Bulletin No. 20. *April*, 1930.

UNIVERSITY OF ALBERTA
COLLEGE OF AGRICULTURE

SOIL SURVEY
OF
ST. ANN SHEET

BY

F. A. WYATT, J. D. NEWTON and T. H. MATHER
(With Appendix I by J. A. Allan)
University of Alberta
Edmonton, Alberta

Distributed by
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The authors of this report wish to acknowledge their appreciation of the sympathy and support given by the Minister of Agriculture and the executive member of the Alberta Department of Agriculture, and those of the Dominion Department of the Interior, who have aided and made possible the preparation and publication of this soil survey report.

The soil survey report for the St. Ann Sheet is the result of co-operation between the Alberta Department of Agriculture, Dominion Department of the Interior, Topographical Branch, and the University of Alberta, Soils Department; together with Dr. J. A. Allan, Professor of Geology.

The Alberta Department of Agriculture has provided the funds for conducting the field work and the cost of printing the soil maps.

The Department of the Interior, Topographical Branch, has supplied the topographical data from the revision survey of this area and has been responsible for the drawing, lithographing and printing of soil maps.

The members of the Soils Department of the University of Alberta have conducted the field and laboratory work in connection with mapping the soil types, collecting the samples, making the physical and chemical analysis and preparing the report. Dr. J. A. Allan has inspected the area covered by this report, and kindly prepared the chapter in the appendix dealing with the geology of the St. Ann Sheet.

(Published by the University of Alberta at the request of Hon. George Hoadley, Minister of Agriculture.)

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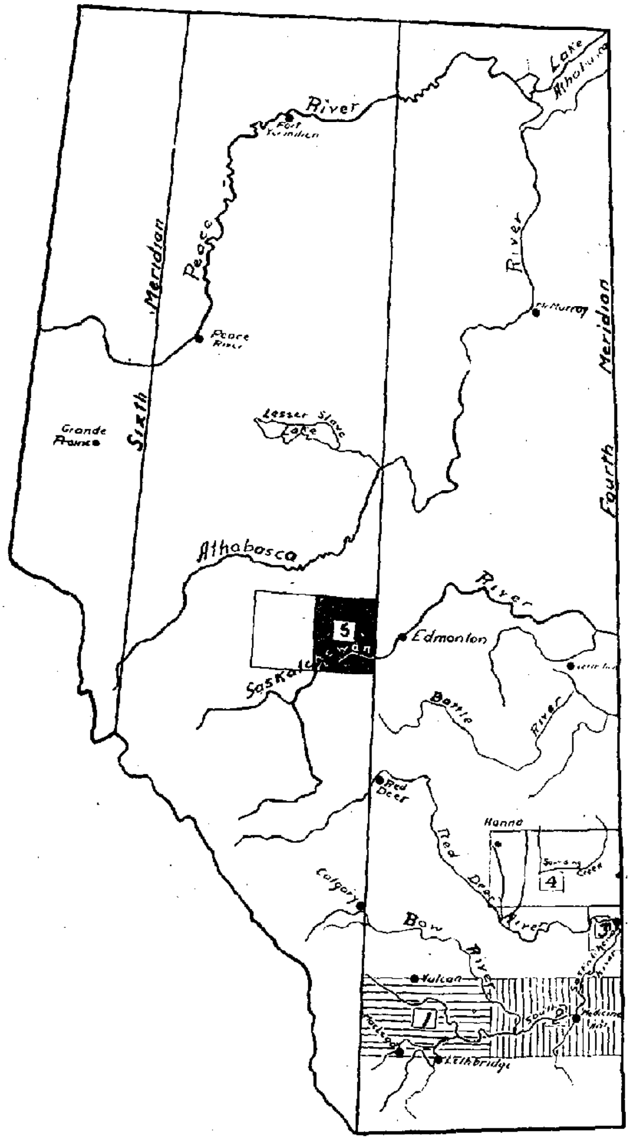

Fig. 1—Sketch map of Alberta, showing locations of surveyed areas. 1, Macleod Sheet; 2, Medicine Hat Sheet; 3, Part of Rainy Hills Sheet; 4, Sounding Creek Sheet; 5, St. Ann Sheet. Reports issued for 1, 2, 4, and 5.

PREFACE

The farmer is among the first to recognize the fact that soils vary tremendously in their power to produce crops. This variation is due to differences in physical, chemical, and biological relationships within the various soil types. The report of the soil survey classifies the lands of the surveyed area according to these various characteristics and relationships, and discusses their effects upon crop production. The report is, therefore, valuable to the farmers, and likewise valuable to any other persons interested in the soils of the surveyed area, as, for example: land seekers, colonization agents, land appraisers, district agricultural representatives, experimental farm officials, bankers, road commissioners, real estate dealers, provincial and Dominion government officials.

The report accompanying the soil map describes the properties of the surface and subsoil of the various soil types, topography, drainage, crop adaptation, water supply, fertility invoice of the soils, systems of farming and methods of soil management, and alkali problems. It also contains a brief discussion of the climate and agricultural development of the area together with the important farm crops, transportation facilities and population.

The soil map is an important part of the report. It is made on the scale of three miles to the inch, and shows not only the different soil types represented by different colors, but also important physical features such as topography, roads, railroads, streams and towns. Furthermore the soil map serves as a very convenient reference by which the better land can be distinguished from the poor land by any person interested in the soils of the surveyed area.

Our best land should be settled first, and since our soil resources are enormous it is unwise to allow farmers to settle on poor land until the good land is taken up. It will mean greater prosperity for the province as a whole, as well as for the individual farmers if only the better land is broken up at first. True, this particular argument does not apply to a considerable part of the area covered in this report, since some of the land was settled long before the survey was conducted. It would have been better to have conducted a survey of this kind before the land was brought under cultivation. Then certain of the poorer tracts which are now being cultivated to some extent, might have been held for range or timber land.

and not broken at all. It would have been a kindness to many of the then prospective settlers who have been unfortunate in their selection of land if this had been done.

The results of crop, fertilizer and cultural method experiments obtained at the larger government experiment stations in our province do not necessarily apply to all parts of the province. The men in charge of the experiments recognize that it is very often necessary to determine whether the results obtained at the stations do or do not apply to the various local districts. When planning extension experiments in various parts of the province the soil maps should prove very valuable, since they would show where the plots should be placed in order to represent important or extensive soil areas. The farmers round about would then knew whether a certain crop or treatment could be expected to bring them results similar to those obtained on the experimental plots, since the soil maps would tell them whether the soils were, or were not, alike.

Similarly, the soil report tends to place the information of one farmer at the disposal of other farmers. If one farmer sees that another farmer on land classified the same as his, is making more money, he can observe what crops the more successful farmer is growing, and how he is working his land, and, by adopting similar crops and methods he may expect to obtain similar results.

Within recent years considerable attention has been paid to the study of plant diseases in the prairie provinces, as it is known that the losses caused by such diseases are frequently very large. The prevalance of certain of these diseases, such as grain root rot and potato scab, is probably influenced by the type of soil, and it would be interesting and important to correlate soil types and plant diseases. Important relationships might likewise be found to exist between soil types and certain insect pests.

If it is worth while to conduct surveys to determine our mineral, timber and various other resources, and to map out in detail the topographical features of the province, surely it is worth while to take an inventory of our most important natural resource, namely, the soil. Soil surveys are of the greatest economic importance and furnish information that can be secured in no other way.

Soil Survey of St. Ann Sheet, Alberta

BY

F. A. WYATT, J. D. NEWTON and T. H. MATHER*

(With Appendix I by J. A. Allan)

DESCRIPTION OF THE AREA

The St. Ann sheet is located in west-central Alberta, or west of the city of Edmonton, as indicated by the sketch map. It consists of an area of 48 miles north and south by 84 miles east and west, but so far only the eastern half of the sheet has been covered by the soil survey, and this report is therefore limited to the eastern half of the St. Ann sheet. More exactly the surveyed area consists of that portion of townships 49 to 56 (inclusive) which occupies ranges 1 to 6 or 7 (inclusive), west of the 5th meridion. The western boundary of the surveyed area is not a straight line, but it follows irregularly through range 7 from north to south. From the northern edge of the sheet it follows the Pembina river more than half way across the sheet, and thence to a point west of the North Saskatchewan river on the southern boundary. The eastern boundary consists of the 5th meridian, which line is about twenty miles west of the city of Edmonton. The town of Stony Plain lies within the sheet, close to the 5th meridian, at a point halfway between the northern and southern boundaries.

The soil map for the area described represents about 52 townships, or about 1,200,000 acres.

The wooded soil belt covers the greater part of northern and west-central Alberta, or about two-thirds of the entire province, and about forty per cent of the area covered by the report lies within this belt. The remainder of the area is made up largely of incipient wooded soils, some areas of which are surrounded by the characteristic wooded soils. At the eastern end of the sheet, in the vicinity of Stony Plain, there is a relatively small area which belongs to the black soil belt. These belts are described later in connection with the topic of soils, and are clearly distinguished on the soil map.

*Messrs. A. Leahey and J. L. Doughty assisted with the field, analytical and mapping work during the course of the preparation of this report.

The surface of the eastern half of the St. Ann sheet is, in greater part, gently rolling or rolling, but there are a few areas of hilly land in various parts of the sheet. There is a fairly large area of hilly land on the northern side of the sheet, a few miles north of Lake St. Ann, and at the eastern end of the sheet, several miles north of Stony Plain, there is a hilly area locally known as the Glory Hills. South of the Saskatchewan river, in ranges 3, 4, and 5, there are two smaller areas of hilly land. The extent of the hilly and rolling areas is shown by the hatching on the map, and is discussed later in connection with the description of the various soil types.

The general elevation of the surveyed area is about 2,500 feet, varying from about 2,300 feet in the north-east corner of the sheet, to about 2,700 feet in the south-west corner of the surveyed area. The St. Ann sheet as a whole slopes upwards in a generally south-westerly direction, towards the Rocky mountains, the elevation in the north-east corner being about 2,300 feet, and in the south-west corner about 3,400 feet.

The eastern end of the St. Ann sheet, including most of the surveyed territory, is drained by the North Saskatchewan river and its tributaries. A small area at the western end of the surveyed territory, mainly in the north-west corner, is drained by the Pembina river. All of the unsurveyed territory in the western half of the St. Ann sheet is drained by the Pembina and McLeod rivers and their tributaries. The McLeod river drains the north-west corner of the sheet, whereas the Pembina river drains the south-west quarter and the north-central part of the sheet.

It is interesting to observe that the McLeod and Pembina rivers are tributaries of the Athabaska river, which flows, northward, towards the Arctic, whereas the North Saskatchewan river flows eastward towards Hudson Bay and the Atlantic. The watershed or height of land between the Arctic and Atlantic therefore passes in a north and south direction through the St. Ann sheet, just east of the Pembina river.

The eastern tributaries of the Pembina river, within the surveyed territory, are all rather small creeks, and the largest tributary of the North Saskatchewan river within this territory is the Sturgeon river, in the north-east quarter of the sheet. All of the surveyed area south of the North Saskatchewan drains directly into this river by means of Buck creek, Strawberry creek, Weed creek, and other tributaries.

Lakes are fairly numerous in the surveyed territory, and the largest of these are Lake Wabamun and Lake St. Ann. Isle and Low-Water lakes come next in order of area, but they are much smaller than the first two mentioned. Low-Water lake lies south of Lake Wabamun; it is drained into the North Saskatchewan river to the south by a short channel called Shoal Lake creek. This lake is very shallow, as its name implies, and the bed of the lake has been partially reclaimed for hay meadow purposes by deepening the drainage channel. Isle lake lies south-west of Lake St. Ann and is drained into Lake St. Ann by the Sturgeon river, the distance separating the two lakes being only three or four miles. Lake St. Ann is drained by a continuation of the Sturgeon river which flows eastward and eventually empties into the North Saskatchewan river near Fort Saskatchewan. Lake Wabamun is drained into the North Saskatchewan to the south-east by a comparatively short drainage channel known as Wabamun creek. This lake originally drained into the same channel that drains Isle lake and Lake St. Ann, by means of an old channel that runs north and east from Lake Wabamun. This old channel is now occupied largely by swamp land. Sandy lake is the largest of a group of lakes in the north-east corner of the surveyed territory, and there are many other smaller lakes in various locations. Cottage lake, several miles south-west of Stony Plain, is a popular summer resort known as Edmonton Beach, and just west of Cottage lake, in township 52, range 2, there are, in this single township, no less than eighteen small lakes. Some of the smaller lakes and swamps are poorly drained and contain considerable quantities of alkali salts. In most cases, however, the lakes of the St. Ann sheet possess outlets and the rainfall is sufficient to keep them comparatively fresh.

Swamps or muskegs are fairly numerous, and the larger of these are outlined on the soil map, and discussed later in connection with the description of the various soil types. The natural drainage of the surveyed territory is generally good, however, the land being, for the most part, gently rolling, or rolling in nature, with few large flat areas of heavy soil.

It is believed that the soil material consists mainly of glacial drift, derived largely from the underlying formations.

Some of the drift material, however, was undoubtedly carried long distances by the Keewatin glaciers which moved down from the region just west of Hudson Bay.

The North Saskatchewan and Pembina rivers draining the area, occupy for the most part the old preglacial valleys, and on their banks and the banks of their tributaries may be seen outcroppings of the parent material underlying the surface covering. These outcrops in the main consist of degraded shales and sandstones, some of which go to make up the existing soils.

The main towns or centers of population occur along the railways, but none of these is very large. The town of Stony Plain, on the main line of the Canadian National Railways, at the eastern edge of the sheet, or about twenty miles west of Edmonton, is the largest. It has a population of about 600 and is the center of a rich farming district. Farther west, along the main line, the summer cottage towns of Wabamun and Seba Beach are located at the eastern and western ends of Wabamun lake, respectively. These towns are to some extent also farming district centers, and the Lakeside coal mine is located just west of Wabamun. At the western edge of the surveyed territory, on the main railway line, the town of Entwistle is located on the eastern side of the Pembina river, and the town of Evansburg on the western side. Evansburg is a coal mining town with a population of about 400. Alberta Beach, on the eastern side of Lake St. Ann, another summer cottage town, lies on the Lake St. Ann branch of the Canadian National Railways. Onoway, a farming district center with a creamery and a population of about 150, lies about six miles east of the lake, or just east of the Whitecourt line junction. Sangudo, another farming district center, is located on the Whitecourt line, where it crosses the Pembina river, at the north-west corner of the surveyed territory. Quite a number of other towns are located along the various railway lines, as shown on the map.

The transportation facilities for a large part of the surveyed territory are good. The new branch line of the Canadian Pacific Railway, running from Lacombe to Leduc, west of the main Edmonton-Calgary line, passes through the south-east corner of the sheet, and greatly improves the transportation for that part of the surveyed area which lies south of the Saskatchewan river. North of the Saskatchewan river the only part of the surveyed area which is very far from a railway is the south-west corner, or the territory between the Saskatchewan and Pembina rivers, south-west of the Tomahawk creek valley. The main line of the Canadian National runs east and west through the center of the sheet, while north of the main line good transportation facilities are provided by the Lake St. Ann and Whitecourt branches of the Canadian National Railways.

Road construction in this area is closely associated with degree of settlement, as might be expected. In the more sparsely settled or heavily wooded parts good graded roads are not numerous, but are constructed as demanded by settlement. The more thickly settled districts are well traversed by public highways, of which the main ones are well graded dirt roads, which are in good condition during the greater part of the year. The Jasper highway is located near the main railway line, and therefore passes east and west through the surveyed territory. The western section of another much-travelled highway between Edmonton and Lake St. Ann runs through the north-east quarter of the sheet. It is altogether likely that these highways will be gravelled in the near future.

