seeded and ten days later the clover transplanted. In each box the barley was planted in two rows, of 30 seeds to the row, and the resulting plants thinned to 10 to the row. With the clover 8 plants were placed in each box.

Table XXIII - Weights of soil, both moist and dry, used in the greenhouse boxes.

Source	Weight of moist soil in each box: Pounds	Weight of dry soil in each box: Pounds	Moisture content on dry basis: Per cent
Anoka peat	21	6.3	233.3
Dibbell peat	28	6.4	337.5
Island peat	33	7.3	352.1
Thurston loam*	50	45.3	10.6

*Mineral soil used as check

Table XXIV - Fertilizers used

Treatment indicated on box	Potassium sulphate: Per acre: Lbs.	Potassium sulphate: Per box: Grms.	Steamed bone-meal: Per acre: Lbs.	Steamed bone-meal: Per box: Grms.	Acid phosphate: Per acre: Lbs.	Acid phosphate: Per box: Grms.	Raw rock phosphate: Per acre: Lbs.	Raw rock phosphate: Per box: Grms.	Ground limestone: Per acre: Lbs.	Ground limestone: Per box: Grms.	Sodium nitrate: Per acre: Lbs.	Sodium nitrate: Per box: Grms.
0	0	0	0	0	0	0	0	0	0	0	0	0
K	400	4.5	0	0	0	0	0	0	0	0	0	0
P	0	0	800	9	400	4.5	800	9	0	0	0	0
L	0	0	0	0	0	0	0	0	4000	45	0	0
KP	400	4.5	800	9	400	4.5	800	9	0	0	0	0
KL	400	4.5	0	0	0	0	0	0	4000	45	0	0
PL	0	0	800	9	400	4.5	800	9	4000	45	0	0
KPL	400	4.5	800	9	400	4.5	800	9	0	0	200	2.2
KNP	400	4.5	800	9	400	4.5	800	9	4000	45	200	2.2
KNPL	400	4.5	800	9	400	4.5	800	9	4000	45	200	2.2

Table XXV - Chemical composition of peats used for greenhouse experiments.

Location	Acidity	Lime (CaO)	Nitrogen	Ash	Insoluble matter	Soluble matter	P_2O_5
		P.ct.	P. ct.	P.ct.	P.ct.	P.ct.	P.ct.
Oak Leaf Experimental Tract	V.slight	1.83	3.30	14.33	10.46	3.87	0.38
Island peat	Strong	1.88	1.53	10.50	6.60	3.90	0.25
Dibbell peat	V.slight	1.63	2.66	7.63	3.36	4.27	0.24

The clovers were harvested when most of the heads were in full bloom. This was on April 9th for all the Anoka boxes except KPac, KPrr and KPacL, and Dibbell boxes, except KLPhm, the latter being harvested April 20. The crop was then oven-dried and weighed, as shown by Tables XXVI to XXX.

The following treatments were used, all being represented by duplicate boxes:

ANOKA PEAT - Barley

1 - Check
2 - Potash
3 - Phosphate, as bone meal
4 - Lime
5 - Potash and phosphate, as bone meal
6 - Potash, lime and phosphate, as bone meal.

ANOKA PEAT - Clover

1 - Check
2 - Potash
3 - Lime
4 - Phosphate, as bone meal
5 - Phosphate, as superphosphate
6 - Phosphate, as raw rock phosphate
7 - Potash and bone meal
8 - Potash and raw rock phosphate
9 - Potash and acid phosphate
10 - Lime, potash and bone meal
11 - Lime, potash and acid phosphate

ISLAND PEAT - Barley

1 - Check
2 - Potash
3 - Phosphate as bone meal
4 - Ground limestone
5 - Potash and bone meal
6 - Potash, bone meal and limestone

DIBBELL PEAT - Clover

1 - Check
2 - Potash
3 - Phosphate, as bone meal
4 - Lime
5 - Potash and bone meal
6 - Potash, bone meal and lime.

The yields from the different treatments are shown in Tables XXV to XXX.

DISCUSSION OF RESULTS

On the University Farm mineral soil, used for comparison, the first crop of clover yielded at the rate of 4.7 tons per acre, but the barley gave only 1.1 tons of straw and 17.5 bushels of grain per acre. The appearance of these pots just before harvest is shown in Plate XI. The unsatisfactory growth of the barley was due probably largely to deficient nitrification on account of the difficulty of keeping the moisture content low enough in boxes of loam soil, unless these are controlled by daily weighings and less frequent additions of water. The weighing method had not been adopted because of the great amount of time it requires.

The effect of the application of fertilizers to Anoka peat was very marked when clover was grown (Table XXVI). Potash alone was of little value, and lime was actually harmful. Phosphates in any form were beneficial, acid phosphate showing the most marked effect and rock phosphate the least. Potash in addition to the phosphate shows no additional benefit over phosphate alone and lime, when added with potash and phosphate, produced a harmful effect. These results agree fully with those obtained in the field at Oak Leaf Farm in 1916.

The results with barley on Anoka peat were not so satisfactory. part of the boxes to which phosphate, as bone meal, had been applied, making a very luxuriant early growth and then suffering blight from which they did not recover. Potash alone increased the yield from 27 to 60 bushels per acre, and when applied with phosphorus and nitrogen it increased the yield to 86 bushels (Table XXVI). Lime depressed the yield of both grain and straw. As the plants on the phosphate alone as well as on the phosphate with potash pots were

blighted the yields from these are of no significance.

Plate VI, shows the effect on the clover of the different treatments and Plate VII their effect on barley.

Phosphate alone and in combination with potash showed very markedly beneficial effects. The lime depressed the yield. Plates VI to XI were taken of the greenhouse boxes. Plates of single boxes were taken in each case, the difference being so slight as to be negligible. In one or two cases the better of the two boxes was photographed, due to the fact that the duplicate was injured or diseased. This difference is shown in Tables XXXVI to XXX.

DIBBELL PEAT - The Dibbell peat is fairly high in lime, is similar in composition to the Anoka peat. The greenhouse results with clover on this peat are similar to those secured with the latter. Lime, both when used alone and in combination with phosphorus and potash, depressed the yield (Table XXX). Phosphate, used in the form of bone meal, increased the yield greatly. Potash showed little or no effect when used alone. The effect of potash when used along with phosphates is uncertain, the yield of the two KP boxes being 94 and 92 grams respectively, compared with 46 and 92 grams on the P boxes. The lack of concordance of the latter is due to the fact that a root disease injured the plants in the first P box about the first of March, many of the leaves dying off, and lessening the growth of the plants.

ISLAND PEAT - The effect of different fertilizers on the clover (Table XXVIII) was very marked, and in general closely resembled that on the Anoka peat. These two soils were similar in chemical composition and so similar results in greenhouse and field experiments are not surprising. Lime had a markedly depressing effect, potash was only slightly beneficial, but phosphorus very beneficial,

increasing the yield by 200 per cent. Potash, when used in addition to bone meal, gave no distinct increase. Lime, both alone and in addition to potash and bone meal, appears to have a depressing effect.

With barley (Table XXIX) similar results were secured. Phosphates in combination with potash raised the yield from 39.5 bushels on the check to 104.5 bushels and the straw from 2.2 to 5.5 tons per acre, while the potash alone had only a slight effect. Unfortunately the supply of soil did not permit of adding boxes with phosphate only. Lime had a depressing effect upon the yield of grain, but none upon the straw.

The general conclusions to be drawn from the greenhouse experiments on the three peats tried are:

1 - Without some fertilization they produce poor yields of barley and clover.

2 - Lime has little or no beneficial effect, often depressing the yield.

3 - That potash alone does not appreciably increase the first crop.

4 - Phosphates greatly increase the yields of all crops.

5 - Potash added to phosphorus gives a yield somewhat greater than phosphorus alone.

6 - That acid phosphate is as effective as steamed bone meal and much more so than rock phosphate.

Table XXVI - Yields of clover hay in the greenhouse experiment with Anoka peat. Only the first crop was harvested.