CLIMATE.

The climate of the St. Ann sheet is fairly typical of the climate of the high plains region of western Canada. It is characterized by long, bright, moderately warm summer days, and bright, cold dry winter weather. High winds, such as occur occasionally in the southern and south-eastern plains region, are very rare, and the crops are seldom affected by hot, dry winds, such as sometimes injure the crops of the treeless plain region to the south. The "Chinooks", which bring about occasional thaws during the winter in the southern plains region, seldom reach Edmonton, or the St. Ann sheet; the winter weather is consequently steadier, and a snow covering is more apt to be maintained throughout the winter months, than in the plains region. The climate is characterized by a high proportional amount of sunshine. The Dominion Meteorological Records state that the average of many years at Edmonton was 2,204 hours of sunshine per year, whereas the averages at several other points in Canada were as follows: Winnipeg 1988, Guelph 1885, and Ottawa 2019 hours, respectively.

Meteorological records show that evaporation from a free water surface is less in central Alberta than on the treeless plains to the south. This is in all probability due chiefly to the higher and more frequent winds of the plains.

At no point in the St. Ann sheet have meteorological records been kept for any great length of time, but such records for Edmonton are generally applicable to the surveyed territory.

Table I, compiled from the Dominion Meteorological Records, shows the average seasonal distribution of precipitation for a period of forty-three years at Edmonton. This distribution is representative of the surveyed territory. For the precipitation see Table II.

TABLE I.—SEASONAL DISTRIBUTION AT EDMONTON.
PRECIPITATION IN INCHES.

	Precipitation 1885–1927				Snow 1885–1914	
	Average Monthly Fall	Greatest Amount in one Month	Total Amount in driest year, 1889	Total Amount in wettest year, 1900	Average Monthly Fall	Greatest Amount in one Month
December	.75	3.21	.31	1.25	6.8	32.1
January	.75	2.49	.05	.78	7.0	24.1
February	.67	2.33	.00	2.18	6.7	23.3
Winter	2.17		0.36	4.21	20.5	
March	.67	1.93	.07	1.93	6.2	19.3
April	.78	2.60	1.17	2.60	3.6	14.0
May	1.86	4.04	.22	2.71	1.3	15.0
Spring	3.32		1.46	7.24	11.1	
June	3.26	8.53	1.30	3.77	T	1.2
July	3.56	11.13	1.85	3.91	......	......
August	2.47	6.43	1.15	4.18	T	1.0
Summer	9.29		4.30	11.86	T	
September	1.40	4.32	1.45	3.16	1.7	10.8
October	.74	2.28	.08	1.16	3.5	16.0
November	.73	3.57	.51	0.18	6.7	35.5
Fall	2.87		2.04	4.50	10.9	
Year	17.64		8.16	27.81	42.5	

From Table I it may be seen that about 53 per cent of the average annual precipitation at Edmonton for the forty-three year period, 1885-1927, fell during the summer months; that the important growth months of May, June, July, and August received over 63 per cent of the yearly precipitation, and that approximately 80 per cent fell during the months of April to October inclusive. With such a favourable distribution the rainfall is decidedly more effective in producing crops than a similar annual precipitation would be if it were more largely distributed over the late fall, winter, and early spring months. The distribution of precipitation is more favourable over the prairie provinces, as a rule, than in the eastern provinces or along the Pacific Coast. In the eastern provinces and along the Pacific Coast a greater proportion of the total precipitation occurs in the late fall, winter, and early spring months, as a rule, and a given annual precipitation is not as affective under these conditions. This helps to explain why large crops are commonly produced in the prairie provinces, in spite of the relatively low annual precipitation.

It may be noted that large differences in annual precipitation sometimes occur, as that of the driest year is less than one-third that of the wettest year. These variations may be further perceived by referring to Table II. The seasonal variability is not nearly as great, however, as in some of the drier sections of the prairie provinces. There is probably as much proportional variation in the distribution of snowfall as of rainfall, but the soils of the sheet usually remain covered during the winter months, which tends to hold the moisture and prevent blowing. Soil drifting is not a serious problem of the St. Ann sheet. In Table II the records for the twenty-four year period, 1904-1927, are given, together with the records for Calgary and Medicine Hat for purposes of comparison.

From Table II it may be noted that at Edmonton the lowest record for the twenty-four year period, 1904-1927, was 12.5 inches, whereas at Calgary the precipitation was less than 10 inches in one year, 1918, and at Medicine Hat the annual precipitation dropped below 10 inches in seven years out of twenty-four. When the annual precipitation is below a certain minimum it is almost impossible to produce a crop for that year, and what little rainfall does come has a very low efficiency factor. This is discussed in connection with the topic of agriculture.

TABLE II.—PRECIPITATION RECORDS FOR EDMONTON, CALGARY, AND MEDICINE HAT, 1904-1927.

	Rainfall in Inches		
	Edmonton	Calgary	Medicine Hat
1904	19.87	11.89	9.70
1905	15.56	14.32	8.99
1906	19.35	16.38	12.62
1907	16.62	13.96	6.86
1908	12.50	18.25	10.22
1909	12.94	13.66	9.78
1910	14.93	11.62	7.55
1911	20.67	19.57	16.24
1912	20.18	21.32	10.38
1913	19.54	17.03	13.62
1914	25.29	16.70	12.17
1915	18.64	18.32	16.13
1916	20.95	13.91	17.90
1917	15.25	11.44	11.13
1918	17.86	8.90	10.19
1919	16.43	12.21	7.66
1920	18.16	14.42	10.74
1921	15.22	13.50	11.74
1922	13.73	10.63	11.34
1923	16.91	23.87	13.64
1924	18.76	25.49	9.86
1925	17.44	18.09	14.64
1926	22.11	24.39	11.90
1927	17.68	29.85	25.28
Average	17.78	16.66	12.09

The frost-free periods have a considerable bearing upon the risk in producing certain of the farm crops, and usually we may expect the time taken to mature the crop to be longest during the wettest years; thus the danger from frost would be increased for the wettest years.

The average length of the frost-free period for the twelve years from 1915 to 1926, inclusive, was 89 days at Edmonton, 95 days at Calgary, and 130 days at Medicine Hat. The shortest frost-free period in any one year, at any one of the three places, was 52 days; this short period occurred at Edmonton in 1918. The shortest frost-free period at Calgary was 54 days, and at Medicine Hat 98 days. The longest frost-free period at Edmonton was 123 days, at Calgary 119 days, and at Medicine Hat 148 days.

It should be noted, however, that the frost-free period is seldom as long as the growing season for wheat and other commonly grown crops. As a rule the earliest fall frosts are too light to damage the ripening wheat and oats, and the late spring frosts seldom affect these grain crops seriously. The average length of periods in which the lowest temperature was six degrees of frost, for the eleven years from 1916 to 1926 (inclusive) was 146 days at Edmonton, 144 days at Calgary, and 168 days at Medicine Hat. The shortest period during these years was 118 days at Edmonton, 105 days at Calgary, and 154 days at Medicine Hat, whereas the longest six-degree frost period was 175 days at Edmonton, 166 days at Calgary, and 209 days at Medicine Hat.

TABLE III.—MONTHLY, SEASONAL AND ANNUAL MEANS AND EXTREMES AT EDMONTON, ALBERTA, 1885-1914.

Month	Temperature.						
	Mean	Mean Maximum	Mean Minimum	Highest Monthly Mean	Lowest Monthly Mean	Extreme Highest	Extreme Lowest
December	16.0	24.7	7.3	25.0	3.9	60	—43
January	5.9	15.6	—3.8	21.9	—13.7	57	—57
February	10.6	21.1	0.1	23.7	—10.4	62	—57
Winter	10.8	20.5	1.2			62	—57
March	23.4	34.9	11.9	36.6	8.5	72	—40
April	40.8	52.9	28.6	48.8	31.2	84	—15
May	51.2	64.4	38.1	57.3	43.6	90	10
Spring	38.5	50.7	26.2			90	—40
June	57.3	70.1	44.4	61.9	52.4	94	25
July	61.2	73.7	48.8	66.4	57.8	94	33
August	59.0	71.6	46.4	63.6	55.9	90	26
Summer	59.2	71.8	46.5			94	25
September	50.4	62.9	37.8	55.4	45.1	87	12
October	41.7	53.2	30.3	47.4	35.5	82	—10
November	24.5	33.3	15.6	38.0	—0.4	74	—37
Fall	38.9	49.8	27.9			87	—37
Year	36.9	48.2	25.6			94	—57

As previously stated, the climate of the surveyed area is characterized by moderately warm summer weather, and cold, dry winter weather, with a high proportional amount of sunshine. An idea of the variations in temperature may be obtained from Table III taken from the Dominion Meteorological Records for the thirty-year period, 1885-1914. In order to make clear the various column headings in Table III let us consider the December figures in the uppermost line.

The first column, first line, simply states the average or mean temperature for December throughout the thirty-year period.

In the second column, first line, is given the mean or average maximum for December. This is obtained as follows: an average of the highest daily temperatures of each of the thirty Decembers is taken and 24.7 represents an average of these thirty figures thus obtained. The mean minimum temperature for December is calculated similarly for column three.

In the fourth column, first line, is given the highest monthly mean, which in this case represents the average temperature of the warmest December, during the thirty-year period. Similarly, the figure in the fifth column represents the average temperature of the coldest December that occurred during the thirty-year period.

In the sixth column, first line, is given the highest or warmest December temperature that occurred in the thirty-year period, and in the seventh the lowest, or coldest.

The yearly mean or average temperature is 36.9 degrees Fahrenheit. The mean maximum yearly temperature is about 48 degrees. This figure represents an average of the highest daily temperatures throughout the year, for the thirty-year period under consideration. Similarly, the mean minimum yearly temperature, which is about 26 degrees, represents an average of the lowest daily temperatures throughout the year, for the thirty-year period under consideration.

The highest temperature recorded is 94 degrees, and the lowest 57 degrees below zero. However, these extremes do not give a correct idea of the usual variations in temperature. A better idea of ordinary temperature variations is given by a consideration of the mean maximum and mean minimum temperatures. The mean maximum for winter is about 20 degrees, and the mean minimum about 1 degree; in other words, the average highest temperature for winter is about twelve degrees below freezing, and the average lowest is about one degree above zero. The mean temperatures for spring and fall are about 39 degrees and nearly equal to one another.

The mean temperature for summer is about 59 degrees, the average maximum being about 72 degrees, and the average minimum about 46 degrees. During this season the mercury seldom reaches the 90 mark, and rarely goes down to the freezing point. In general, the summer has long, warm days of bright sunshine which permits of very rapid growth of crops. The nights are cool, almost always.

AGRICULTURE.

The first railway to cross the surveyed territory was the Grand Trunk railway, now the Canadian National, and it was built west of Edmonton about 1910. Land in the vicinity of Stony Plain was brought under cultivation many years before this date, however, as the distance to Edmonton is only about twenty miles.

Only a small proportion of the St. Ann sheet has as yet been brought under cultivation, as it has been roughly estimated that about seven per cent. of the surveyed area is now being cultivated, and a much smaller proportion of the western half of the sheet is at present under cultivation. Generally speaking a high percentage of the black belt soils is being cultivated, a smaller percentage of the incipient wooded belt soils, and a very small percentage of the wooded belt soils. This is what one would naturally expect in the early stages of settlement, as the black belt soils are usually brought under cultivation relatively easily, whereas the wooded belt soils are generally the most difficult to clear. It should be pointed out, however, that the tree growth is mainly poplar, within the surveyed area, and that large trees are uncommon, so that the clearing is rather light as compared for example, to land clearing in the eastern provinces.

The eastern half of the surveyed territory is cultivated to a considerbaly greater extent than the western half. The township in which Stony Plain is located is cultivated to a greater extent than any other, and several of the surrounding townships are also cultivated quite extensively. There is a large area of heavy soils, belonging to the incipient wooded soil belt, in the south-west corner of the surveyed territory, which is cultivated to a greater extent than any other large area in the western half of the territory. Tomahawk, north of the Saskatchewan river, and Lindale, south of the river, are located within this area.

The total acreage under crops is quite small as yet, and it is difficult to estimate at all accurately the acreage and average yields of the various crops produced within the surveyed territory. This is especially true because the average crop yield figures available are given for crop districts or census divisions, and these divisions do not coincide with the surveyed territory. Most of the surveyed territory lies at the western end of Census Division No. 11 (Edmonton), but only a very small proportion of the crops produced in this division are produced within the surveyed territory. It is believed that a much better idea of total crop production and yields within the surveyed territory, at the present time, can be obtained from yields given for Census Division No. 12, which lies west of No. 11 (Edmonton) Census Division. Table IV, prepared from data in the Annual Report of the Department of Agriculture of the Province of Alberta for the year 1927, shows crops produced by Census Division No. 12 in 1927.

TABLE IV.—CROPS PRODUCED BY CENSUS DIVISION NO. 12, 1927.

	Wheat	Oats	Barley	Rye	Mixed Grains	Peas
Acres	20,000	25,000	3,200	300	210	50
Bu. per acre	22.4	29.5	20.0	13.0		

	Green Feed	Hay and Clover	Alfalfa	Sun-flowers	Potatoes	Turnips and Mangolds
Acres	22,000	5,000	50	90	500	440

Figures for the comparative yields in bushels per acre of spring wheat obtained in Census Division No. 12, are reported in Table V. These figures were also taken from the Annual Report of the Department of Agriculture of the Province of Alberta for the year 1927.

TABLE V.—COMPARATIVE YIELDS OF SPRING WHEAT IN ALBERTA—7-YEAR AVERAGE, 1921-1927.

	Bu. per acre.
Census Division No. 12	21.10
Census Division No. 11 (Edmonton Division)	23.81
Census Division No. 1 (Medicine Hat Division)	12.04
Average for province	18.14

Yields for Census Division No. 11 (Edmonton), and No. 1 (Medicine Hat), and for the province as a whole, are included in this table in order to compare the yields of Census Division No. 12 with the yields of the Edmonton Census Division, one of the best in the province, and with the Medicine Hat Census Division, in the extreme south-east, one of the driest in the province, as well as with the average yield of the province as a whole. Wheat yields are probably the only crop yields of the widely separated provincial divisions that can be satisfactorily compared. The wooded belt soils, which make up a fairly large proportion of the surveyed territory, are not as well adapted to wheat growing as the black belt soils, and are not likely to produce as high an average yield of wheat.

The amount and distribution of annual rainfall are two of the most important factors in the production of crops. Fluctuations in wheat yields are closely related to fluctuations in annual precipitation in the prairie provinces, and there is sometimes an even closer agreement between fluctuations in wheat yields and precipitation during the principal wheat growing months of April, May, June and July. In order to show the relationship of wheat yields, total precipitation, and precipitation during the principal wheat growing months, Table VI has been constructed. Precipitation records for Edmonton are used in this table, as these are generally applicable to the surveyed territory. Yields of wheat for the Lake St. Ann and Stony Plain constituencies are taken as these are probably the most representative that can be obtained, although these constituencies do not coincide exactly with the surveyed territory.

TABLE VI.—WHEAT YIELDS, SEASONAL AND ANNUAL PRECIPITATION, 1913-1923.

Year	Annual Precipitation Edmonton	Precipitation April, May, June, July	Lake St. Ann Constituency		Stony Plain Constituency	
			Bushels per acre	Bu. per inch of Annual Precip.	Bushels per acre	Bu. per inch of Annual Precip.
1913	19.55	9.82	24.84	1.27	19.83	1.02
1914	25.29	13.95	20.67	.82	20.37	.80
1915	18.64	11.92	23.01	1.23	22.59	1.22
1916	20.95	5.51	14.87	.71	22.00	1.05
1917	15.25	6.82	17.00	1.11	19.00	1.24
1918	17.86	8.58	11.64	.65	8.38	.47
1919	16.43	6.88	9.22	.56	29.75	1.81
1920	18.16	10.09	25.88	1.42	31.82	1.75
1921	15.22	8.33	22.50	1.47	25.54	1.57
1922	13.73	5.56	14.00	1.02	15.90	1.16
1923	16.91	9.38	24.83	1.47	30.31	1.80
Average	18.00	8.80	18.95	1.06	22.32	1.27

By dividing the yield in bushels by the rainfall in inches for the corresponding year we obtain figures represenitng the bushels of wheat produced for each inch of rainfall. Such values for 11 consecutive years are reported in Table VI. It will be observed that there is a good deal of variation from season to season and that the efficiency of a unit of rainfall is usually lower in the drier than in the moister seasons.

The lowest yield does not always occur during the season of lowest rainfall, neither does the highest yield always occur during the season of greatest rainfall, otherwise 1922 should have shown the lowest yield and 1914 the highest. Other factors, such as succession of either wet or dry years, distribution of rainfall, severe frosts, crop diseases, etc., prevent absolute harmony between rainfall and yields. However, in general, the seasons of low rainfall are the seasons of low yields, and likewise the seasons of high rainfall are the seasons of high crop yields.

It was observed in earlier soil survey reports of southern Alberta areas that the economic efficiency of a unit of rainfall decreased to three-quarters of a bushel of wheat or less per inch of rainfall in many of the drier seasons. In the Lake St. Ann and Stony Plain constituencies the wheat yield does not fall below three-quarters of a bushel per inch of precipitation as often, particularly in the Stony Plain constituency. The average efficiency of a unit of rainfall in the Stony Plain constituency, including as it does the black and incipient wooded belt soils of the Stony Plain and Tomahawk districts, is greater than in the Lake St. Ann constituency, and greater, as one might expect, than in the drier parts of Alberta. This is shown by the following summarized tabulation.

POUNDS OF WATER REQUIRED TO PRODUCE ONE POUND OF DRY MATTER.

	Stony Plain Constituency	Lake St. Ann Constituency	Acadia Constituency
Grain and Straw..............	1,519	1,788	1,628
Grain only (wheat)	3,038	3,576	3,256
Bushels of wheat per acre per inch annual precipitation	1.27	1.06	1.16

It is shown, in Table VI, that each inch of annual rainfall produced, as an average of 11 years, 1.27 bushels of wheat per acre in the Stony Plain constituency. From this it may be calculated that each pound of wheat (grain only) required about 3,038 pounds of water. Now, if we assume that the yield of straw per acre is equal to the yield of grain we have an average water requirement of 1,519 pounds for each pound of dry matter produced in the form of the wheat crop. Similarly, the water requirement of the Lake St. Ann constituency would be 1,788 pounds for each pound of dry matter. These figures represent, fairly well, the actual conditions as they exist in the surveyed area according to the present system and methods of farming. It is interesting to observe that the water requirement per unit of crop in the Stony Plain constituency was lower than in the Lake St. Ann constituency, and this is probably due to the greater proportion of black belt soils in the Stony Plain constituency. It is well known that less water is required to produce a given crop growth on a fertile soil than on a poor soil, and the farmer can make better use of available moisture by increasing the soil's fertility.

As previously stated, only a small proportion of the surveyed territory has as yet been brought under cultivation, and the parts that are cultivated consist mainly of black and incipient wooded soils. A system of farming suitable for the wooded soil belt, generally, is as yet to be established. There are strong indications that it must be a system of mixed farming, involving the growing of clovers and other legumes to increase the fertility of the soil, supplemented, in many cases, by the use of limestone to neutralize soil acidity, and by the application of phosphates and possibly other commercial fertilizers. The growing of forage crops will, of course, involve the keeping of livestock, and the marketing of meat and dairy produce. This mixed farming system has already been adopted by some farmers in the wood soil belt, and should be developed gradually as the land is settled and cleared. In the incipient wooded belt the soils are generally more easily cleared and more fertile to begin with, but even here the mixed farming system is more desirable than a system of straight grain growing.

SOILS.

Soil classification, unlike geological classification, deals with a relative shallow portion of the earth's crust, and though the mineral constituents of the soil may be influenced by their geological origin, nevertheless the more important features of the soil zone are due to the influence of rainfall, vegetation, temperature, and the periods to which this soil layer has been subject to the action of these climatic forces.

The section of the soil from the surface to the unweathered layer below is spoken of as the soil profile, and a study of the various horizons or layers found in this vertical section, their position in the profile, their texture, structure and composition, in so far as these are related to the growing of crops, is the basis commonly accepted for soil classification today.

The different vegetative coverings, rates of precipitation, rates of evaporation, and the periods to which the individual soil profiles have been subject to these climatic forces are in general the factors governing the position within the profile of the various horizons and the distribution of certain mineral constituents required by the plant.

The soils of Alberta are divided first into several large divisions or soil belts, on the basis of extreme differences in the soil profile. These large divisions are fairly closely associated with the different sets of climatic conditions and the vegetative covering. The following descriptions will give in general, the extent to which certain belts are represented in the soils of the province.

(1) The black soils belt has its greatest development in the south central part of the province. Its widest, east and west dimension, is to be found in the neighborhood of Edmonton, extending east along the south side of the North Saskatchewan river to the Saskatchewan boundary and west to Stony Plain in the St. Ann sheet. This belt becomes very narrow as it extends southward. The greatest north and south dimension is about 200 miles. Other important areas of the modified black soils are to be found in the vicinity of the Peace river. In area, the black soils are only about 60 per cent as extensive as the brown soils found in the south-eastern part of the province, and about 12 per cent as extensive as the wooded soil belt.

The southern extremity of the black belt consists of bald prairie land, but this belt is generally characterized by the presence of clumps and scattered areas of poplar, willows and other trees. In fact, the black soils belt largely coincides with what is termed the "Park belt". The trees have encroached upon the original prairie land, but this encroachment has been too recent to cause the development of podsol-like profiles in the soils.

(2) The wooded soil belt is the largest belt of soils in Alberta. This soil belt is situated to the north and west of the black soil belt, occupying, with the exception of local areas, such as those in the neighborhood of Peace River and Grande Prairie, the entire northern portion of Alberta, and extending southward along the western border of the black soil belt. These soils cover approximately two-thirds of the total area of the province of Alberta, and belong to the forest area, being covered with a tree growth of poplar, spruce and some tamarack. It is this soil belt to which the peat areas and swamps characteristically belong. Some swamps and peat areas will be found in the incipient podsolic wooded soil belt and even occasionally around the borders of the black soil belt, but these peat soils truly belong to the wooded belt.

The settlement of Alberta land has followed as far as possible the open park areas, the areas belonging to the black and brown soil belts, and has avoided the wooded soils belt, due to the greater difficulties of clearing, drainage and transportation.

(3) In the incipient podsolic wooded soil belt the soils have received greater leaching than the soils of the black belt and yet have not reached the stage of maturity characteristic of the wooded belt of soils. It is found on the borders of the other two classes, between the black belt and the wooded belt and also distributed in local areas throughout the wooded belt, and is in general covered with a growth of poplar trees.

This belt is the smaller of the three belts above mentioned. The exact area is difficult to estimate as it does not occupy any one large district, but is scattered along the fringes of the other belts. It is the belt with the greatest variations in profile of any of the soil belts of the province, due to its being a division which includes the soils between two main soil belts.

The profiles, as mentioned above, are divided into layers or horizons which are designed by the letters, A, B, and C. The A layer includes the horizons at the surface, extending from the surface to the bottom of the layer of greatest leaching. The B horizons include both the layer in which the greatest accumulation of fine soil particles occur, and the lime concentration layer. The C horizon is that layer below the lime concentration layer and extending into the unweathered portion or parent material.

The horizons A, B and C may again be divided into as many divisions as are visible in the profile, and are designated by a numeral following the letter.

A typical profile of the black soil belt of central Alberta (see Table VII and Plate II, Fig. 2) is characterized for the most part by a dark colored surface horizon A_1. This horizon has an average thickness of 8 to 12 inches. It is a heavy black loam, rich in organic matter, with no pronounced structure, and contains .53 per cent of nitrogen and is about neutral in reaction.

The A_2 horizon has an average thickness of 4 to 10 inches. It is a brown to dark gray clay loam to clay soil, with a slight tendency toward columnar structure, but mainly granular, and contains .11 per cent nitrogen. This horizon is the one in which the greatest amount of leaching has taken place. Particles of fine soil have been removed from this horizon to the one immediately below.

The B_1 horizon is the layer in which the greatest concentration of fine particles occurs. The average thickness is 14 inches. It is gray colored clay loam to clay in texture, somewhat columnar in structure, and contains .06 per cent nitrogen.

The B_2 horizon contains the lime layer. It averages 6 inches in thickness, is a gray colored clay somewhat columnar in structure and contains .04 per cent of nitrogen.

The C_1 horizon is found at the average depth of 42 inches. The parent material consists of light yellow clay derived from underlying shales or glacial drift. It is spotted with occasional iron stains and contains .04 per cent nitrogen.

The wooded soil belt, lying to the west and north of the main black soil belt, is fairly heavily wooded for the most part. The part adjoining the black soils belt, for a distance of from 50 to 100 miles back from it, consists mainly of a poplar forest ossociation, with trees up to eight inches in diameter, accompanied by a luxuriant ground vegetation, chiefly shrubs together with grasses. Continuing in a north and west direction, the poplar association is gradually replaced by spruce and pine so that in the extreme northern part of the wooded belt the poplar association is superceded by a coniferous forest, in which ground vegetation is very sparse or entirely absent. About two-thirds of the entire area of Alberta lies within the boundaries of this wooded soil belt. This belt also includes the greater part of the "muskeg" and swamp areas.

Typical wooded soils in Alberta have the following characteristic profile (see Table VII, and Plate I, Fig. 2). The upper layer or horizon A_0 consists largely of organic matter varying in thickness from 1 to 4 inches. Immediately under this there is a very thin layer, A_1 of drab to brown colored mineral soil which varies in thickness from ½ to about 2 inches. The A_1 layer is not always present in the wooded soils. This second layer is underlaid by a light colored badly leached A_2 layer varying in thickness from 4 to 12 inches. Below the leached light colored layer is found a somewhat darker colored B_1 layer, which is much heavier in texture than the above layers, and contains large quantities of the finer clay particles, which have passed downward during processes of leaching. This layer varies in thickness from about 1 to 4 feet. The B_2 or lime layer is not encountered in these wooded soils nearer the surface than from 4 to 6 feet. From the above statement it will be understood that the wooded soils have suffered rather extensive leaching. This explains the

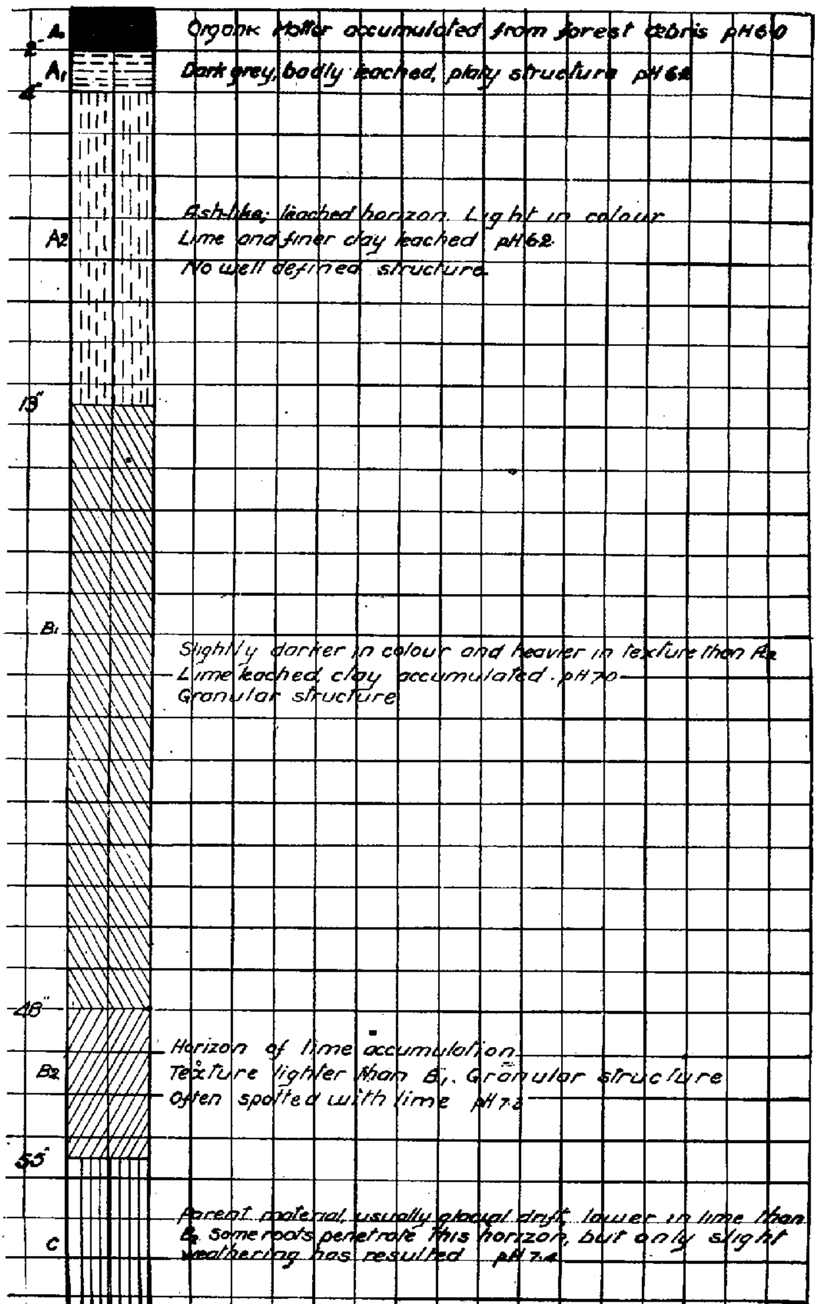

Fig. 2—Diagram of profile from typical wooded soil (Alberta).

fact that they are at present slightly acid in reaction. The leached layers—A_1 to B_1 inclusive—vary in acidity from about pH 6.8 to 6.0.

The nature of these wooded soils may be somewhat better understood by referring to Figure 2 which represents the arrangement of the various horizons found in the soil profile. This shows a relatively thin A_0 horizon, as well as leached horizons A_1 to B_1. It may be noted that the leached horizons occur very near the surface. When such soils are plowed, the entire field often has a light colored ashy appearance.

TABLE VII.—COMPOSITION OF TYPICAL WOODED AND TYPICAL BLACK SOILS OF ALBERTA.