Treatment	No. of plants per box	No. of heads per box	Per acre: Tons	Average per acre: Tons a	Tons b	Dry weight Per individual box: Grams
Check, 1	6	0	1.24	1.8	2.0	26
2	8	5	2.45			51
K, 1	8	8	2.17			45
2	8	8	2.40	2.3	2.6	50
P, Bone meal, 1	5	19	3.65			76
2	5	25	4.18	3.9	4.3	87
P, Acid phosphate, 1	7	10	4.22			88
2	7	10	4.18	4.2	4.7	87
P, Rock phosphate, 1	7	22	2.78			58
2	8	37	3.31	3.0	3.3	69
L, 1	8	5	1.30			27
2	8	5	.81	1.1	1.2	17
KP, Bone meal, 1	5	25	2.88			60
2	8	40	5.23	4.1	4.5	109
KP, Acid phosphate, 1	7	20	4.61			96
2	7	8	3.40	4.0	4.4	71
KP, Raw rock phosphate, 1	7	36	3.40			71
2	7	16	3.05	3.2	3.6	64
KLP, Acid phosphate, 1	7	16	3.31			69
2	6	4	2.30	2.8	3.1	48
KLP, Bone meal, 1	7	27	2.35			49
2	8	42	3.00	2.7	3.0	62

a - On the oven-dried basis.
b - On the field cured basis, assuming 10 per cent moisture in the hay.

Table XXVII - Yield of barley in the greenhouse experiments with Anoka peat*.

Treatment	Data per box: No. of heads	Grain: air-dry	Straw: air-dry	Straw: oven-dry	Grain per acre, air-dry: Individual	Grain per acre, air-dry: Average	Straw per acre, air-dry: Individual	Straw per acre, air-dry: Average
		Grams	Grams	Grams	Bushels	Bushels	Tons	Tons
O, 1	20	16.0	50.0	46.2	32.0		2.4	
2	20	11.3	43.7	40.4	22.6	27.3	2.1	2.2
K, 1	25	28.1	59.9	56.5	56.2		2.8	
2	27	32.1	61.9	58.4	64.2	60.2	2.7	2.7
P, 1	42	12.0	109.0	100.0	24.0		5.2	
2	3	0.0	35.0	33.7	0.0	12.0	1.7	3.5
L, 1	16	5.3	20.4	19.6	6.2		1.0	
2	13	2.6	17.5	16.4	5.2	5.7	0.8	0.9
KPN, 1	44	33.0	116.0	102.4	66.0		5.5	
2	2	0.0	67.0	61.2	0.0	33.0	3.2	4.3
KPL, 1	27	26.8	61.1	59.4	53.8		2.9	
2	29	30.5	68.5	63.8	61.1	57.4	3.8	3.3
KP, 1	1	0.0	42.0	39.3	0.0		2.0	
2	0	0.0	35.0	32.9	0.0	0.0	1.7	1.9

*Duplicates of P and KPN and both boxes of KP were blighted and yielded no crop.

Table XXVIII - Yields of clover hay in the greenhouse experiment with Island peat.

Treatment	No.of plants per box	No.of heads per box	Per acre: Tons	Average per acre: Tons a	Average per acre: Tons b	Dry weight per individual box: Grams
O, 1	7	8	1.01			20
2	7	9	1.39	1.1	1.2	27
K, 1	8	7	1.60			32
2	8	10	1.30	1.4	1.6	26
P, 1	8	16	4.30			90
2	6	6	3.50	3.9	4.3	72
L, 1	8	3	0.7			15
2	8	4	1.0	0.9	1.0	21
KP, 1	7	16	4.9			103
2	7	14	4.3	4.6	5.1	90
KPL, 1	7	7	3.9			81
2	7	8	3.2	3.5	3.9	67

a - On oven-dried basis.
b - On the field-cured basis, assuming 10 per cent moisture in the hay.

Table XXIX - Yields of barley in the greenhouse experiments with Island peat and University Farm mineral soil.

Treatment	Date per box: No. of heads	Grain air-dry	Straw air-dry	Straw oven-dry	Grain per acre, air-dry: Individual	Grain per acre, air-dry: Average	Straw per acre, air-dry: Individual	Straw per acre, air-dry: Average
		Grams	Grams	Grams	Bushels	Bushels	Tons	Tons
O, 1	24	23.9	46.5	42.3	47.8		2.2	
2	20	15.6	46.1	41.9	31.2	39.5	2.2	2.2
K, 1	22	20.0	87.3	81.4	55.4		4.4	
2	23	27.7	51.0	79.2	40.0	47.7	2.5	3.5
KP, 1	48	52.0	121.0	50.8	104.2		5.8	
2	45	52.4	109.6	112.2	104.8	104.5	5.2	5.5
KPL, 1	44	37.9	144.1	114.6	75.5		6.9	
2	36	30.3	89.7	85.4	60.6	68.0	4.3	5.6
				UNIVERSITY FARM				
O, 1	18	9.7	23.3	22.2	19.4		1.1	
2	15	7.6	22.4	21.1	15.6	17.5	1.1	1.1

Table XXX - Yields of clover hay in the greenhouse experiment with Dibbell peat.

Treatment	No. of plants per box	No. of heads per box	Per acre	Average per acre		Dry weight per individual box
			Tons	Tons a	Tons b	Grams
0, 1	7	7	0.6			12
2	8	0	0.8	0.7	0.8	17
K, 1	7	2	1.2			24
2	8	4	0.7	0.9	1.0	15
P, 1	7	21	2.2			46
2	7	16	4.5	3.4	3.8	94
KP, 1	7	18	4.5			94
2	7	25	4.4	4.5	5.0	92
L, 1	8	4	1.0			20
2	8	4	1.3	1.2	1.3	28
KPL, 1	7	19	1.3			19
2	7	10	1.1	1.2	1.3	10

a - On the oven-dried basis.
b - On the field-cured basis, assuming 10 per cent moisture in the hay.

Plate VI

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Plate VI - Clover on peat from Oak Leaf Farm, Anoka, showing the influence of different fertilizer treatments.

Fig. 1 - **0.** Left untreated.
K. Potassium sulphate, 400 lbs. per acre.
Pb. Steamed bone meal, 800 lbs. per acre.

Fig. 2 - **P r.** Raw rock phosphate, 2000 lbs. per acre.
P a. Acid phosphate, 400 lbs. per acre.

Fig. 3 - L. Ground limestone, 4000 lbs. per acre.
KPb. Potassium sulphate (400 lbs.), steamed bone meal (800 lbs.)
KPa. Potassium sulphate (400 lbs.) acid phosphate (400 lbs.).

Fig. 4 - **KPr.** Potassium sulphate (400 lbs.), raw rock phosphate (2000 lbs.).
KPaL. Potassium sulphate (400 lbs.), acid phosphate (400 lbs.), ground limestone (4000 lbs.).
KPbL. Potassium sulphate (400 lbs.) steamed bone meal (800 lbs.) ground limestone (4,000 lbs.).

Plate VII - Barley on peat from Oak Leaf Farm, Anoka, showing the influence of different fertilizer treatments.

Fig. 1 - O. Left untreated.
K. Potassium sulphate, 400 lbs. per acre
P. Steamed bone meal, 800 lbs. per acre

Fig. 2 - KP. Potassium sulphate (400 lbs.) steamed bone meal (800 lbs.)
L. Ground limestone, 4000 lbs. per acre.
KNP. Potassium sulphate (400 lbs.) sodium nitrate (200 lbs.) steamed bone meal (800 lbs.)
KPL. Potassium sulphate (400 lbs.) steamed bone meal (800 lbs.) ground limestone (4000 lbs.)

Plate VII

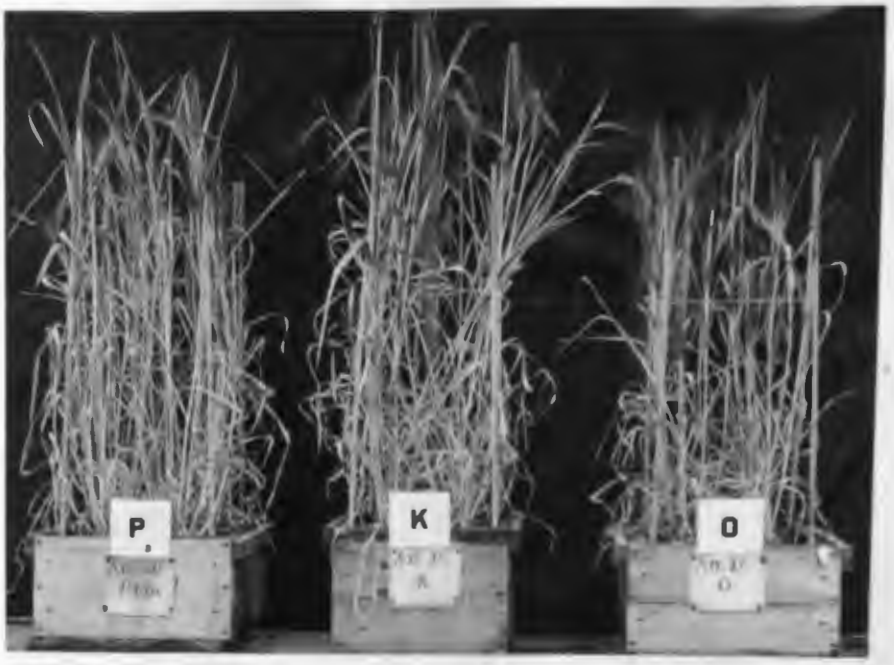


Fig. 1.

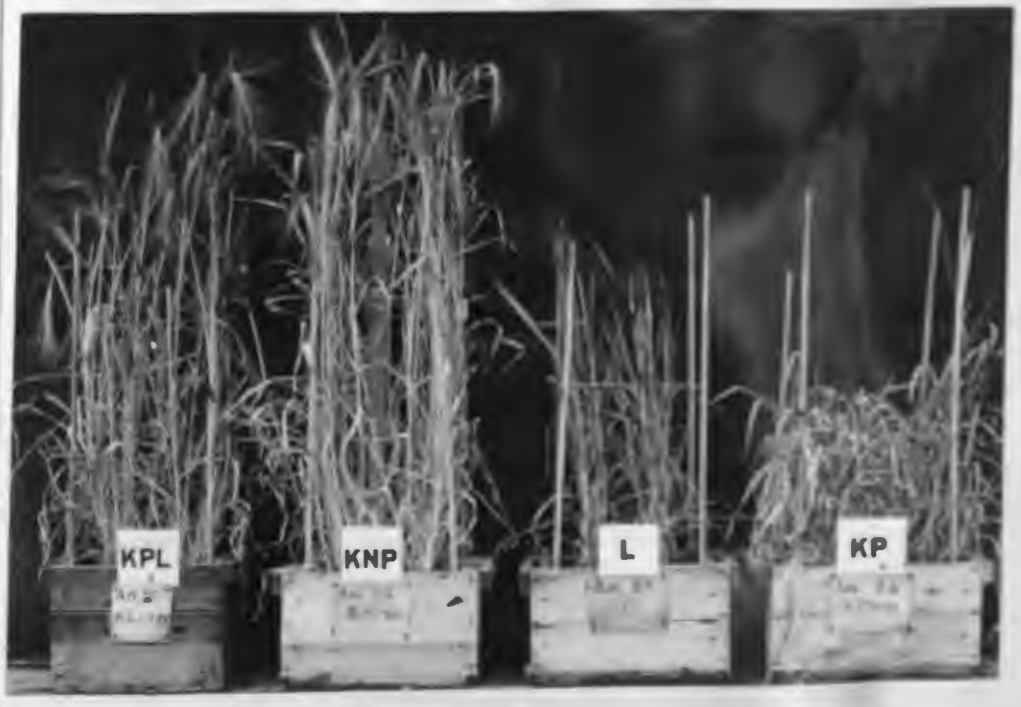


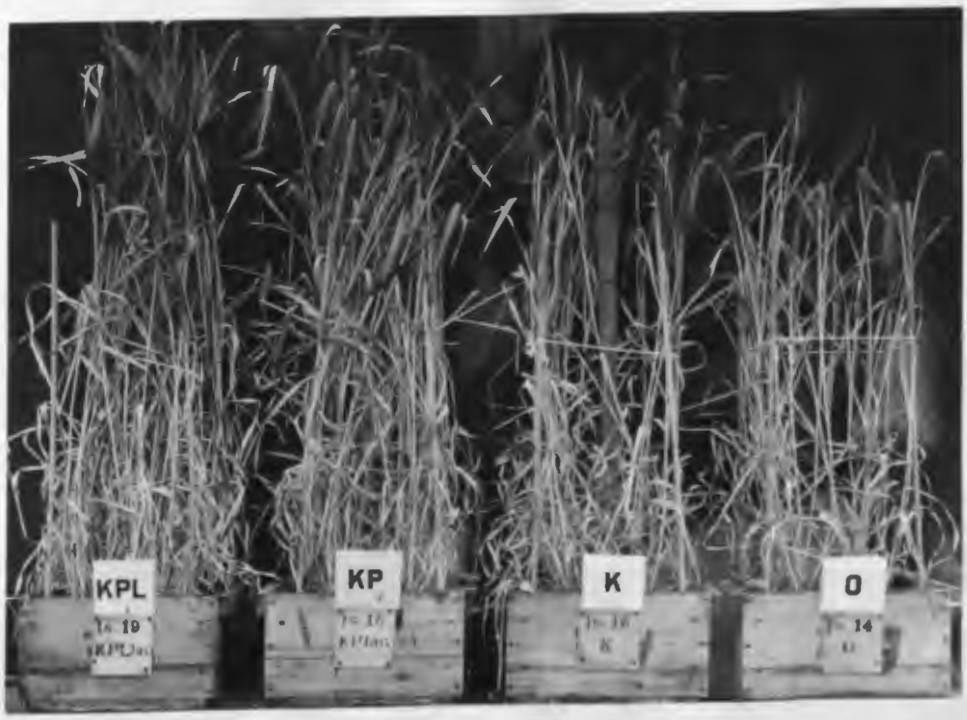
Fig. 2.

Plate VIII - Clover grown on peat from the Hartley Farm at Island, St. Louis County, showing the influence of different fertilizer treatments.

Fig. 1 - O. Left untreated.
K. Potassium sulphate, 400 lbs. per acre.
P. Steamed bone meal, 800 lbs. per acre.

Fig. 2 - L. Ground limestone, 4000 lbs. per acre
KP. Potassium sulphate (400 lbs.) steamed bone meal (800 lbs.), ground limestone (4000 lbs.).

Plate IX



Barley grown on peat from the Hartley Farm at Island, St. Louis County, showing the influence of different fertiliser treatments.

O. Left untreated
K. Potassium sulphate, 400 lbs. per acre.
KP. Potassium sulphate (400 lbs.) steamed bone meal (800 lbs.)
KPL. Potassium sulphate (400 lbs.) steamed bone meal (800 lbs.) ground limestone (4000 lbs.).

Plate X - Clover on peat from Dibbell, St. Louis County, showing the influence of different fertilizer treatments.

Fig. 1 - **O.** Left untreated
K. Potassium sulphate, 400 lbs. per acre
P. Steamed bone meal, 800 lbs. per acre

Fig. 2 - L. Ground limestone, 4000 lbs. per acre
KPL. Potassium sulphate (400 lbs.), steamed bone meal (800 lbs.) and ground limestone (4000 lbs.).

Plate XI

Clover on a mineral soil, a silt loam, from the University Farm, employed as a check for peat soils. The plants were started at the same time as those on the latter.

FIELD EXPERIMENTS

Plot experiments were carried out on one of the fields of the Oak Leaf Farm belonging to Messrs. George D. and George N. Dayton, who kindly provided all the labor, seed, limestone, lumber, etc. needed in connection with the work. The experimental tract occupied about 5 acres, located in the 30 acre field broken late in 1915, it being in the NW¼ of Sec. 24 in Ham Lake township.

The depth of the peat ranged from 30 inches on the northwest and southwest corners of the area to 68 on the northeast and 102 on the northwest, the average exceeding 60 inches. The surface material consisted of fairly well decomposed peat, free from roots of trees. The natural vegetation had consisted of grasses and sedges and the field had, for many years, been used as a meadow and pasture. The peat on this field is similar in chemical and physical character to the larger peat areas of the county. The site was entirely satisfactory for the work, except in respect to drainage. The early part of the season being unusually wet and the drainage quite inadequate, all the early sown crops proved a more or less complete failure.