Horizon	Depth in inches	N	P	Ca	Mg	$CaCO_3$	pH
		Per cent.					
Wooded Soil.							
A_0	0-2	.49	.09	1.18	.35	......	6.0
A_1	2-4	.09	.06	.55	.33	......	6.2
A_2	4-19	.03	.03	.61	.56	......	6.2
B_1	19-48	.04	.03	.56	.45	......	7.0
B_2	48-55	.02	.04	2.68	.84	7.67	7.3
C	55-	.03	.05	1.96	.76	4.11	7.4
Black Soil.							
A_1	0-12	.53	.10	.94	.50	......	6.0
A_2	12-16	.11	.05	.65	.64	......	6.4
B_1	16-30	.06	.04	.71	.69	......	6.8
B_2	34-40	.04	.05	3.11	.76	7.04	7.6
C	40-	.04	.05	1.38	.75	3.06	7.6

The differences in the chemical composition of the various horizons of the typical wooded soil profile are shown in Table VII. This table also contains similar data for a typical profile from the black soils. It will be seen that the upper 2 inches of the wooded soil is almost identical in composition with the upper 12 inches of the black soil. In the first case, the horizon consists chiefly of organic matter whereas the corresponding horizon in the black soil is characteristically mineral in nature and contains a large amount of organic matter (grass roots) intimately mixed with the soil. The A_2 horizon in the black soil occurs at a greater depth than in the wooded soil and also contains more nitrogen and phosphorus. On the other hand the B_2 (lime layer) is encountered at a depth of only 34 inches in the black soil and at 48 inches in the wooded soil. This indicates severer leaching in the wooded soil than in the black soil. Except for the upper 4 inches (A_0 and A_1) the wooded soil is rather low in phosphorus and nitrogen. In fact the nitrogen and phosphorus content of the wooded soil at a depth of from 5 inches downward is about the same as that in the black soil at a depth of from 34 inches downward.

The differences in depth and composition of the corresponding horizons for these two soils is brought out more clearly in Table VIII where the total amounts of the various constituents have been computed for each of the upper 3 feet. An inspection of Table VIII shows that the greatest difference in composition between these two soils occurs in the first foot, where it will be seen that the black soil contains six times as much nitrogen and more than twice as much phosphorus as the wooded soil. There is likewise more nitrogen and phosphorus respectively in the second and third foot depths of the black soil than is found in the corresponding depths for the wooded soil. The totals for the upper 3 feet bring out the following relationship: about four times as much nitrogen, twice as much phosphorus, twice as much calcium, and more magnesium in the black soil than in the wooded soil. Appreciable quantities of calcium carbonate are likewise found in the third foot of the black soil, whereas carbonates are not encountered in the wooded soil nearer the surface than the fifth foot.

TABLE VIII.—TOTAL PLANT FOODS IN UPPER THREE FEET OF TYPICAL WOODED AND TYPICAL BLACK SOILS OF ALBERTA (POUNDS PER ACRE).

Depth.	N	P	Ca	Mg	$CaCO_3$
		Wooded Soil.			
1st foot	3,082	1,557	20,794	14,675	....
2nd "	1,200	1,050	20,600	17,950	....
3rd "	1,400	1,050	19,600	15,750	....
Total	5,682	3,657	60,994	48,375	....
		Black Soil.			
1st foot	18,500	3,500	32,900	17,500	....
2nd "	3,232	1,766	27,400	26,767	....
3rd "	1,750	1,575	66,850	25,370	123,200
Total	23,482	6,841	127,150	69,637	123,200

The above comparisons show that the wooded soil contains much smaller quantities of plant foods than are found in the black soil, and it may be presumed that the wooded soil is decidedly deficient in plant foods. However, it should be stated that the analysis of the wooded soil as shown by the data in the above tables would indicate that it compares favorably with a great many of the world's fertile soils; and from the analysis alone one would be at a loss to explain the reason why such a soil would not give satisfactory crop returns. The fact still remains that the poorer phases of our wooded soil in most cases show unsatisfactory crop returns.

The better phases of the wooded soils—those intermediate between the typical black and the typical wooded soils—usually give satisfactory crop yields, whereas the poorer phases usually give yields which are somewhat disappointing. This is especially so during an unfavorable season and often entire crop failures are experienced from the wooded soils whereas average yields are returned from the black soils.

SOILS OF THE ST. ANN SHEET.

The area surveyed occupies the eastern portion of the St. Ann sheet (see map accompanying report) extending approximately as far west as the Pembina river. The area covers approximately the east six and a half ranges of the St. Ann sheet or in the neighborhood of 1,202,720 acres.

The geological formations underlying these soils consist of the Paskapoo formation to the west and the Edmonton formation in the east. (For detailed geology of the area see Appendix I by Dr. J. A. Allan.) The soils, however, are for the most part the result of the weathering of glacial debris deposited by the retreating ice sheet. This covering is relatively shallow in some places and deep in others. The general relief is due largely to pre-glacial erosion and the deeper deposits of glacial drift are to be found in the preglacial valleys.

The surveyed area is subdivided into areas of gently rolling to rolling, rolling to heavily rolling, and heavily rolling to hilly country. In general the topography is uneven. Very little flat or level country is to be found, and as a result of the unevenness of the topography the area contains a fairly large water surface, approximately 74,728 acres in the form of lakes. The small lakes are quite numerous and a number of the largest lakes in the vicinity of Edmonton are found in this district, Wabamun, Isle and St. Ann being the most important of these.

Swamps are prevalent in the area, particularly to the south and west, though they are also found scattered throughout the whole district. The smaller swamps such as would cover a quarter section in area are not mapped, but the larger areas are mapped, totaling about 35,560 acres of this type of country. These peat areas have for the most part a tree covering of spruce or tamarack and to date are of very little agricultural value (see Plate III).

As stated above, the entire area is uneven in topography. The area north of and including township 53, though containing the large area of gently rolling land, is more choppy in surface topography than the area south of this line. The area to the south has higher elevations and deeper valleys, but the slopes are more uniform, and the southern part of the area is less stony than the northern portion.

Two Indian reserves are located in the area, one north of Lake St. Ann, the other east of Lake Wabamun, totaling 30,528 acres. Another reserve extends into the sheet about one mile at the north-east corner of the area, but it is not included in the above acreage. These areas have not been surveyed, the soil divisions extending only to the borders of the reserves.

Table IX contains the acreage of each class of soil found within the surveyed area, together with the percentage of the total area, as well as the percentages of land found in each topographical division. From this table it may be further seen that the area of soil belonging to the black belt within the St. Ann sheet is approximately 40,000 acres, or 4 per cent of the total. The areas or incipient podsolic soils comprise over one-half million acres or 43 per cent. of the total, whereas the wooded soils constitute a little less than one-half million acres or 38 per cent of the total.

TABLE IX—EXTENT OF VARIOUS AREAS IN ST. ANN SHEET.

No. of Area	Soil Type	Acres	Per cent
4111	Sandy loam	2,880	0.2
4121	Fine sandy loam	576	0.1
4141	Loam	20,160	1.7
4142	Loam	8,064	0.7
4241	Loam	8,640	0.7
6111	Sandy loam	4,032	0.3
6121	Fine sandy loam	16,552	1.4
6141	Loam	156,520	13.0
6151	Silt loam.	84,160	7.0
6261	Clay loam	29,376	2.4
6271	Clay	176,680	14.7
6311	Sandy loam	13,824	1.1
6321	Fine sandy loam	14,400	1.2
6341	Loam	22,888	1.9
6281	Mixed	5,760	0.5
8111	Sandy loam	8,640	0.7
8121	Fine sandy loam	25,920	2.2
8141	Loam	312,040	25.9
8151	Silt loam	93,160	7.7
8161	Clay loam	4,032	0.3
8991	Peat	35,560	2.9
8181	Mixed	14,400	1.2
	River bottom	43,200	3.6
	Indian reserve	30,528	2.5
	Water	74,728	6.1
Total		1,206,720	100.0
Area of heavily rolling land		50,112	4.2
Area of rolling land		436,241	36.2
Area of gently rolling land		571,911	47.4
Area of peat		34,560	2.9
Area of the black belt		40,320	4.0
Area of the incipient podsolic wooded belt		524,192	43.1
Area of the wooded belt		493,752	37.8

Three of the large soil divisions or belts are represented within the St. Ann sheet; the black soil belt, the incipient podsolic wooded soil belt and the wooded soil belt. The black soil belt is represented by the smallest area of the three. It is situated largely in the vicinity of Stony Plain, and another smaller area belonging to this belt is found in the extreme south-east of the sheet.

The second or incipient podsolic wooded soil belt consists of an irregular strip of soils bordering the black soils belt on the west. This belt of soils is found mainly along the eastern side of the sheet and in the south-western part of the surveyed territory in the vicinity of the North Saskatchewan river. There are also a number of areas of these podsolic wooded soils scattered throughout the third group of soils to the west. This is the largest belt of soils represented on the surveyed area.

The wooded soil belt or third belt represented on the St. Ann sheet is the belt to which the main area of wooded soils of Alberta belong. The area of this belt is less than that of the incipient wooded belt, due to the surveyed area being largely within the zone of transition, between the black soil belt and the wooded soil belt.

The swamp soils are largely represented in this area. They form a soil series within the wooded soils belt and they cover an area of 35,560 acres or about 2.9 per cent of the soils. These swamps are larger and more numerous in the wooded soil belt and represent a class of soils that belong to the wooded soil belt. The other belts contain certain areas of this class of soil along their northern and western borders, but the swamps within the boundaries of the other belts are of the same class as found in the wooded soil belt and are classed within this belt regardless of where they are located.

SYSTEM OF SOIL CLASSIFICATION

The area is first divided into the soil belts on the basis of large differences in soil profile. The belts are again divided into series on the basis of local profile differences and the series are finally divided into soil classes on the basis of the texture of the A horizon, the topography, freedom from stones and sometimes other factors.

On the map accompanying this report the soil classes are shown in different colors and each class carries a number. The number indicates the class, series and belt to which the soil belongs. The numbers consist of four figures; the first two figures on the right indicate the class, the third figure the series, and the fourth figure the soil belt.

The numbers used are from 4,000 to 10,000; the black soil belt is allotted the numbers 4,000 to 6,000, the incipient podsolic wooded soil belt 6,000 to 8,000, and the wooded soil belt the numbers 8,000 to 10,000. A legend also accompanies the map which indicates the texture of the different classes of soil.

DESCRIPTION OF SOIL CLASSES.

Loam (wooded soil) 8141.

This class of soil occupies 312,000 acres or 25.9 per cent of the entire area. It is the largest single class of soils in the St. Ann area, and represents the main class of well drained soil found under wooded conditions.

The greatest single area of this type of soil in the St. Ann sheet is to be found in the north and west parts of the surveyed area. There are also two areas south of the Saskatchewan river, a small area east of Genesee post office along the river, and a larger area along the bottom of the sheet and extending as far north as the river.

The topography in this class of soil varies considerably. North of Lake Wabamun the area is largely gently rolling, but the land though showing no high elevations is quite choppy and is much stonier than the soils south of this lake. There is a small area of hilly land at the north of the sheet around Old Man lake, and the rolling class extends fairly well north along the Pembina river. This rolling area consists of high and low elevations with long slopes of quite uniform land. South of the Saskatchewan river the western part of the loam soil area is rougher than the eastern part, with a small area of hilly land in the vicinity of Coyote lake.

The forest vegetation on these loam soils consists mainly of poplars varying in size up to 12 inches in diameter and in density from small scattered scrubby growths to dense wooded areas (see Plate IV). These areas have at one time been covered with heavy poplar growth, but forest fires have removed a large part of it, and the settlement follows in general the areas that have been partially cleared in this manner.

As has been previously mentioned the wooded soil belt contains the major portion of the peat areas. In the depressions throughout this class of soil are to be found many peat swamps of varying size with principally a spruce covering. These peat areas are, in general, of very little agricultural value at present.

The loam soils, whether burned over recently or not, show on ploughing the grayish white appearance characteristic of the A_2 horizon of the wooded soil (see Plate I). Where unburned a shallow A_0 layer consisting of leaves and decayed vegetation is found on the surface, but the A_2 horizon is the same kind of soil in both cases and is not altered to any appreciable extent by forest fires. On the higher slopes of these areas are to be found the lightest colored soils. They receive the most vigorous burning in case of fires, thus removing the A_0 horizon, and as the higher areas are best drained the grass growth is not as great as in the lower areas. The soil bordering on a creek or swamp may be, therefore, richer in organic matter than the upland soils, but with the usual white A_2 horizon at a little lower depth (see Plate V, Fig. 1).

The average depth of A_0 horizon in the loam class of soils is 2 to 4 inches. The A_1 horizon is not always present, but where found is a drab colored layer with platy structure and about 1 to 2 inches thick. Immediately below this layer is found the leached A_2 layer, 4 to 12 inches thick. Below A_2 is the concentration layer B_1 which is much heavier in texture, due to the collection of fine particles leached from the horizons above. This layer is yellowish in color and is from 1 to 4 feet thick (Plate I). The lime layer is next encountered at a depth of from 4 to 6 feet, and below the lime layer is located horizon C_1, largely unweathered and consisting of the parent materials.

The loam class of soil is the main agricultural class in the wooded soil belt and is the one most important in the agriculture of the wooded soil belt. It is a soil of poor physical condition due to the removal of the finer constituents to lower depths. It is acid due to the removal of lime from the surface and is lacking in some of the essential plant foods. It is a soil that will require a rebuilding process of farming, in order to return to the soil the organic matter and colloids necessary to maintain a physical condition best suited to cropping.

Silt loam (wooded soil) 8151.

The silt loam is the second largest class of the wooded soils. There are a number of areas in the St. Ann district comprising in all 93,160 acres, or 7.7 per cent of the surveyed area. The largest area is situated south of Lake Wabamun, another area in the south-west corner of the surveyed territory, a third area south of Genesee, a small area north of the Indian reserve east of Lake Wabamun, and a small patch on a point of land extending into Lake St. Ann. This class of soil is in general covered by a heavier growth of poplar than the loam class, with a spruce poplar mixture in some places. With the exception of the area in the south-west and the small patch near Lake St. Ann the class is almost entirely rolling country with some fairly high elevations in the large area south of Lake Wabamun.

Due to the heavy clearing, the area is not under cultivation to the same extent as the more easily cleared areas in the loam class. Peat areas are found in the depressions throughout this class, similar to the areas in the loam class.

The profile consists in the A_0 horizon of 2 to 5 inches of leaf mold and decayed vegetation. The A_1 horizon is absent for the most part in this class. The leached A_2 horizon averaging 4 to 8 inches in depth is not quite as deep as this horizon in the loam class. The remainder of the profile is similar to that described in the loam class above.

The A_2 horizon in the silt loam class of soil has in general suffered less leaching than is the case in the loam class. This accounts for the heavier texture of the surface soil.

This class of soil is much more difficult to bring under cultivation than the extensively burned over loam areas, due to the heavy clearing, but is slightly superior to the loam soils in having a somewhat shallower A_2 horizon or badly leached layer. These soils, however, will require much the same treatment required by the loam class, but should respond somewhat sooner to such treatment.

Sandy loam (*wooded soil belt*) 8111.

There are two areas of this class of soil, one south of Seba Beach, and the other bordering the north-east shore of Lake St. Ann. The area south of Seba Beach is rolling country, but instead of the long slopes and high elevations found over most of the rolling area, this is very rough and choppy, with many grass sloughs. The knolls are quite sandy, while the sloughs contain heavier soils.

The area north of Lake St. Ann is quite sandy, particularly along the eastern shore of the lake, but it is not as rough in topography as the southern area. These two areas do not show the clear division of horizons in profile found in the heavier soil classes, but they have the shallow layer of organic matter in A_0 horizon, the depth of leached layer and the lime at the lower depths characteristic of wooded soils. The area south of Seba Beach is too rough to be of much value agriculturally, and except for the part on the north of Lake St. Ann this area is too sandy for good farming.

Fine sandy loam (wooded soil belt) 8121.

There are three areas of this class of soil, the largest one south-east of Onoway, a very rough and hilly piece of country, another one west of Lake St. Ann, and a smaller one in the southern part of the sheet near Warburg post office, comprising in all about 25,920 acres, or 2.2 per cent of the surveyed area. In the area between Lake Isle and Lake St. Ann is a class of soil that has been modified to some extent by the waters of the former lakes. It is a somewhat mixed area, with a narrow strip of soil along the Sturgeon river heavy in texture and marshy in places, while the rough land along the borders of the old channel is fairly light in texture.