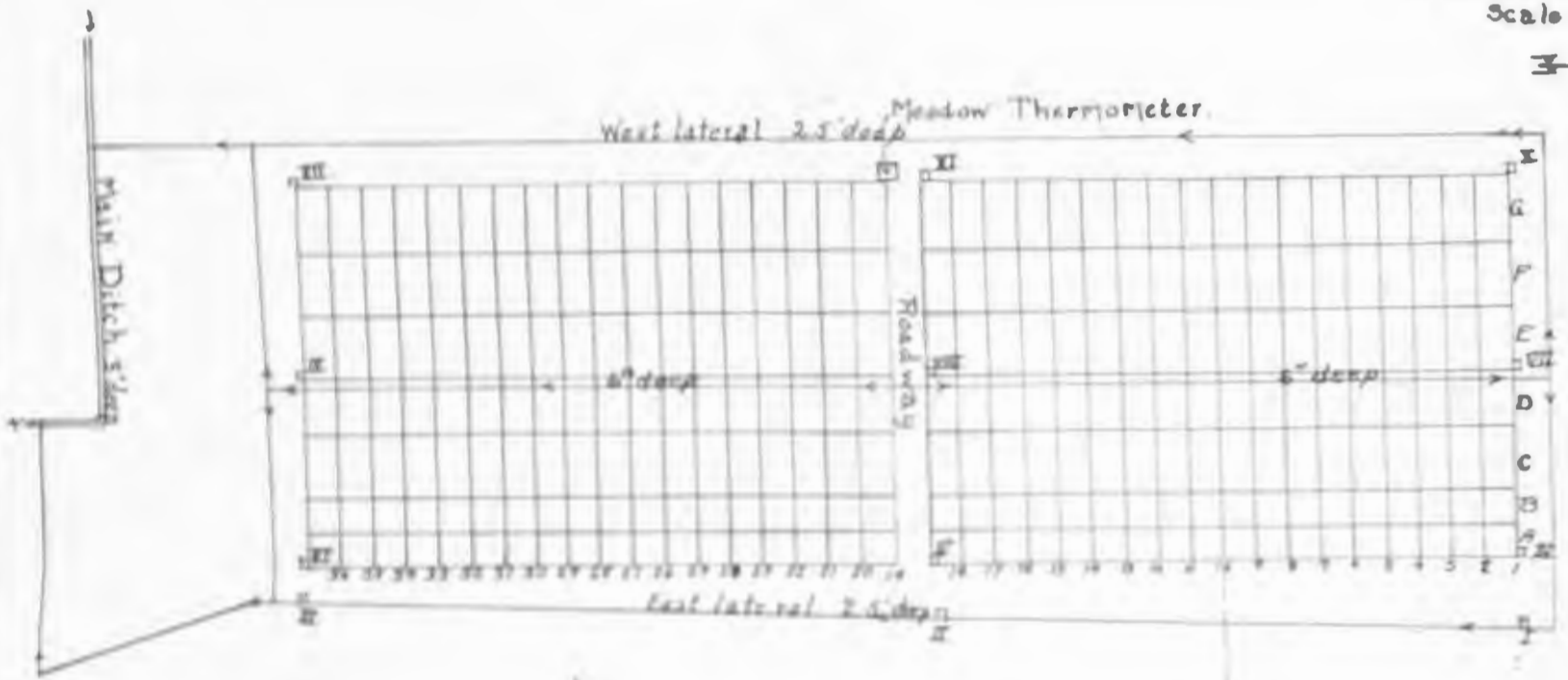
ARRANGEMENT OF THE PLOTS - The arrangement of the plots and crops is shown in the accompanying diagram (Fig 2) and the treatment of each is reported in Table XXXI).

There were 36 plots, arranged in two series of 18 each. Each series was surrounded by a roadway one rod wide. The plots were one rod wide by 12 rods long, and separated from one another by 3 foot paths.

OAK LEAF EXPERIMENTAL PLOTS

Fertilizer Plots - 1 rod wide
Crop Units - 1x1 and 1x2 rods.
Paths - 3 feet wide
□ Wells I - XII.
Scale 3/16 inch = 1 rod.

N



□ Upland Thermometer

Table XXXI - Fertilization of the different plots

Plot Nos.	Treatment and rate of application, per acre
1, 19	Check
2, 20	Quicklime, 1 ton
3, 21	Ground limestone, 2 tons
4, 22	Check
5, 23	Sulphate of potash, 400 lbs.
6, 24	Steamed bone meal, 800 lbs.
7, 25	Check
8, 26	Ground limestone, 2 tons, sulphate of potash 400 lbs.
9, 27	Ground limestone, 2 tons, steamed bone meal, 800 lbs.
10, 28	Check
11, 29	Ground limestone, 2 tons, sulphate of potash 400 lbs. steamed bone meal, 800 lbs.
12, 30	Ground limestone, 2 tons, sulphate of potash 400 lbs. steamed bone meal, 800 lbs., Nitrate of soda 200 lbs. (in 2 applications)
13, 31	Check
14, 32	Sulphate of potash, 400 lbs., steamed bone meal 800 lbs.
15, 33	Sulphate of potash, 400 lbs., steamed bone meal 800 lbs. Nitrate of soda, 200 lbs. (in two applications).
16, 34	Check
17, 35	Stable manure, 10 tons
18, 36	Stable manure, 20 tons

DRAINAGE CONDITIONS - It has been mentioned that the drainage of the area was unsatisfactory. The early part of the season was very wet (Table XXXIII) no field work with teams or caterpillar tractor being possible before July.

At the first of July Professor J. T. Stewart surveyed the area and laid out a system of laterals connecting with the main ditch leading to Coon Creek. He found the surface practically level, the fall amounting to only one-eighth of an inch in 1000 yards.

A large ditch runs along the south side of the tract, turns south and finally 2 miles below drains into Coon Creek. This ditch was originally 3 feet deep, but during the early part of the experiment it was partly filled with sand and brush. In the first part of July the new system of ditches was dug around the plots. As is shown by the outline on Fig. 2 the lateral on the west side of the tract is 2 feet deep at the north end and 3 feet where it drains into the main ditch; the east lateral is 1.5 feet at the north and 3 feet where it drains into the main ditch; at each end of the tract a lateral 6 inches deep in the center and sloping both to the east and to the west, and reaching 30 inches at the end carries off the water from the end rapidly. A 6 inch ditch extends lengthwise throughout the plot and takes care of the surface water from the center, its purpose being to draw off the water from rains as quickly as possible. This set of ditches had for its object the drainage of the area to a depth of 18 or 24 inches.

Professor Stewart states that in order to secure adequate drainage the main ditch would require both cleaning and deepening throughout its length to Coon Creek and that the ditches on the tract would have to be deepened. They would then take care of the water and place the field in proper condition for cultivation.

From the opening of spring until July the water-level was less than 3 inches below the surface and remained less than 6 inches until the 7th of July when the digging of the new laterals around the experimental tract and the cleaning of the old main ditches lowered the water-level. The 12 wells, the positions of which are shown in Fig. 2 were placed in the tract at that time and records of the levels kept from then until the end of the season.

Table XXXII shows that when the wells were placed in July the water-table was at an average of 15 inches below the surface of the soil and that this gradually lowered at the average rate of half an inch per day until September 1, when the average depth was 30 inches, at which level it remained, this being due to the fact that the bottom of the new ditches was at this level. After these were dug the surface water drained off to such an extent that after rains of half an inch or even more the level was raised only by 1 or 2 inches.

With the exception of the manure the fertilizers were all applied by hand. The quicklime, ground limestone, bone meal and manure were applied on June 19 and 20 before the crops were put in, while the potash and the first half of the sodium nitrate were applied on July 6, immediately after the crops were all in the ground. The second half of the sodium nitrate was added two weeks later, on July 20.

CULTIVATION - The field had been plowed with a caterpillar tractor and gang plows in the fall of 1915. The wet spring and the inadequate drainage prevented any further work on the field until the latter part of June, when it was double disced and harrowed twice. It was attempted to roll the tract to make a compact seedbed, but the soft condition of the soil, due to the inadequate drainage, made it impossible to use the roller on the land. All the cultivating was done with the tractor, which succeeded easily with its large caterpillar wheels in traveling over the wet peat. The grains and grasses were all sown broadcast and then harrowed once. The arrangement of the crops is shown on the diagram.

Table XXXII - Water-levels on the Experimental Tract. The distance reported in inches, indicates the depth of the water level below the surface of the soil.