This class in general has a shallow A_0 horizon, no A_1 horizon, and a 4 to 12 inch leached layer. The surface soils are fairly porous and therefore have assisted the leaching process. The B_1 horizon is from 1 to 4 feet thick, but is not as heavy in texture as the loams and silt loams, due in part to the sandier soils having less fine particles to wash down by leaching. The lime layer is usually found at from 4 to 7 feet, but may be deeper if the upper horizons are very sandy. These soils have a greater subsurface drainage than in the loams and silt loams, and have not the peat areas found in the other classes, but they may suffer sooner from drought during dry seasons than the heavier classes.

Clay loam (wooded soil) 8161.

There is only one area of this class of soil in the sheet. It is a flat lying piece of country near Rich Valley, has numerous swamps on its southern border, and is fairly stony.

In the profile the A_0 layer is quite shallow, 2 to 3 inches. Immediately below is the A_2 leached layer which is fairly shallow, 3 to 8 inches in thickness. The next horizon, B_1, ranges in thickness from 1 to 3 feet and the lime layer is situated at from 3 to 5 feet from the surface. The area where uncleared is covered with scrubby poplar, the poor growth being due in part to the very hard impervious B_1 horizon that proves very unfavorable to root development. This same heavy subsoil will also prove unfavorable to crops, particularly in dry weather.

PLATE I.

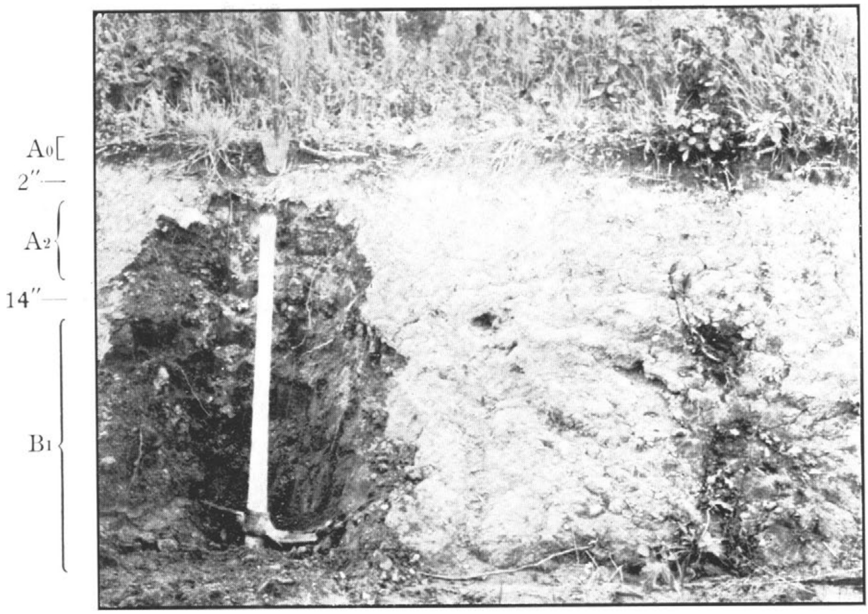

Fig. 1—Wooded soil profile. Note dark surface organic matter layer, about 3 inches thick, above the ashy, light colored, leached A_2 layer. (See p. 19.)

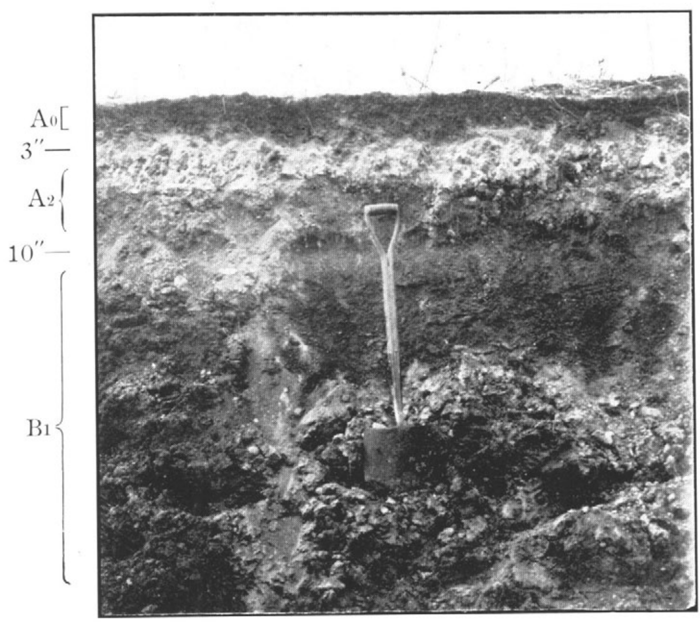

Fig. 2—Wooded soil profile. Note thin layer of organic matter or vegetable debris at the surface, and light colored, leached layer immediately below. (See p. 19.)

PLATE II.

Fig. 1 — Incipient podsolic soil profile. Note heavy granular subsoil, typical of much of this area, below the thin light colored leached layer. (See p. 18.)

Fig. 2—Black soil profile. Note dark surface organic matter layer, in this case over a foot thick. (See p. 17.)

PLATE III.

Fig. 1—Muskeg area with scattered spruce trees. (See p. 31.)

Fig. 2—Open muskeg area. (See p. 31.)

PLATE IV.

Fig. 1—Heavily wooded area. The tree growth is mainly poplar. (See p. 27.)

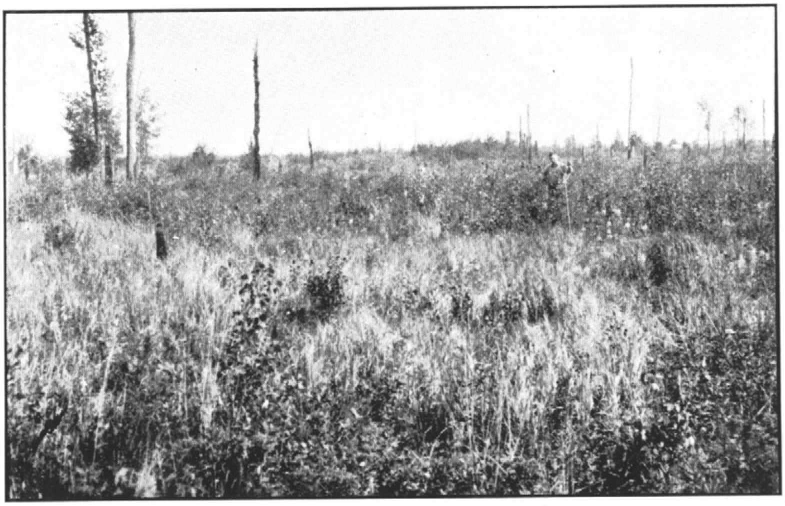

Fig. 2—Burned-over wooded area. Note burned stumps and fresh undergrowth. (See p. 27.)

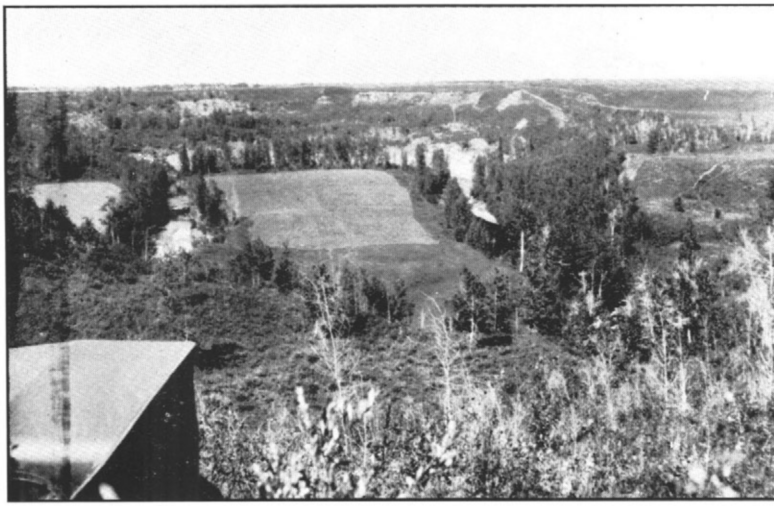

Fig. 1—Creek cut-bank and small low areas of rich alluvial soil. (See p. 28.)

Fig. 2—A heavy stand of red clover on wooded soil. The soil was well prepared and heavily manured before seeding the clover. This crop would furnish excellent feed and improve the wooded soils if proper efforts were taken to insure its growth. Clovers should be especially included in any program dealing with the management of the wooded soils. (See p. 48.)

Mixed area (wooded soil belt) 8181.

These soils are limited to one area south and east of Sangudo. There is 14,400 acres in the area, or about 1.2 per cent of the total area. These soils are on gently rolling but rather choppy country and are a mixture of sands, fine sandy loams, and loam soils. The uncultivated areas are covered with a short poplar growth, with a few scattered swamps of spruce or tamarack in the low areas.

The profile of this class of soils varies with the individual type of soil, and these types will correspond fairly closely to the wooded soil belts as described above.

Peat (wood soil belt) 8991.

The peat areas are placed in the wooded soil class even though quite a percentage of them are found in the other two soil belts. The peat areas, however, are more characteristic of the wooded soil belt than of either of the other soil belts and the type of peat is much the same in all three belts. There are 34,560 acres mapped as this class of country, or about 2.9 per cent of the area. There is quite an area of peat that is not mapped due to the small size of many of the swamps.

This class of land, due to the expense of draining and clearing, is of little agricultural value today. Some local areas may be drained fairly easily and if used for pasture for a period of time may be economically brought into crop land. They consist mainly of organic matter, whereas the wooded soils and all other ordinary soils consist mainly of mineral matter.

The peats are usually underlaid by clay or other soil material fine enough to hold the moisture in basins or flats, which permitted and encouraged the growth of sphagnum moss and other moisture loving plants. The accumulation of these plants under water-logged conditions resulted in the formation of peat bogs. The muskegs are generally covered by a shrubby growth of Labrador tea (*Ledum groenlandicum*) and frequently there is a scattered growth of small evergreens consisting of spruce and tamarack. (Plate III.)

Very little experimental work with peats or muskegs has as yet been done in Alberta, and we are still uncertain as to the best methods of reclaiming them or bringing them under cultivation. The first step naturally would be to drain the peat land. Most of the peats of the St. Ann sheet are not in an advanced stage of decomposition. It would therefore require considerable time after drainage before they are in proper condition for seeding. If it is not essential that the land be brought under cultivation as soon as possible it would probably be wise, following drainage, to fence it off with pasture land and allow stock to tramp and pasture it for two or three years. The muskeg will settle considerably and it can then be broken. The freshly plowed land should be packed to make a firm seed bed. Greenfeed might be produced at first and later it should be possible to ripen grain successfully on some of this land.

Peats differ greatly in their ability to produce crops, and for this reason their fertilizer requirements cannot often be predicted without actual field trials. The application of barnyard manure is apt to be highly beneficial, and it is likely that the application of nitrogen fertilizers and lime and probably phosphate and potash will prove beneficial. Where marl deposits rich in lime are conveniently located this material may be applied to a part of the muskeg at the rate of say one ton per acre, and its effects can then be observed. Peats vary in reaction, but many of them are very acid, and should respond to treatment with lime. All fertilizers should be tested on small areas and if beneficial should be applied to larger areas.

Burning the muskeg after it has been drained may be desirable in some cases, but it should be practised only after a careful consideration of the local conditions, as it may leave the field in a very irregular condition.

INCIPIENT PODSOLIC WOODED SOIL BELT.

The incipient podsolic wooded soil belt is a division of soils midway in development between the soils of the black belt and the leached soils of the wooded belt. These incipient wooded soils show the greatest profile variation of the three soil belts. They are soils which have for the most part been subject to wooded conditions for a relative short period, when compared to the true wooded belt soils, and are beginning to show the effect of the climatic forces in a breaking down and removal of the organic matter from the surface horizon. These degradation agencies have produced a shallow grayish white leached horizon, similar to that in wooded soils.

The surface horizon A_0 consists largely of partially decomposed leaves and organic matter, varying from 1 to 5 inches in depth. The A_1 horizon is generally absent, but if present is very shallow. The leached A_2 horizon will vary in depth from 2 to 7 inches depending on the stage of development of the soil. Many of these soils are such that deep plowing will turn up some of the B_1 horizon, or the horizon below the leached layer. The darker colored B_1 horizon will vary in thickness from 1 to 3 feet. This horizon, however, does not contain the quantity of finer soil material characteristic of the wooded soils, and consequently is not quite so impervious. The B_2 lime layer may be found at 3 to 5 feet in depth and the C horizon below this.

Clay (*incipient podsolic wooded soil belt*) 6271.

The principal area of these soils is located in the Lyndale, Tomahawk, and Rocky Rapids districts, in the south-western part of the surveyed area. There are a number of areas of the same soil scattered throughout the sheet, one area in the vicinity of Magnolia, another near Sangudo, one at Genesee, and an area near Rich Valley, besides a few scattered small areas in different parts of the sheet.

The areas with this class of soil are fairly well settled due to the relatively thin covering of small poplar, and the greater ease with which the land can be brought under cultivation. The topography of this class of soil is for the most part rolling with the exception of part of the Rich Valley area and some of the Rocky Rapids district. In the rolling areas, particularly the Tomahawk district, there is quite an area of peat, much of which is not mapped due to its being patchy and many of the areas too small to map.

There are 176,680 acres within this class of soil, about 14.7 per cent of the surveyed area. It is the second largest class of soils on the sheet. A large part of this class of soil occurs along drainage courses such as the Pembina or North Saskatchewan rivers and their tributaries, and much of the unevenness of topography is due to the rapid erosion that has taken place in this fine textured soil.

The A_0 horizon is not distinct in the clay soils. The A_1 horizon is 4 to 6 inches in depth, heavy in texture, and somewhat granular. The B_1 horizon is 15 to 24 inches thick; a heavy textured dark colored soil, with some brown mottlings. The lime layer is located at from 30 to 40 inches from the surface, not so deep as in the wooded soil belt nor as deep as in some of the lighter soil classes of the incipient podsolic soil belt. The C_1 layer is found at about 5 feet, and consists of weathered shale. There are some outcroppings of the underlying sandstone in these areas. On the borders of the areas the soil changes into the true wood soil profile and the leached horizon becomes somewhat thicker.

The heavier textured soils in general have not quite as deep a leached layer as the lighter soils due to the larger percentage of fine soil particles in the original vertical section and the lack of subsurface drainage.

Loam (incipient podsolic wooded soil belt) 6141

The principal area of this soil is situated in the north-east corner of the sheet. Two smaller areas are located south of the Saskatchewan river in the eastern part of the sheet, and a small area to the south of Lake St. Ann comprising in all 156,520 acres, or 13 per cent of the surveyed area.

The area in the north-east is largely gently rolling country with two small areas of rolling land, and is cut up to some extent with small lakes and sloughs. The area south of the Saskatchewan river near Wilton Park post office is quite uniform and is largely under cultivation. The uncultivated areas are covered with small poplar trees.

The A_0 horizon is 2 to 4 inches thick and consists of decayed leaves and grasses. No A_1 horizon can be detected. The A_2 horizon or leached layer is 4 to 8 inches in thickness, of gray color, and sandy loam to silt loam texture. The lime layer occurs at a depth of 3 to 4 feet and the C horizon consisting of the parent material lies immediately below.