Date	Well I	Well II	Well III	Well IV	Well V	Well VI	Well VII	Well VIII	Well IX	Well X	Well XI	Well XII
July	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
14	29	19	18	19	17	23	15	14	15	18	18	20
15	28	17	18	19	17	25	15	14	14	16	16	19
16	29	17	18	19	17	20	12	12	15	18	17	20
17	28	17	16	15	14	22	9	11	16	16	16	18
18	26	18	12	12	12	23	12	12	13	12	12	14
19	27	16	18	15	13	24	13	14	15	15	15	16
20	27	18	19	16	14	26	15	15	16	16	16	18
21	28	20	20	19	17	27	18	16	18	20	20	21
22	30	20	21	20	19	27	20	16	18	20	20	22
23	30	20	23	20	20	27	20	16	19	21	20	23
24	30	21	24	20	21	28	21	17	20	22	21	24
25	31	21	25	21	21	28	21	19	20	22	21	24
26	31	22	25	22	22	29	21	19	20	22	21	25
27	31	23	26	23	22	22	22	19	21	22	21	26
28	32	23	26	23	22	22	22	19	21	23	22	26
29	34	24	26	23	23	21	23	20	22	23	22	26
30	36	24	27	24	23	21	23	21	22	24	22	27
31	37	25	29	27	23	27	27	25	27	28	27	29
Aug.												
1	37	25	30	27	28	32	28	26	27	29	28	29
2	27	25	31	28	28	33	28	27	27	29	29	30
3	30	25	31	29	28	34	29	27	27	29	29	30
4	30	20	16	16	20	24	16	19	20	18	21	19
5	30	20	16	16	20	24	16	19	21	17	21	19
6	30	20	15	16	20	24	17	19	21	18	21	19
7	30	20	17	19	20	24	17	19	21	20	21	20
8	32	20	20	22	20	24	20	22	22	22	20	21
9	32	20	20	22	20	24	20	22	22	23	20	22
10	32	21	20	22	20	25	20	22	22	22	20	22
11	33	21	20	22	21	25	20	22	23	23	20	22
12	33	21	21	22	21	26	21	22	23	24	20	22
13	33	22	21	25	22	23	21	22	24	24	20	23
14	33	22	22	24	22	21	23	24	24	24	21	24
15	24	22	23	22	23	26	22	24	26	27	23	26
16	25	22	22	22	24	26	22	24	26	27	23	26
17	25	22	23	22	24	27	23	26	26	28	24	27
18	24	23	24	22	22	21	21	23	22	26	22	28
19	20	24	24	23	23	21	21	24	24	24	23	26
20	20	19	20	24	22	24	21	23	23	26	22	28
21	21	19	20	24	22	24	21	23	23	27	23	28
22	21	20	20	24	22	24	21	23	24	27	24	28
23	21	21	21	24	22	24	21	23	25	28	24	28
24	21	21	22	24	23	24	21	24	25	23	25	26
25	23	24	24	26	23	26	22	24	25	24	25	25
26	23	25	25	26	24	26	23	24	25	24	25	26
27	23	25	26	26	24	26	24	25	26	24	24	26
28	23	25	26	27	25	27	24	24	26	25	25	26
29	23	25	26	27	26	27	25	25	26	25	25	26
30	36	28	27	28	27	30	27	28	28	28	27	29

Table XXXII - (Continued)

Date: Sept:	Well I Ins.	Well II Ins.	Well III Ins.	Well IV Ins.	Well V Ins.	Well VI Ins.	Well VII Ins.	Well VIII Ins.	Well IX Ins.	Well X Ins.	Well XI Ins.	Well XII Ins.
1	36	30	29	28	28	32	28	28	29	29	28	29
2	36	31	30	28	30	32	30	30	30	30	30	31
3	36	31	30	28	30	32	30	30	30	30	30	32
4	36	31	30	28	30	32	28	30	31	32	30	32
5	36	32	30	28	30	32	28	30	31	32	31	32
6	36	32	31	28	31	33	29	31	32	32	32	33
7	36	33	31	28	32	34	27	31	32	32	32	34

RAINFALL - The departure of the precipitation from normal for the season from October 1, 1915 to September 30, 1916 is shown in Table XXXIII where the data are reported by months. The nearest weather stations to Oak Leaf Farm are Minneapolis and St. Paul. It will be seen that April, May and June of 1916 were unusually wet months. The rainfall at Minneapolis (Table XXXIII) was 3.07 inches for April, which is .63 above normal; for May 6.97 inches, which is 2.05 inches above normal, and for June 4.84, .55 inches above normal.

From June 28th until September 30, the total rainfall at Oak Leaf amounted to 10.6 inches, most of this falling in the first part of July and in the first part of August, (Table XXXIV). The excessive rains of May and June kept the peat marsh in such a wet condition that it was impossible to do any field work before the latter part of June. The 2.0 inches of rainfall on July 14 and 17 completely flooded the experimental tract and it was a week before it had drained off so that the surface was free of water. This resulted in the rotting of the potatoes and injured the barley, oats, flax and millet, the barley and oats turning yellow and soon dying.

The August rains did not damage the remaining crops as July had been a very dry month and the soil was dry and so in a condition to absorb most of the rainfall at this time. Further new ditches had been dug in the meantime. Later in the month, on August 20, the experimental tract again became so wet as to make it impossible to use horses on the tract.

Table XXXIII -Precipitation affecting the crop season of 1916 compared with the normal.

Month:	1915-1916			Normal	
	St. Paul:	Minneapolis:	Oak Leaf Farm*:	St. Paul:	Minneapolis
Oct.	1.59	2.59		2.24	2.58
Nov.	2.64	3.62		1.30	.82
Dec.	.53	.46		1.06	.95
Jan.	2.60	2.88		.90	.69
Feb.	.39	.32		.87	.76
March:	1.26	1.19		1.60	1.65
April:	3.03	3.07		2.33	2.44
May	5.89	6.97		3.62	3.92
June	3.79	4.54		4.41	4.01
July	.75	1.27	2.7	3.40	3.81
Aug.	1.60	1.66	4.4	3.46	3.93
Sept.	1.81	2.42	3.52	3.42	3.66
12 Months:	25.88	30.99		28.61	29.22

*Incomplete

Table XXXIV - Rainfall at Experimental Farm, 1916.*

Date	Inches	Date	Inches	Date	Inches
Apr. 1	0	May 19	.0	July 6	0
2	0	20	.0	7	0
3	.01	21	1.74	8	0
4	.23	22	.17	9	0
5	.0	23	.0	10	0
6	.0	24	.16	11	0
7	.03	25	1.76	12	T
8	.0	26	.44	13	0
9	.0	27	.0	14	1.0
10	.0	28	.15	15	0
11	T	29	.0	16	0
12	T	30	.0	17	1.6
13	.0	31	.38	18	T
14	.0	June 1	.10	19	0
15	.44	2	.04	20	0
16	.78	3	T	21	0
17	.0	4	.0	22	0
18	.02	5	.0	23	T
19	.24	6	.0	24	0
20	.13	7	.39	25	.1
21	.48	8	.05	26	0
22	T	9	.07	27	0
23	T	10	.0	28	0
24	T	11	.12	29	0
25	.18	12	.42	30	0
26	T	13	T	31	0
27	0	14	.05	Aug. 1	0
28	0	15	.62	2	0
29	.53	16	.07	3	0
30	.0	17	.0	4	0
May 1	.05	18	.0	5	1.8
2	.17	19	.0	6	0
3	.0	20	.0	7	.2
4	T	21	T	8	0
5	T	22	.10	9	0
6	.0	23	.36	10	1.2
7	.32	24	.0	11	0
8	.0	25	.75	12	.9
9	T	26	.0	13	0
10	.07	27	.0	14	0
11	.0	28	.0	15	0
12	.0	29	1.2	16	0
13	.14	30	.0	17	.4
14	1.28	July 1	.0	18	0
15	.10	2	T	19	0
16	T	3	T	20	2.1
17	.0	4	.0	21	0
18	.04	5	.0	22	0

Table XXXIV - (Continued)

Date	Inches	Date	Inches	Date	Inches
Aug. 23	.0	Sept. 5	.0	Sept. 18	.0
24	.0	6	.5	19	.0
25	.0	7	.0	20	.0
26	.0	8	.0	21	T
27	.2	9	.0	22	.1
28	.0	10	.5	23	.0
29	.0	11	.0	24	.0
30	.0	12	.6	25	.0
31	.0	13	.0	26	.03
Sept. 1	.0	14	.4	27	.01
2	.0	15	T	28	.19
3	.0	16	.12	29	.0
4	1.1	17	.0	30	.0

*Rainfall records from April 1 to June 28 taken from the Minneapolis reports. All readings were made at Oak Leaf Farm by Mr. Edward Miller.

TEMPERATURE CONDITIONS - As has been mentioned above peat areas are peculiarly liable to summer frosts, due, not to the location, but to the properties of the peat. However, some bogs are much more subject to these frosts than are others nearby. This made it important to determine how the minimum temperatures on the bogs compared with these on the adjacent mineral soil.

The bog thermometers were placed in a ventilated shelter beside Well No. 11, Fig. 2, while the others were 9 rods away on a sand hill 4 rods from the edge of the peat, and 4.1 feet higher. Both pairs were placed one foot above the surface. The readings were made daily at 7:00 A.M. The record covers only the period July 15 to September 16.