These soils are somewhat similar in profile to the loam class in the wooded soil belt, except that they have not received quite as much leaching and therefore have a shallower leached layer, and the lime layer is generally found somewhat closer to the surface. There is generally more organic matter in the A_0 horizon than found in the A_0 horizon of the wooded soil profile.

Silt loam (incipient podsolic wooded soil belt) 6151.

The silt loam class occupies an area of 84,160 acres, or 7.0 per cent of the total. The principal area is located east and south of Duffield, extending south along the northern side of the Saskatchewan river. There are three small areas of this class of soil in the Telfordville district, three in the Onoway district, one at Rich Valley and one small area on the south-east shore of Lake St. Ann. Two of the areas near Onoway and the northern and western part of the area near Duffield are in rolling country, while the remainder is located on gently rolling topography.

This class of soil is quite extensively cultivated. The area east of Duffield is largely under cultivation and the area south of Telfordville is also well settled, while the northern areas in the Onoway district have not the same proportion of land under crops.

The A_1 horizon contains 3 to 5 inches of leaf mold and other decayed vegetation. The A_2 layer varies a good deal as it does in all the incipient podsolic wooded soils, but is in general about 3 to 7 inches thick. The remainder of the profile is similar to the horizons described under the loam class of the incipient podsolic wooded soils.

These soils are among the best agricultural soils of this belt, and consequently most of the area is homesteaded.

Clay loam (incipient podsolic wooded soil belt) 6261.

There are three areas of this class of soil, one small area bordering Strawberry creek north of Warburg post office, two larger areas, one at Telfordville, and the other north of Cherhill. The land is quite uniform in topography and is well settled and largely under cultivation. The original forest covering consists of poplar and willow, and until fairly well cleared was poorly drained in places.

The A_1 horizon consists of 4 to 6 inches of heavy textured clay loam soil, rich in organic matter. The A_2 horizon is fairly shallow, 1 to 3 inches thick and consists of the characteristic leached gray colored soil. The horizons below A_2 are similar to the horizons of the clay areas of the same series described above.

Sandy loam (incipient podsolic wooded soil belt) 6111.

There are two small areas of this class of soil, one at Heatherdown and one on the east border of the sheet, north of the Sturgeon river. The soils of the area at Heatherdown are the result of the depositions by a stream that once occupied the old drainage course that extends from the east end of Lake Wabamun north-east to the Sturgeon river valley near Onoway, and the resulting soils are therefore somewhat mixed.

They consist chiefly of sandy loams with patches or deposits of gravel. There is a large Canadian National Railways gravel pit at Heatherdown from which gravel is transported to the main line by a spur from the Onoway line.

The A_1 horizon is 2 to 4 inches thick and consists of soil and decayed vegetation. The A_2 horizon or the leached layer is 6 to 13 inches thick, sandy porous soil, yellowish gray in color. The remainder of the profile is similar to the profile of the same series as described under the loam class. The area is farmed to a slight extent, the main feature of the area at Heatherdown being the gravel pit.

Fine sandy loam (incipient podsolic wooded soil belt) 6121.

Of the two areas of this class of soil, one is situated east of Pemburton post office, south of the North Saskatchewan river, and the main area is located south of Onoway. The area near Onoway is part rolling and part gently rolling and the southern area is gently rolling. This class of soil is covered with a growth of small poplar, and the area near Onoway is somewhat stony in places.

The A_1 horizon is 2 to 4 inches thick and consists of leaf mold and decayed organic matter. The leached A_2 layer is 4 to 8 inches thick and is light in both color and texture, with very little pronounced structure. The lower horizons are again similar to the horizons of the loam class. The area contains 16,552 acres, or 1.3 per cent of the total area, and is only partially farmed.

Sandy loam (incipient podsolic wooded soil belt) 6311.

These soils are found in four areas as follows: a tract of land along the Sturgeon river east of Onoway, an area west of Stony Plain around Cottage lake, a tract of land south of the south-eastern corner of the Indian reserve near Duffield, and a small area south of the Duffield area near the Saskatchewan river.

These soils belong to a series other than the ones above described as will be seen from their different number and the color of the areas on the accompanying map. The classes are the same as some of the classes within the incipient podsolic soil belt, but are placed in a different series on the basis of their difference of lower horizons. The chief difference is the lighter texture of the B horizons of this series.

This class of soils is very sandy, and therefore does not show the distinct profile divisions characteristic of the heavier textured soils. The area near Onoway is somewhat irregular, showing the effect of the Sturgeon river on the soil formation. The area in the vicinity of Cottage like is located in a district cut up by small lakes and is very sandy in places. The other two areas are very sandy also with a considerable stand of jack pine on the larger area of the two.

These soils, with the exception of the Onoway area, are not extensively farmed due to their sandy nature and the tendency of crops to suffer from drought on such soils. There is also the difficulty of soil drifting in these soils after they are cropped a few years.

The A_1 horizon is 2 to 4 inches thick and consists of a light sandy yellowish colored soil with a little decayed organic matter in it. The A_2 horizon is 5 to 12 inches thick, similar in color to the surface layer and shows very little leached appearance due to the sandy texture. The B_1 horizon is 1 to 3 feet thick, yellowish brown in color, sandy loam to silt loam in texture with practically no noticeable structure, and shows the concentration of finer particles far less than in the other series of this belt. The lime layer varies a good deal depending on the sandiness of the B_1 horizon, but is generally found at around 4 to 6 feet.

Fine sandy loam (*incipient podsolic wooded soil belt*) 6321.

There are five areas of this class of soils totaling 14,400 acres, or 1.2 per cent of the surveyed area. The two larger areas are situated west of Stony Plain, one near Brightbank post office, and the other north-east of Cottage lake. The three other areas are south of the Saskatchewan river, one east of Genesee, a second near Warburg post office, and the last north-west of Thorsby post office.

These areas are quite extensively settled and under cultivation. The original covering was a poplar forest of fairly heavy growth. The A_1 horizon contains decayed vegetation to a depth of 2 to 5 inches. It is a fine sandy loam soil, yellowish in color. The A_2 horizon is 4 to 12 inches thick, grayish yellow in color and practically structureless. The lower horizons are similar to the description given above for this series of soils.

Loam (incipient podsolic wooded soils belt) 6341.

Three areas of these soils are outlined covering 22,888 acres, or 1.9 per cent of the soils area. The largest area is situated north-west of Stony Plain, another east of Brightbank post office, and a third smaller area along the Saskatchewan river south of Duffield.

Next to the silt loam area this loam area has the greatest percentage of cultivation among the incipient podsolic soils.

The A_1 horizon is 2 to 3 inches thick consisting of decayed leaves and grasses and dark colored soil. Immediately below is the leached layer 2 to 8 inches thick, grayish yellow in color and fairly sandy in many places. The remainder of the profile is similar to the profile described above for this series under the sandy loam class. The northern area is somewhat lighter in texture and the lime layer is at a lower depth.

Mixed areas (incipient podsolic wooded soil belt) 6281.

Two areas have been placed in this class because the soils are too badly mixed to separate into the various classes. One area is situated north of Genesee post office along the river and the other is a long narrow strip of land west of Telfordville extending north-west toward Genesee. The area north of Genesee is a mixture of sand, sandy loams, clay and peat. The more uniform soils are found in the southern part of the area and the greatest mixture toward the north. Where soil classes can be separated the profiles are similar to those described above for these same classes. The same is true of the area west of Telfordville. This area consists of silt loams, clay loams, and clays. It is situated in a depression extending from the Genesee district to the district around Telfordville, and it contains some patches of very impervious subsoil.

Loam (black soil belt) 4141.

This is the soil which in profile is characteristic of the black belt soils. There are 20,160 acres of these soils in the sheet, or 1.7 per cent of the surveyed area. The topography is gently rolling and the area is well settled and extensively cultivated. (See Plate II, Fig. 2.)

The A_1 horizon is 8 to 14 inches thick, of heavy black loam, rich in organic matter, with no pronounced structure. The A_2 horizon has an average thickness of 14 inches. It is a dark grayish brown silt loam to clay loam soil, with a slight tendency toward columnar structure. This soil horizon is the one of greatest leaching, but as explained in the description of the characteristic profiles these soils have not undergone the extreme leaching characteristic of the wooded or the incipient wooded soils.

The B_1 horizon is on an average 14 inches thick, of gray colored clay loam to clay in texture, and somewhat columnar in structure. The lime layer is on the average 6 inches thick, but the soils below this six-inch layer are usually well supplied with lime, often found in small pockets in the soil layer. The C horizon occurs as usual below the lime layer at an average depth of 42 inches.

Loam (black soil belt) 4142.

This is another class of loam separated within the class described above, as being a particularly fine tract of farm land within the loam class. It has very uniform topography, and is almost entirely under cultivation.

The profile is practically the same as in the other loam class, the main difference for the separation being the uniformity of topography and surface soils.

Sandy loam (black soil belt) 4111.

There is one small area of this soil covering 2,280 acres. It is situated on the eastern border of the sheet just north of the Saskatchewan river, and the soils are in the main formed from river sands.

The A_1 horizon is 1 to 3 inches thick, sandy in texture, with some decayed vegetation consisting largely of leaves and coarse grasses on the surface. The A_2 horizon is a sandy layer 6 to 14 inches thick. The B_1 has a slight concentration of the finer soil particles, but is itself fairly porous, and the lime layer is situated at 4 to 7 feet from the surface.

These soils are too sandy to be considered with the best agricultural soils.

Fine sandy loam (black soils belt) 4121.

This is a very small area of about a section in size with a fine sandy loam surface soil. It is situated north of Stony Plain on the eastern border of the sheet. The horizons below the A_1 horizon are the same as those described under loam soil in this belt.

Loam (black soils belt) 4241

This area is another loam soil within the black belt, but within a different series to the classes described above. It is given the different series classification on the basis of the heavier texture of profile.

This is an area in the south-east corner of the sheet covering 8,640 acres, or 0.7 per cent of the total. The topography is quite uniform and the area is drained by Weed creek.

The profile of this area shows the A_1 horizon 10 to 15 inches in depth, black in color, high in organic matter and heavy loam in texture. The A_1 horizon is a dark brown heavy loam to silt loam layer, from 8 to 12 inches in thickness. Underlying this layer is the B_1 horizon, grayish brown in color, somewhat columnar in structure, clay loam to clay in texture and from 1 to 3 feet thick. Beneath this layer is the grayish yellow lime layer 4 to 8 inches thick, granular in structure, and clay loam to clay in texture. It is highly calcareous and not so impervious as the layer immediately above it. Below is the slightly modified C horizon, yellowish brown in color, with some lime spots, and below this is the unmodified parent material.

There are some peat swamps in this area, and some grass swamps bordering the branches of the Weed creek.

COMPOSITION OF THE SOILS OF THE ST. ANN SHEET.

The average chemical compositions of the horizons of various soil profiles from the St. Ann sheet are reported in Table X. This table shows that for all soils the nitrogen content is greatest in the surface horizon and decreases rapidly below the A_1 horizon. This is accounted for by the fact that nearly all the nitrogen is held in the form of organic matter, and most of the organic matter is found near the surface. The nitrogen content of the surface horizon is very high (.53 to .98 per cent) for all soils. In the case of the wooded soils (8141 and 8151) this high nitrogen horizon is relatively thin (2 to 3 inches), whereas it is from 10 to 16 inches thick in the case of the black soils (4141).

The horizon containing the greatest amount of nitrogen also contains the greatest amount of phosphorus. This surface horizon likewise contains about twice as high a percentage of calcium as is found in the second and third horizons. Here again the calcium is associated with a greater amount of organic matter. On the other hand the greatest amount of calcium is found in the horizons (B_2 and C) which have not suffered loss of this element by leaching, but in the case of the B_2 horizon has actually received some calcium from the upper horizons. There is no free limestone ($CaCO_3$) in the upper horizons (A_0 to B_1 inclusive) and limestone is not encountered in these soils nearer the surface than about 2½ feet for the heavy textured soils (6271) and about 4 feet for the severely leached wooded soils (8141 and 8151). This condition is distinctly different from that found in the brown or dry plains soils in which free limestone is usually found within 9 to 20 inches from the surface, and at times occurs in the surface horizon.

TABLE X.—AVERAGE CHEMICAL COMPOSITION OF THE HORIZONS OF VARIOUS SOIL PROFILES FROM ST. ANN SHEET.

Horizon	Depth in inches	Nitrogen %	Phosphorus %	Calcium %	Magnesium %	Carbonates in terms of $CaCO_3$	pH*
			Wooded podsolic loam (8141)				
A_0	0-3	.636	.124	1.27	.33	none	6.7
A_1	3-5	.102	.053	.61	.31	none	6.2
A_2	5-14	.042	.040	.51	.38	none	6.4
B_1	14-48	.044	.034	.58	.52	none	6.7
B_2	48-56	.025	.044	2.71	.83	7.53	7.4
C	56-	.027	.042	2.22	.71	5.41	7.4
			Wooded podsolic silt loam (8151)				
A_0	0-3	.544	.104	1.02	.36	none	7.5
A_1	3-5	.132	.064	.51	.37	none	6.8
A_2	5-14	.075	.046	.62	.50	none	6.8
B_1	14-52	.055	.039	.70	.65	none	7.0
B_2	52-64	.047	.051	1.71	.99	3.42	7.2
C	64-	.041	.060	2.04	.93	3.42	7.2
			Incipient podsolic clay loam (6261)				
A_1	0-4	.978	.117	1.78	.47	none	7.0
A_2	4-10	.137	.038	.53	.48	none	6.9
B_1	10-40	.076	.028	.60	.59	none	7.1
B_2	40-48	.058	.064	2.62	1.10	5.87	7.5
C	48-	.055	.064	3.28	1.12	8.44	7.4

Incipient podsolic clay (6271)

A_1	0-6	.530	.100	1.17	.84	none	6.9
A_2	6-11	.140	.071	.66	.98	none	6.8
B_1	11-24	.099	.062	.91	1.22	none	7.4
B_2	24-36	.079	.054	3.32	1.29	7.45	7.4
C	36-	.057	.057	2.58	1.20	5.23	7.4

Black soil loam (4141)

A_1	0-10	.544	.118	1.04	.47	none	6.8
A_2	10-20	.213	.059	.79	.71	none	6.9
B_1	20-36	.073	.043	.69	.59	none	6.9
B_2	36-48	.043	.056	2.56	.58	6.20	7.3
C	48-	.033	.060	1.66	.56	3.61	7.4

*It should be explained that pH 7 on the reaction scale represents neutrality, and that lower values represent acidity, whereas higher values represent alkalinity. At pH 6 the soil is not too acid for the satisfactory growth of our common crops, but at pH 4 the acidity is often distinctly injurious.

Phosphorus, unlike calcium, is not carried downward to any appreciable extent by leaching. On the other hand, it tends to accumulate in the surface horizons. This accumulation is caused by the phosphorus combined with plant material in the surface horizon. This is more clearly shown by comparing the phosphorus content found in the B_1 horizon of the individual soils with the phosphorus content of the horizons both above and below the B_1. The phosphorus content of the surface horizon is quite adequate, but the phosphorus found in the lower horizons is relatively low.

No data are reported in the table for the potassium content of these soils. It should be stated, however, that these soils are fairly well supplied with potassium, and that they vary from 1.4 to about 2 per cent of potassium.