It will be seen from Table XXXV that the temperatures on the bog are very nearly the same as those on the mineral soil, except that the maximum is usually from 1 to 7 degrees higher on the latter, and the minimum from 1 to 4 degrees lower on the former.

This indicates that, for sensitive crops, the growing season on peat soils may be shortened by late spring and early autumn frosts, and that early maturing varieties would meet with most success on the peat.

Table XXXV - Maximum and minimum temperatures on the bog and on the adjacent mineral soil.

Date	Upland		Bog		Difference	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
July 15	78	68	79	66	-1	+2
16	90	72	91.5	70	-1.5	+2
17	85	69	87	67	-2	+2
18	83	70	86	68	-3	+2
19	89	72	90	71	-2	+1
20	90	56	80	83	0	+3
21	82	61	85	57	-3	+4
22	87	65	88	62	-1	+3
23	82	60	88	59	-6	+1
24	85	60	86	53	-1	+8
25	80	60	80	61	-0	+1
26	90	68	92	65	-2	+3
27	92	69	94	66	-2	+3
28	91	67	94	69	-3	-2
29	90	64	92	65	-2	-1
30	90	63	90	63	0	0
31	95	63	95	61	0	+2
Aug. 1	88	62	90	59	-2	+3
2	82	60	83	61	-1	-1
3	91	62	90	59	+1	+3
4	90	62	90	59	0	+3
5	93	60	91	59	+1	+1
6	92	60	91	59	+1	+1
7	88	60	89	59	-1	+1
8	93	66	92	64	+1	+2
9	80	57	82	55	-2	+2
10	85	66	85	64	0	+2
11	82	66	83	66	0	0
12	68	53	75	51	-7	+2
13	62	40	61	38	+1	+2
14	52	44	58	42	-6	+2
15	72	48	72	45	0	+3
16	80	57	81	54	-1	+3
17	81	55	81	55	0	+0
18	86	58	87	57	-1	+1
19	89	60	89	60	0	+0
20	87	60	88	60	-1	+0
21	90	80	90	80	0	+0
22	88	58	89	57	-1	+1
23	90	55	90	53	0	+2
24	80	58	81	55	-1	+3
25	73	49	73	44	0	+5
26	72	40	73	39	-1	+1
27	68	40	70	39	-2	+1
28	70	42	72	42	-2	0
29	72	45	74	43	-2	+2
30	-	-	-	-	-	-
31	80	47	81	47	-1	0
Sept. 1	77	55	75	54	+2	+1
2	67	39	65	36	+2	+3
3	76	54	75	54	+1	0
4	85	68	82	66	+3	+2

Table XXXV - (Continued)

Date	Upland		Bog		Difference	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Sept. 5:	83	61	82	60	+ 1	+1
6:	85	44	83	44	+ 2	0
7:	70	44	68	44	-2	0
8:	74	47	75	47	-1	0
9:	72	45	72	45	0	0
10:	70	47	70	47	0	0
11:	73	50	74	48	-1	+ 2
12:	69	48	68	48	+1	0
13:	67	45	68	45	-1	0
14:	68	47	70	47	-2	0
15:	55	37	54	35	+1	+ 2
16:	44	34	43	29	+1	+ 5

*A plus sign indicates a higher and a minus sign indicates a lower temperature on the mineral soil than on the marsh. Mr. Edward Miller made the temperature readings at the Oak Leaf Experimental Tract.

CROPS PLANTED - In Table-XXXVI there are reported the crops, the width of area devoted to each, the varieties, the rates and dates of seeding and the date of the appearance above the surface of the first plants.

Table XXXVI - Crops used in field experiment

Plot No.	Width of plot	Crop	Variety	Rate of seeding per acre:	Date of planting:	First appearance
A	1 rod	Potatoes	Early Cobbler	10 bush.	July 1	
B	1 rod	Buckwheat	Early Japanese	4 pks.	July 1	July 5
C	2 rod	Millet	Siberian	4 pks.	July 7	July 10
D	2 rod	Barley	Minnesota 105	2.5 bush.	July 1	July 5
E	2 rod	Grass mixture	Northrup-King 103	20 pounds	July 1	July 5
				2.5 bush.	July 5	July 10
F	2 rod	Oats	Big Four	5 pks.	July 1	July 4
G	2 rod	Flax	Minnesota 25			

The potatoes planted on July 1 failed to form a fair stand, the soil being so wet that they rotted. In August the plot was disced, rolled and harrowed in preparation for winter wheat.

The oats grew to a height of 8 or 10 inches on most of the plots before they turned yellow and began to die. On plots 14, 16, 30 and 33 they had grown to a height of 2.5 feet and were heading out when a herd of cattle broke in and ate off all of the barley, oats, millet and clovers.

The flax was partly on a ridge that extended the length of the tract and on this, higher and better drained than the rest, it made a good growth. On all the plots it grew to a height of 18 inches but the thickest stand was on those plots which had received an application of phosphorus in the form of bone meal. The most luxuriant growth was made on the plots to which nitrogen in the form of sodium nitrate had been applied in addition to the bone meal. The flax on the plots was forming seed when the cattle broke in and trampled it down to such an extent as to make harvesting useless.

Plate XII

Flax bundles taken as composite samples on the Oak Leaf Experimental Tract - 1, from plots 1 to 18; 2, from plots 19 to 36.

Plate XII shows samples of the flax taken from these plots.

The barley showed a strong germination and the young plants grew well until about 4 inches high, when they withered, turned yellow and died off. The barley on the plots which received applications of sodium nitrate, 12, 15, 20 and 35, grew to a height of 10 inches before dying off, but showed the same effects as the plots with the shorter crop.

Evidently the oat and barley plants suffered from the insufficient drainage which caused a lack of aeration and consequent nitrification. The lack of nitrogen was shown by the growth made on the plots to which an application of nitrogen had been made.

The millet, being able to stand the wet soil conditions better than the barley or oats, made a better showing than these. On the four plots receiving nitrate it grew to a height of 1 foot and had headed out before being destroyed by the cattle. On plots 11 and 29 and on 14 and 22 it had reached a height of 8 inches and was heading out when destroyed by the cattle. The first two plots had received limestone, potash and bone meal, while the other two had had an application of potash and bone meal. On plots 6 and 34, receiving bone meal only, and on 9 and 27 with bone meal and limestone it grew to a height of 6 inches and then began to die off. On all other plots it grew to a height of only 1 or 2 inches before dying.

The grass mixture sown alone and with the barley, oats and flax consisted of a mixture of timothy, redtop, meadow fescue, alsike and medium red clover in the proportions 36, 16, 4, 16 and 28, respectively. This was sown at the rate of 20 pounds per acre.

The grass and clover grew well up to the time it was eaten off by the cattle, August 24, after which it came on again. A careful examination had been made about the middle of August, when the clovers and grasses made a fine showing on all the plots receiving phosphorus, on these having stooled out, covered the ground and grown to a height of 6 inches, all being vigorous. A considerable amount of smartweed grew in these phosphorus-fertilized plots, especially on those to which no lime had been added. Where lime was added in addition to the bone meal the growth of smartweed was very light. This held true on all the plots where the grass mixture was seeded with grain as well as where it was sown alone. On the plots not receiving an application of phosphorus the growth of clover was smaller and scattering and very little of the grasses was showing. The height of the clover on these plots was only from 1 to 2 inches. The manured plots made a better showing than the checks, but not nearly so good as the phosphorus fertilized plots, the clover and grasses growing to a height of 4 inches and covering the ground fairly well. The general conclusion drawn was that phosphate produced a markedly beneficial effect, which was still more marked when potash also was applied. Nitrogen added to the above gave a more luxuriant growth. The bone meal favored the growth of smartweed, which, however, was greatly lessened by the simultaneous addition of ground limestone. Potash and limestone, both alone and together, showed no distinct benefit.

The buckwheat did the best of all. This was able to withstand the very wet soil conditions. Sown on July 1, it was one inch high 4 days later and from then on made a vigorous growth. By July 29 it was in full bloom and was harvested on September 23.

The results of the buckwheat plots are shown in Table XXXVII.

Table XXXVII- Growth and yield of buckwheat on the plots. The data for the two series, E and W, are reported as well as the averages.

Plot No.	Treatment	Height of Plants	Yield per acre					
			Grain			Straw		
			E.	W.	Average	E	W	Average
		Inches	Bushel	Bushel	Bushel	cwt.	cwt.	cwt.
1,19	Check	4--6	1.7	.4	1.0	1.5	.3	.9
2,20	L, hydrated	6	2.0	.7	1.3	2.2	1.0	1.6
3,21	L, ground	6	2.6	1.1	2.8	2.1	.9	1.5
4,22	Check	4--6	2.4	.7	1.5	1.1	.5	.8
5,23	K	8-12	2.1	3.8	2.9	.8	3.3	2.0
6,24	P	18-24	10.3	10.8	10.5	9.3	7.9	8.6
7,25	Check	6-8	1.5	2.9	2.2	1.7	2.6	2.1
8,26	LK	8-12	1.1	1.0	1.0	1.3	.7	1.0
9,27	LP	18-22	13.9	19.8	16.8	8.8	8.9	8.8
10,28	Check	8-10	4.4	1.2	2.8	3.7	.1	1.9
11,29	KLP	20-26	15.5	14.5	15.0	17.3	23.0	20.1
12,30	KNPL	30-36	19.6	35.5	27.0	18.5	25.3	21.9
13,31	Check	10-16	5.8	7.9	6.8	4.3	5.4	4.8
14,32	KP	20-26	19.8	21.5	20.6	15.7	21.1	18.9
15,33	KNP	33-36	12.3	17.6	15.0	17.8	27.4	22.6
16,34	Check	6--8	2.9	2.2	2.6	2.6	3.1	2.3
17,35	Manure,10 T:	12	3.9	5.6	4.7	3.5	3.1	3.3
18,36	Manure,20 T:	12-18	7.9	12.8	10.0	3.9	3.3	3.6

From the above table it will be seen that lime alone, both in the form of quicklime and as ground limestone, shows no distinctly beneficial effect upon the yield of either straw or grain. This also holds true with both the potash alone and the potash with lime. Phosphorus, on the contrary, increased the yield of grain from 2.73 bushels on the check to 10.56, while the addition of lime in the form of ground limestone to the bone meal gave an average of 16.81 bushels per acre, and potash with phosphate gave 20.66 bushels. Thus we see that, while neither the lime nor the potash alone, seem to have any beneficial effect, yet when added with phosphate they almost doubled the yield. The addition of nitrate caused an increased yield of straw, but showed an uncertain effect upon the yield of grain. Thus the yields on the NKPL plots were better than on the KPL, but those on the NKP plots were lower than those on the KP plots.

The general conclusion from the work with buckwheat is that an addition of phosphate is absolutely necessary to secure satisfactory returns, while the addition of potash or lime in addition to the phosphorus will increase the yields. Better drainage would probably have increased the yields on all the plots.

Winter grain crops were seeded on plots A, C, E and F on September 1, after the plots had been plowed, double disced and harrowed twice. The next day they were seeded with a drill - plots A and C to rye, E and F to Turkey red winter wheat, after which they were rolled twice and left for the winter. Plots D and G were allowed to remain for the grass mixture to develop for the second year's growth.

Plate XIII

Fig. 1 - Samples taken from the buckwheat plots, Oak Leaf Experimental Tract, 1 to 9, showing the effects of the various fertilizer treatments. There are 30 plants in each bundle.

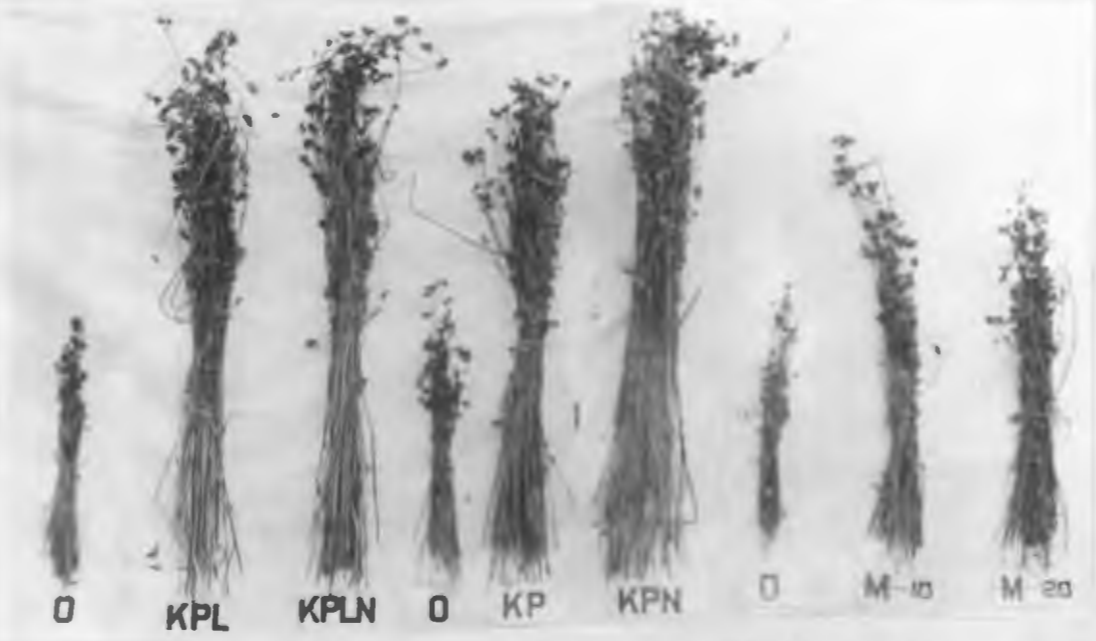


Fig. 2 - Buckwheat samples from plots 10 to 18 from Oak Leaf Tract.

Plate XIV

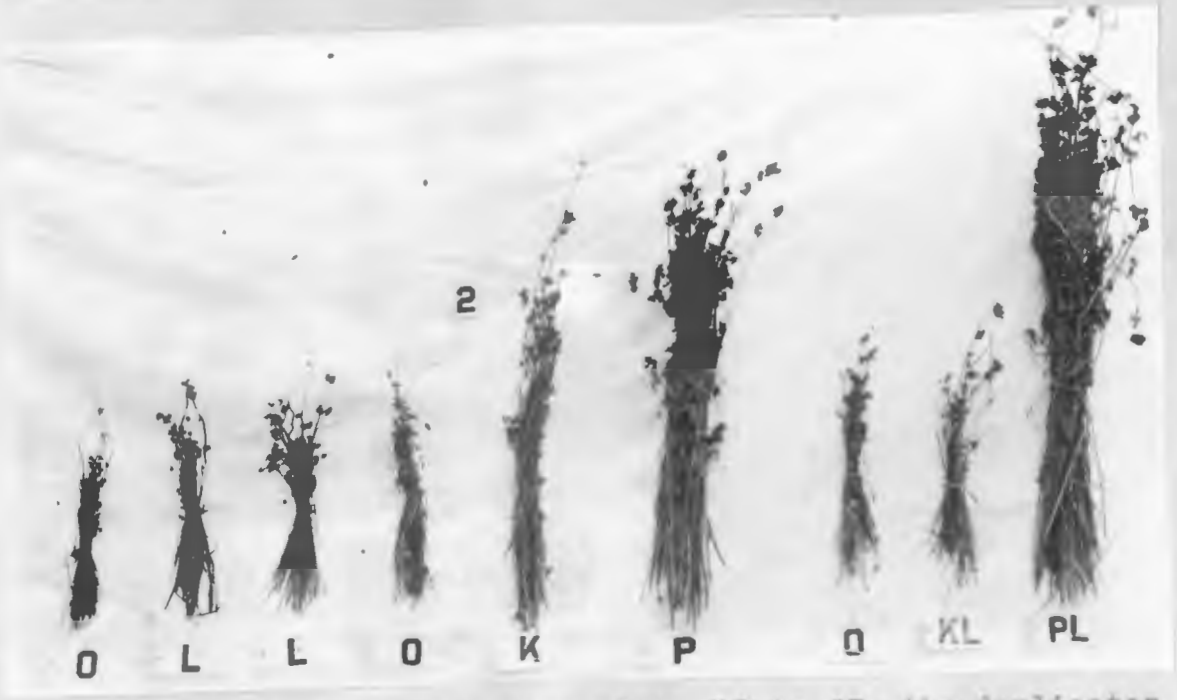


Fig. 1 - Buckwheat samples from plots 19 to 27, the duplicates of plots 1 to 9, mentioned in Plate XIII