The wooded soils have suffered a greater amount of leaching than have the black soils. This statement is substantiated by data not reported in this bulletin dealing with the iron, aluminum and silica content, which show that there is a higher content of iron and aluminum in the B_1 horizon than is found in the A_2 horizon and conversely the silica content of the A_2

horizon is greater than that of the B_1 horizon. These conditions indicate that the wooded soils have suffered considerable degradation due to leaching, which has been increased owing to the fact that they have supported an abundant tree vegetation rather than a grass vegetation.* However, despite the fact that the distribution or iron, aluminum, silica and phsophorus, etc., in the various horizons of the wooded soils indicate that they have suffered considerable degredation, it is clearly shown by the pH values of the various horizons of the wooded soils that they have not yet become distinctly acid. In fact, the pH values indicate that the reactions of these soils are on the whole satisfactory. While these soils are not distinctly acid they have suffered sufficient loss of bases due to leaching to cause the A horizon to bake badly when dry and thus create an undesirable physical condition whenever this horizon is turned up by the plow.

The upper 3 inches of the wooded soil is almost identical in composition with the upper 10 inches of the black soil. In the first case the horizon consists chiefly of organic matter, whereas the corresponding horizon in the black soil is characteristically mineral in nature, and contains a large amount of organic matter (grass roots) intimately mixed with the soil.

The differences in depth and composition of the corresponding horizons for these two soils is more clearly shown in Table XI, where the total amount of some of the constituents have been computed for each of the upper 3 feet. An inspection of this table shows that the greatest difference in composition between these two soils occurs in the first foot, where it will be seen that the black soil contains about four times as much nitrogen and more than twice as much phosphorus as the wooded soil. There are likewise greater quantities of nitrogen, phosphorus, calcium, and magnesium respectively in the second and third foot depths of the black soil than occur in the corresponding depths of the wooded soil. The totals for the upper three feet bring out the following relationship: almost four times as much nitrogen, one and one-half times as much phosphorus and calcium, and one and one-third times as much magnesium in the black soil as in the wooded soil.

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*Grass roots form a thick network close to the surface and this tends to prevent leaching. Furthermore, it is doubtful if the original wooded soil material contained as much free lime as the black belt soils. After the free lime is removed by weathering process leaching or soil degradation occurs rather readily.

However, it should be stated that the analysis of the wooded soil as shown by the data in the above tables would indicate that it compares favorably with a great many of the world's fertile soils; and from the analysis alone one would

TABLE XI.—TOTAL PLANT FOODS IN UPPER THREE FEET OF WOODED AND BLACK SOILS FROM THE ST. ANN SHEET

(Pounds per acre)

Depth.	Nitrogen	Phosphorus	Calcium	Magnesium
Wooded soil loam (8141)				
1st foot	4,530	1,685	19,600	10,800
2nd foot	1,638	1,600	21,315	18,625
3rd foot	1,650	1,275	21,750	19,800
Total	7,818	4,560	62,665	49,225
Black soil loam (4141)				
1st foot	19,040	3,835	36,400	17,650
2nd foot	6,937	2,092	28,875	25,725
3rd foot	2,737	1,612	25,875	22,125
Total	28,714	7,539	91,150	65,500

be at a loss to explain the reason why such a soil would not give satisfactory crop returns. The fact still remains that the poorer phases of our wooded soil in most cases show unsatisfactory crop returns.

The better phases of the wooded soils—those intermediate between the typical black and the typical wooded soils—usually give satisfactory crop yields, whereas the poorer phases usually give yields which are somewhat disappointing. This is especially so during an unfavorable season, and often entire crop failures are experienced from the wooded soils whereas average yields are returned from the black soils.

The conditions thus revealed by farming practices on these wooded areas led us to outline experiments in an attempt to explain these differences and if possible to find a remedy. The results of these experiments are outlined below.

Originally the soil used in the following experiments had supported a fairly heavy tree growth, consisting chiefly of poplars, willows, and native shrubs together with long grasses, and some native legumes.

The soil was collected July 5th, 1925, from an area which had just been broken the previous season. The breaking had been done to a depth of 5 or 6 inches, and some of the light colored A_2 layer had been turned up. About one-half ton of soil for experimental purposes was taken to the depth of breaking (5 to 6 inches) and consisted of the A_0, A_1 and the upper inch of A_2 horizons. These horizons were not separated for analysis, but a composite sample showed the following results: nitrogen .114, phosphorus .036, calcium .43, magnesium .35 per cent respectively, with a pH of 6.5. This soil represents the poorer phase of the wooded soils and may be considered as in its virgin condition since it had grown no cultivated crops. In texture this soil is silt loam, and when moist is easily cultivated, but upon drying it packs and becomes very difficult to till. This is characteristic of the greater part of the wooded soils of Alberta.

The soil was air-dried and thoroughly mixed and 8 pounds weighed into each of 87 glazed earthenware jars of 1 gallon capacity. These were divided into three series and treated as follows:

Jar No.	Treatment.
1-6	Nothing.
7-9	Farm manure, 30 tons per acre.
10-12	Nitrogen ($NaNO_3$), 500 lbs. per acre.
13-15	Lime ($CaCO_3$), 5 tons per acre.
16-18	Phosphorus (acid phosphate), 2 tons per acre.
19-24	Lime and phosphorus, 5 and 2 tons per acre respectively.
25-27	Mixed fertilizers (3:10:7), 1 ton per acre.
28-30	Potassium (K_2SO_4), 400 lbs. per acre.
31-33	Sulphur, 200 lbs. per acre.

Series 1 and 2 consisted of 27 jars each with fertilizer treatment in triplicate, excepting in the case of the lime and phosphorus jars and again in the case of the controls. In both of these instances there were 6 jars instead of 3. Series 3 contained 33 jars, the first 27 being treated as in series 1 and 2, and, in addition, 3 jars receiving K_2SO_4 and 3 receiving sulphur.

Series 1 produced barley in 1925, sweet clover in 1926, wheat in 1927, oats in 1928, and rape in 1929. Fertilizers were applied to this series in 1925 and again in 1927.

Series 2 produced sweet clover, wheat, barley, wheat and red clover in the above order with the fertilizers applied to the sweet clover and barley crops.

Series 3 produced barley, sweet clover (failed to germinate), and red clover. Fertilizers were applied to the barley and red clover crops.

During the five years, 1925 to 1929, the following crops were grown: 3 crops barley, 2 crops sweet clover, 3 crops wheat, 1 crop oats and 3 crops red clover. The relative yields computed on the basis of 100 for the controls (average of 6 jars) are reported in Table XII.

After seeding, the jars were kept at optimum moisture in the greenhouse until considerable growth had taken place. They were then placed out in the open until maturity. The natural rain water was supplemented with distilled water whenever necessary throughout the entire growing period of the plants.

The following general observations were noted regarding the appearance of the plants grown with the different fertilizer treatments:

(1) Seeds germinated more rapidly where phosphorus in any form had been applied.

(2) Growth of plants was most vigorous and rapid where phosphorus had been applied.

(3) Plants matured more rapidly in case of phosphorus applications—grain crops and legumes blossomed from 1 to 2 weeks earlier for the jars receiving phosphorus.

(4) The total produce, as indicated by final yields, was greatest for the treatments carrying phosphorus.

An inspection of the averages of all crops in Table XII shows that the greatest responses in crop yields were experienced wherever phosphorus was added; that is, phosphorus alone, phosphorus and lime, mixed with fertilizer or manure. In the case of the mixed fertilizer treatment the increases in crop yields were caused largely by the phosphorus rather than by the potash or nitrogen, since nitrogen alone gave but small increases and potash alone gave yields identical with the controls.

General averages for all the crops grown showed increases for the various fertilizer treatments as follows: nitrogen 14, lime 33, manue 55, phosphorus 70, mixed fertilizer 69, lime and phosphorus 79 per cent, respectively. The potassium and sulphur treatments gave yields identical with the controls.

TABLE XII.—CROP YIELDS AS AFFECTED BY FERTILIZERS APPLIED TO WOODED SOILS (ALBERTA).

Results as relative yields where average of checks equals 100.

			Fertilizer Treatments								
Series	Fertilizers Applied	Crop	None	Manure	Nitrogen	Lime	Phosphorus	Lime and Phosphorus	Mixed Fertilizer	Potash	Sulphur
1	1925	Barley grain	100	75	26	113	123	160	165		
		Barley straw	100	61	154	123	133	138	211		
2	1925	Sweet Clover	100	83	125	100	122	130	135		
1		Sweet Clover	100	113	105	119	127	147	106		
2		Wheat grain	Grain destroyed by birds July 24th. Straw harvested Aug. 6th.								
		Wheat straw	100	133	115	117	114	137	129		
3	1926	Barley grain	100	121	112	119	138	133	85	103	102
		Barley straw	100	140	121	110	136	163	163	85	86
1	1927	Wheat grain	100	116	121	151	164	164	141		
		Wheat straw	100	111	150	170	193	188	203		
2	1927	Barley grain	100	114	160	161	145	149	182		
		Barley straw	100	87	151	155	144	138	278		
3		Sweet Clover	Failed to germinate.								
1		Oats grain	100	144	86	122	102	112	103		
		Oats straw	100	201	104	127	121	148	118		
2		Wheat grain	100	134	100	111	112	111	106		
		Wheat straw	100	171	102	108	126	128	108		
3	1928	Red Clover	100	556	132	164	449	488	370	109	100
1		Rape	Germination poor, crop stand irregular.								
2		Red clover	100	216	98	169	319	300	213		
3		Red Clover	100	281	103	174	305	288	221	100	100
		Averages.	100	155	114	133	170	179	169	99	97

For each of the legume crops grown, 3 of the control jars and 3 of the lime and phosphorus jars were inoculated and 3 jars in each of the above treatments were left uninoculated. There were no appreciable differences in the yields from the inoculated and uninoculated jars. Nodules were found on the roots of all legume plants.

It should be stated that even though this soil was slightly acid no difficulty was experienced in getting legumes to produce fair crops without the application of lime after such crops had become established. However, the application of lime gave appreciable increases in yield for all the crops grown.

Under field conditions the farmer often experiences difficulty in getting a satisfactory stand of the legume crops on the wooded soils owing largely to the undesirable physical condition of the soil. This is due to the great tendency of the wooded soils to bake when they become dry. The difficulty above mentioned can largely be overcome by the generous application of farm manure. The authors have seen very good stands of sweet clover, alfalfa, red clover and alsike clovers growing on the wooded soils, but almost invariably such desirable results have accompanied or followed the use of farm manures. (See Plate V, Fig. 2.)

It should be kept in mind that the results above reported were obtained under control conditions and that moisture at no time was a limiting factor. The farmer under field conditions is dependent upon the rainfall and at certain times moisture will be a limiting factor. Therefore he may receive increases for treatment (similar to those reported above) which may at times be much less in magnitude and at other times may even be greater in magnitude than those found by us. At any rate, the results obtained from the experiments above reported seem to indicate that it would not only be profitable to apply such fertilizers as phosphorus, lime or marl, and farm manures to certain areas of our poorest wooded soils, but that this practice together with the use of some legume crop in the rotation would be absolutely necessary if satisfactory crop yields are to be obtained. There is no question of a doubt about the possibility of growing legumes on the wooded soils, provided proper care is taken to insure these crops being established.

It has already been pointed out that the poorer phases of the wooded soils are relatively lower in plant foods than are the incipient wooded soils. (See Tables X and XI.) Furthermore, when these wooded soils are broken up the light colored leached horizon is often turned up by the plow. This produces an undesirable physical condition in the seed bed due to exposure of the leached layer which bakes badly when dry. It seems apparent that the lower productive power of the wooded soils is in part at least due to the undesirable physical condition. The most practical way to improve this physical condition is to introduce organic matter into the soil. This could best be done by the growth of legume crops which will improve the physical condition of the soil and at the same time add nitrogen. See Plate V, Fig. 2.)

The virgin wooded soils do not appear to have a nitrogen deficiency at present, but undoubtedly will develop need for this constituent before a great many crops have been grown on the soil.

SUMMARY.

The St. Ann Sheet is located in west central Alberta. It consists of an area of 48 miles north and south by 84 miles east and west, but so far only the eastern half of the sheet has been covered by the survey, and this report is limited to the eastern half of the sheet. The surveyed area consists of that portion of townships 49 to 56 inclusive which occupies ranges 1 to 6 or 7 inclusive, west of the 5th meridian. The soil map for the area represents about 52 townships, or 1,200,000 acres.

The general elevation of the surveyed area is about 2,500 feet, varying from about 2,300 feet in the north-east corner of the sheet to about 2,700 feet in the south-west corner of the surveyed area. The general slope of the St. Ann Sheet is towards the north and east.

Most of the surveyed area is drained by the North Saskatchewan river and its tributaries. A small area in the north-western corner of the surveyed area is drained by the Pembina river, which is tributary to the Athabaska. Lakes are fairly numerous in the surveyed territory, the largest being Lake Wabamun and Lake St. Ann. Isle and Low Water lakes come next in order of size, but they are much smaller than the first two mentioned. In township 52, range 2, there are no less than 18 small lakes. Some of the smaller lakes and swamps are poorly drained and contain some alkali salts. In most cases, however, the lakes of the St. Ann sheet possess outlets and the rainfall is sufficient to keep them comparatively fresh. Swamps and muskegs are fairly numerous, and the larger of these are outlined on the soil map. The natural drainage of the surveyed territory is good, the land being for the most part gently rolling or rolling in nature with few flat areas of heavy soil.

The main towns or centers of population occur along the railways, but none of these is very large. The transportation facilities for a large part of the surveyed territory are fairly good. The only part of the surveyed area which is very far from a railway is the south-west corner, or the territory between the Saskatchewan and the Pembina rivers, south-west of the Tomahawk creek valley.

The climate of the St. Ann sheet is fairly typical of the climate of the high plains region of western Canada. It is characterized by long, bright, moderately warm summer days, and bright, cold, dry winter weather. High winds, such as occur occasionally in the southern and south-eastern plains region, are very rare, and the crops are seldom affected by hot, dry winds, such as sometimes injure the crops of the treeless plain region to the south. The Chinooks which bring about occasional thaws during the winter in the southern plains region, seldom reach Edmonton, or the St. Ann sheet; the winter weather is consequently steadier, and a snow covering is more apt to be maintained throughout the winter months than in the plains region. The climate is characterized by a high proprotional amount of sunshine. The Dominion Meteorological Records state that the average of many years at Edmonton was 2,204 hours of sunshine per year, whereas the averages at several other points in Canada were as follows: Winnipeg, 1,988; Guelph, 1,885; and Ottawa, 2,019 hours, respectively.

At no point in the St. Ann sheet have meteorological records been kept for any great length of time, but such records for Edmonton are generally applicable to the surveyed territory. These records show that the average annual precipitation for a 43 year period was 17.64 inches, with the range between 8.16 inches for the driest year and 27.81 inches for the wettest year. About 53% of the average annual precipitation occurs during the summer months; the important growth months of May, June, July and August receive over 63% of the yearly precipitation and about 80% occurs during the months of April to October inclusive.

The average length of the frost free period for the 12 years from 1915 to 1926 inclusive was 89 days at Edmonton, 95 days at Calgary, and 103 days at Medicine Hat. The shortest frost free period in any one year at any one of the three places was 52 days. This short period occurred at Edmonton in 1918. The shortest frost free period in Calgary was 54 days and in Medicine Hat 98 days. The longest frost free period at Edmonton was 123 days, at Calgary 119 days, and at Medicine Hat 148 days.

Only a small proportion of the St. Ann shee has as yet been brought under cultivation. It has been roughly estimated that about 7% of the surveyed area is now being cultivated. Generally speaking, a high percentage of the black belt soils is being cultivated and a very small percentage of the wooded belt soils. This is what one would naturally expect in the early stages of settlement. It should be pointed out, however, that the tree growth is mainly poplar within the surveyed area, and that large trees are uncommon, so that the clearing is rather light as compared, for example, to land clearing in the eastern provinces.