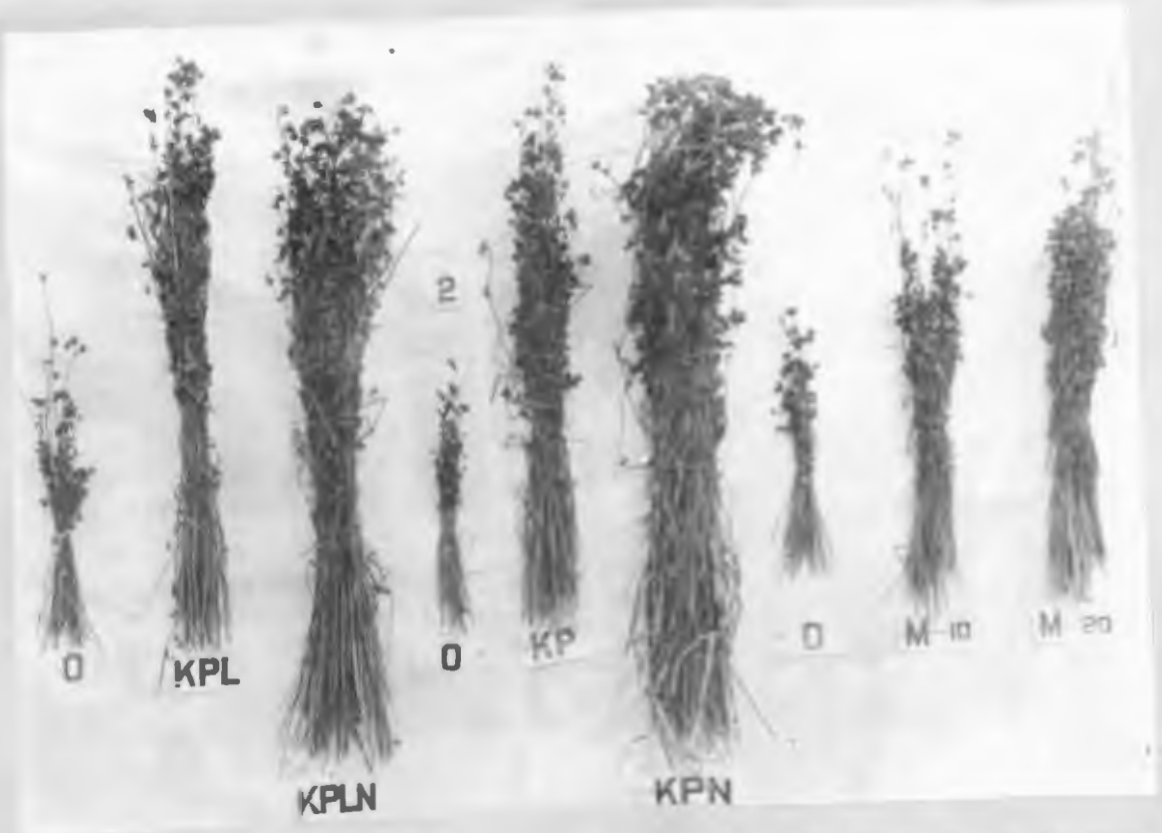


Fig. 2 - Buckwheat samples from plots 27 to 36, the duplicates of plots 10 to 18 in Plate XIII.

GENERAL CONCLUSIONS FROM FIELD EXPERIMENTS - From the growth of the crops on the experimental tract it is very evident that for the first crop at least, and probably for the first few crops the peat on the Oak Leaf Farm lacks phosphorus more than any other plant food, while the addition of potash alone has no immediately beneficial effect. The supply of lime is sufficient to prevent an application of it showing any beneficial effect on the first season with clover, both when used alone and with either potash or phosphate, or both. With the buckwheat it had no effect alone, but appeared to heighten the effect of the phosphate. The latter fact together with its depressing effect upon the smartweed may possibly make an application of ground limestone profitable for some crops, although not essential for satisfactory yields. Potash applications appear not essential for the first crop or two, but experience everywhere else warns us that they will be absolutely necessary within a few years. Stable manure, even in the 20 ton applications, had a very disappointing effect compared with that of the phosphate.

In the greenhouse experiments on this soil, as reported above, 400 pounds of acid phosphate, costing $3.40, had as beneficial an effect as 800 pounds of bone meal, costing $12.00. The increase in the yield of buckwheat and clovers would be sufficient to make it a highly paying proposition, provided the peat areas were properly drained. If smartweed should bother seriously, which is improbable, the addition of ground limestone at the rate of 2 tons per acre, will control this. Potash, although increasing the yield, will, during the duration of the war, be sold only at prohibitive prices, $400.00 per ton or upwards. However, it will be necessary to add potash in some form after a very few years of cultivation.

RELATION OF THE RESULTS OF THE FIELD AND GREENHOUSE EXPERIMENT TO THE CHEMICAL COMPOSITION OF THE PEAT

The chemical analysis of the samples of peat soil from all parts of Anoka County show that the main areas of its peat lands are similar in composition to those of the experimental tract on the Oak Leaf Farm. Accordingly, the results of experiments with the latter are applicable to most of the peat land of the county. While many of the areas are richer in lime than the experimental tract the amount even in this is sufficiently high to render liming unnecessary. Notwithstanding the general prevalence of high-lime peats there are scattered all over the county limited tracts with a lime content so low as to make it probable that liming will be an indispensable first treatment in their reclamation.

The field experiments showed the phosphates so deficient as to render an immediate application of a commercial form of these indispensable, unless stable manure be procurable, but the latter can be more profitably employed on mineral soils. The greenhouse experiments confirmed this, but in addition showed that said phosphate in a more economical form than either steamed bone meal or raw rock phosphate. Potash, while showing little or no effect when applied alone, proved beneficial when added with the phosphate, both in the field and in the plant house. The lime, while showing no beneficial effect upon clover and grass in the field did not there exert a distinctly depressing effect as it did in the greenhouse. Nitrogen fertilizers, the most valuable constituents of stable manure, appear from both field and greenhouse experiments to be superfluous.

On the whole the indications as to the necessary fertilization

revealed by the three methods, chemical analysis, pot experiment, and field experiment, are in satisfactory agreement.

CONCLUSIONS

The peat lands of Anoka County occupy about 90,000 acres, 31 per cent of its surface, large bogs being found in every township. Of the total peat acreage about 95 per cent has a peat layer of more than 18 inches in depth. Most of it is from 3 to 10 feet deep, although about one-sixth of it is more than 10 feet deep.

The vegetation on the bogs consists chiefly of redtop, wire-grass, other sedges, tamarack, rushes, willow, elder and poplar brush and cranberries.

The wire-grass is used for carpet manufacture, while the redtop and sedges are cut for hay. The most profitable use of the unreclaimed peat land at present is for the production of wire-grass for carpet manufacture. Only about 100 acres are under cultivation and of this only 5 acres produced a crop in 1916.

The average net return above the cost of labor for the whole of the peat acreage of the county is estimated at $1.00 per acre.

Most of the marsh areas are underlain by black or yellow sand and the rest by clay or marl.

Samples from all parts of the county were analyzed and these, with a few exceptions, showed a high percentage of soluble ash, nitrogen and lime. The degree of acidity of the various samples indicated by the Truog test corresponded in general with the lime content. In general the peats with a high proportion of soluble ash had a high lime content, and showed little or no acidity with the Truog test. The peat of the cranberry marshes possessed a low ash and low lime content and showed a high degree of acidity.

The numerous marl deposits of the county have a calcium carbonate content varying from 25 to 65 per cent. These could be employ-

ed in the reclamation of the limited areas of lime-deficient peat, in their immediate vicinity.

Greenhouse experiments with clover and barley indicated that lime has a depressing effect while phosphates greatly increase the yield. Potash applied alone showed no benefit, but when used in addition to phosphate, it increased the yield. Three forms of phosphate - steamed bone meal, acid phosphate and raw rock phosphate, were compared. All increased the yield, but the acid phosphate proved the most profitable as well as giving the largest returns.

The results of the field experiments with lime, phosphorus and potassium are in accord with those obtained in the greenhouse. Manure, when added at the rate of 10 tons per acre, increased the yield, and at twice that rate to a still greater extent. But even the latter did not have as beneficial an effect as 800 pounds of steamed bone meal.

While the deficiency of both phosphates and potash may be more or less fully met by applications of stable manure or by repeatedly burning off the surface layers of the peat, neither of these methods is likely to prove economical. For the reclamation of most of the peat lands of Anoka neither lime nor nitrogen fertilizers will be necessary, but some form of phosphate will be needed in the first year. Potash may be omitted for a year or two, but within a few years at most, it is to be expected that it will prove as deficient as the phosphate does with the first crop.