It is estimated that the following three crops: oats, wheat, and greenfeed, constitute about 87% of the total acreage now being cropped; oats constituting 31% and wheat and greenfeed each 28%. The remaining 13% consists of hay and clover, barley, potatoes, turnips and mangels, rye, mixed grain, peas and alfalfa in the order named.

The above figures are vastly different from those previously reported in soil survey reports for the southern part of the province in which it was shown that 70% of the acreage cropped consisted of wheat and 20% of the total area oats. The estimates for the St. Ann sheet show that mixed farming is practised only to a very limited extent. In fact the system of farming suitable for the wooded soil belt in general is as yet to be established. There are strong indications that it must be a system of mixed farming involving the growing of clovers and other legumes to increase the fertility of the soil, supplemented in many cases by the use of limestone and the application of phosphates.

The soils of the St. Ann sheet (see soil map, also page 23 and Appendix I) consist chiefly of glacial drift derived largely from materials weathered from the underlying shale and sandstone formations. These underlying formations, especially the shales, have been very largely responsible for the texture of the soils. Thus we find that the greater proportion of the soils are intermediate to heavy in texture and the lighter soils, including the sands and sandy loams constitute only about 7% of the total area. In certain local areas the soils are entirely residual, whereas in other local areas they consist entirely of glacial drift. In general, however, the soils are made up largely of a small proportion of material brought in from outside regions by the glaciers, mixed with a large proportion of soil material which belongs to the underlying formations.

In general the topography is uneven, very little flat or level country is to be found, and as a result of the unevenness of topography the area contains fairly large water surfaces. The general relief is due largely to preglacial erosion and the deeper deposits of glacial drift in the preglacial valleys.

The mineral constituents of the soils of the St. Ann sheet have been influenced by their geological origin. Nevertheless, the more important features of the soil zones found in the sheet are due to the influence of rainfall, vegetation, temperature and the periods to which the soil layer has been subjected to the action of these climatic forces. The soils of the St. Ann sheet are divided into three main divisions or soil belts on the basis of extreme differences in the soil profile. These large divisions are fairly closely associated with the different sets of climatic conditions and the vegetative covering. These main soil belts consist of the black soils, wooded (podsolic) soils, and the transition belt (incipient podsolic) between the above two belts. The soils of the surveyed area consist of about 4% black soils, about 38% wooded soils, and about 43% of incipient podsolic soils. In addition to this about 6% of the area is water and about 3% peats.

The wooded (podsolic) soils have suffered a greater amount of leaching than have the black soils. The upper three inches of the wooded soils are similar in composition to the upper 10 inches of the black soils. In the first case the horizon consists chiefly of organic matter, whereas the corresponding horizon in the black soils is characteristically mineral in natire, and contains a large amount of organic matter mixed with the soil. The greatest difference in composition between these two soils occurs in the first foot where it is found that the black soil contains about four times as much nitrogen and more than twice as much phosphorus as the wooded soil. There are likewise greater quantities of nitrogen, phosphorus, calcium and magnesium respectively in the second and third foot depths of the black soils than occur in the corresponding depths of the wooded soils. The totals for the upper three feet bring out the following relationships: Almost 4 times as much nitrogen, 1½ times as much phosphorus and calcium, and 1 1/3 times as much magnesium in the black soils as in the wooded soils.

The better phases of the wooded soils usually give satisfactory crop yields, whereas the poorer phases usually give yields which are somewhat disappointing. This is especially so during an unfavorable season, and even entire crop failures are experienced from the wooded soils, whereas fair yields are returned from the black soils.

Results from experiments in the greenhouse with the poorer phases of wooded soils have shown that the average increases for several crops were as follows: Nitrogen 14, lime 33, manure 55, phosphorus 70, mixed fertilizer 69, lime and phosphorus 79 per cent respectively. Potassium and sulphur treatments gave yields identical with the controls. The greatest responses to these fertilizers, however, were shown by the legume crops. The soil was slightly acid, but no difficulty was experienced in getting legumes to produce fair crops without the application of lime, after such crops had become established. However, as above indicated, the application of lime gave appreciable increases in yields for all the crops mentioned.

Under field conditions the farmers have experienced difficulty in getting a satisfactory stand of the legume crops on the wooded soils owing largely to the undesirable physical condition of the soil. This is due to the great tendency of the wooded soils to bake when they become dry. The difficulty above mentioned can largely be overcome by the generous application of farm manure. The results thus far obtained from the experiments above reported seem to indicate that it would not only be profitable to apply such fertilizers as phosphorus, lime or marl, and farm manures to certain areas of our poorest wooded soils, but that this practice, together with the use of some legume crop in the rotation would be absolutely necessary if satisfactory crop yields are to be obtained. There is no question of a doubt about the possibility of growing legumes on the wooded soils, provided proper care is taken to insure these crops becoming established.

The most practical way to insure the improvement of the physical condition of the wooded soils is to introduce organic matter into the soil. This could best be done by the growth of legume crops.

The virgin wooded soils do not appear to have a nitrogen deficiency at present, but undoubtedly will develop need for this constituent before a great many crops have been grown on these soils. Nitrogen as well as organic matter is added to the soil by the growth of legumes.

In Appendix I (see page 54) will be found a discussion of the geology of the area by Dr. J. A. Allan, Professor of Geology, in the University of Alberta.

APPENDIX I.

THE RELATION OF THE GEOLOGY TO THE SOILS IN THE LAKE ST. ANN DISTRICT

BY

JOHN A. ALLAN.*

Introduction.—Soils may be regarded as unconsolidated rock. Most soils have been derived from the decomposition and disintegration of older rocks and are found either close to where they were formed, or occur in deposits consisting of transported material. The material may have been transported a very short distance, even only a few miles, or it may have been transported several hundreds of miles. There is usually a close relationship between the soils in a particular area and the geology in or close to that area.

Much of the surface of Alberta east of the Rocky Mountains is mantled with unconsolidated deposits of Pleistocene and Recent ages. The soils of Pleistocene age are chiefly of glacial origin or have been derived from the glacial load, either in the form of glacial debris or in the form of deposits formed in water in basins close to the front of the ice. The younger Recent deposits have been derived largely from older glacial deposits that have been worked over by rain and wind, or from the disintegration and decomposition of the rocks immediately underlying the soil. The depth of these deposits varies from a few inches to several hundred feet, depending upon the locality. Along valley depressions the depth of unconsolidated deposits is usually found to be the greatest, provided the depression has been formed in pre-glacial time. This condition of soil origin occurs throughout almost all of the Lake St. Ann district sheet. The map accompanying this report, which is entitled "Soil Survey Map of Lake St. Ann District," is the eastern half of sectional map No. 314, called St. Ann sheet and published by the Topographical Survey of Canada.

The entire area shown on this soil survey map has been traversed in part by the writer and much more extensively by Dr. R. L. Rutherford, geologist at the University of

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Alberta, who has made a detailed survey of parts of this district and has prepared a geological map and report which were published by the Scientific and Industrial Research Council of Alberta in 1928 as report No. 19. Many of the geological details recorded in this appendix have been taken freely from Rutherford's report, for which due acknowledgment is hereby given.

An attempt will be made to point out how some of the more prominent geological features are responsible for the distribution of several of the soil types shown on the map accompanying this report. It would require more detailed field observations before all soil types in this area could be correctly interpreted. A correct interpretation of the soil occurrences requires a knowledge of the sub-surface geology and the structure of the rocks, as well as a knowledge of the character of the material in the unconsolidated deposits.

Topography.—The surface topography in the Lake St. Ann district is shown on the accompanying map by means of very general sketch contour lines drawn at 100-foot intervals. As this is a district of comparatively low relief, the contour interval would have to be considerably less than 100 feet to show topographical details. This district may be described physiographically as an upland of low relief, similar to that further east in Alberta, and even in the Edmonton district. The depression occupied by North Saskatchewan river, with a meandering course, is incised to a depth of 300 to 500 feet into the upland in the southern part of the map, although the actual valley is about 200 feet in depth, while on the west side of the map, Pembina river, much smaller in size than the North Saskatchewan, follows an extremely meandering course and has cut a valley 200 to 400 feet into the upland. The surface elevations in this sheet range from 2,150 in the south-eastern corner in the Saskatchewan valley, to 2,850 feet in the western side of the sheet. In general the surface mean elavation rises gradually from east to west.

Rutherford states[1]:

"The present surface is a composite resulting from erosion and deposition which may be referred to in three time divisions, namely, pre-glacial erosion, glacial deposition, and post-glacial erosion. The major relief is largely due to pre-glacial erosion. There is considerable evidence in central and eastern Alberta which indicates that a relatively long and active period of erosion preceded glaciation."

[1]Rutherford, R. L., Sci. & Ind. Res. Coun., Alta., Rept. No. 19, 1928, p. 5.

He also refers to the character of the surface as follows:

"The deposits resulting from glaciation are spread over the whole area, but are thickest in the lower parts of the bigger valleys. This deposition temporarily dammed some of the streams and diverted the drainage, but the larger streams in most places now occupy pre-glacial valleys. Erosion since glaciation has deepened the valleys to some extent, but the surface aspect is largely the same as it was in pre-glacial times following a prolonged erosion period."

The valley of the Saskatchewan from Rocky Rapids east averages about two miles in width, but it is wider from Berrymoor Ferry, in section 18, township 50, range 6, west of 5th meridian, east to the boundary of the map than it is from the ferry west to Rocky Rapids. There are numerous large islands, consisting chiefly of river gravels, and the sides of the valley are terraced, in some places more distinctly than in others.

Referring to the lakes in this area, Rutherford notes that:

"The lakes occupying considerable portions of the central part of the area are a noticeable feature of the drainage system. Chip lake, Isle lake, Wabamun lake, and Low Water lake are the largest of these. Lake St. Ann, of similar magnitude, borders the area northeast of Isle lake. There is some evidence which indicates that these lakes are remnants of much larger water-bodies, which perhaps resulted from melting ice following glaciation.

"The trend of Chip lake, Isle lake and Lake St. Ann, and their outlets, is suggestive of the possible occurrence at one time of a long, narrow, continuous body of water with an east-west trend. The in-flow and out-flow of Chip lake are dominantly in a west to east direction, and Isle lake drains areas west almost to the Pembina near the mouth of Lobstick river. Wabamun and Low Water lakes may have been extensions of the same water-body. The low divide between Wabamun and Isle lakes, between Seba Beach and Gainford, suggests a possible connection of the two lakes when their water-level stood at higher elevations. Wabamun lake possibly extended much farther east at one time and covered the general area east and beyond Duffield. The numerous small lakes south of Duffield are possibly remnants of a greater Wabamun lake."

He also observes that there have undoubtedly been several changes in recent geological time in the size and extent of the lakes and also of the stream courses in this area. Many of these changes were brought about by glacial deposition and by lakes resulting from the damming up of former courses by glacial deposits. There seems to be quite definite evidence that the valley of the Pembina throughout at least part of this sheet, and particularly around Evansburg, is of post-glacial origin. On the other hand, the North Saskatchewan in this area is considered to be flowing in a pre-glacial valley. There are many other minor topographical details that need not be included in this report.

Sub-surface geology.—A few notes are here given on the geological formations that underly Lake St. Ann district. The formations that underly the whole of this area, exclusive of the Pleistocene and Recent unconsolidated deposits, belong to the uppermost Cretaceous and lower Tertiary periods. In order of age, from the youngest to the oldest, the rocks and unconsolidated material may be divided as follows:

Quaternary	Recent
	Pleistocene
Tertiary	Paskapoo
Upper Cretaceous	Edmonton

As the first two groups will be discussed under surficial deposits in the next part of this report, no further mention of them will be made here. The outcrop of the contact between the *Edmonton* and *Paskapoo* formations, as shown on Rutherford's map No. 13 which accompanies his report referred to above, is represented by an irregular line extending from the southeast corner of the map accompanying this report, to the northwest corner in township 54, range 7. As these two formations are lying in a comparatively horizontal attitude, the line of contact bends sharply up the North Saskatchewan valley and crosses about the center of township 50, range 5. The contact line also extends up the Pembina to a point a short distance above Evansburg. There is an eastward projection of the *Paskapoo* extending eastward between Wabamun lake and Isle lake, so that the contact between the two formations occurs at the east side of township 53, range 5. In other words, of the larger lakes, Low Water lake is underlain by *Paskapoo*, whereas Wabamun, Isle lake, Lake St. Ann and Sandy lake are underlain by the *Edmonton* formation.

The *Edmonton* formation represents the uppermost Cretaceous strata in Alberta. A complete section of this formation is exposed along Red Deer river in the vicinity of Drumheller. This section of the *Edmonton* has been measured by the writer and has a thickness of 1,242 feet.[2] J. B. Tyrrell, who reported on the district west of Edmonton in 1887, considered that the Edmonton formation has a maximum thick-

2Allan, J. A., Geology of Alberta coal, Trans., Can. Inst. Mining & Metallurgy, Vol. XXVIII, 1925, p. 387.

ness of about 700 feet in the Lake St. Ann district. Rutherford reports that the thickness of this formation is believed to be over 1,000 feet in the Lake St. Ann district. The *Edmonton* formation strata apparently were deposited near the shore of bodies of fresh water of shallow depth. The strata in the *Edmonton* formation are markedly uniform in character and are described by Rutherford[3] as follows:

"The *Edmonton* formation in its eastern development is characterized both vertically and laterally by the presence of light-colored bentonitic clays. The greater part of the formation is composed of clays or shales, while sandstones constitute only a minor part, and these also are in most cases bentonitic. Thus any exposed section of the *Edmonton* formation is usually very light grey in color, due principally to the bentonitic clay material so universally distributed throughout the whole formation. Where the beds are dominantly clays they are often characterized by the presence of clay-ironstone nodules which weather to a reddish brown color. These nodules vary from an inch to about ten inches in diameter, and frequently occur in rows or bands. In addition, the Edmonton formation is characterized by coal seams varying in thickness from a few inches up to as much as 25 feet. The thickest seams occur in the upper part of the formation and are present in this area. These are discussed in more detail below. There are also seams of commercial thickness occurring in the lower part of the formation in the vicinity of Edmonton east of this area. On the whole, the Edmonton formation is remarkably free from beds of coarse, clastic matrial."

The lime content in these rocks is high, and in some beds the cementing material holding the sand together is high in lime. Bentonite, commonly known as "gumbo" in the impure form, is an important constituent of the sandstones in the *Edmonton* formation. Very heavy clay and gumbo-high soils are formed from the residual weathering of the *Edmonton* rocks. The high gumbo content in many of the soils in the Lake St. Ann district may be accounted for in this way. That is, these soils have been derived very largely from the *Edmonton* bentonitic sandstones and clays. This, however, does not seem to be a characteristic type of soil in the Lake St. Ann sheet because the bentonitic debris has been mixed with lighter types of soil. It is probable that the loamy types that occur between the eastern side of the map in the vicinity of Stony Plain and Duffield are formed largely from the bentonitic rocks in this formation. This also applies to the sandy loams and silt loams in both the incipient podsolic types and wooded podsolic types in the east half of the map, and more particularly in the northeast corner of the map.

[3]Rutherford, R. L., Sci. & Ind. Res. Coun., Alta., Rept. 19, 1928, p. 11.

The most detailed analytical study of the rocks in the *Edmonton* formation has been made by Sanderson in a report to the National Research Council.[4] Thin sections of *Edmonton* rocks, when examined under the microscope, show that feldspars are an abundant constituent in the rock. Many of these feldspars are highly kaolinized, others appear less altered. The potash feldspar is a very common variety in the specimens examined. In the early part of this report, on page 54 under the chapter "Composition of the Soils of the St. Ann Sheet", it was noted that the soils in this area contain a fairly high potassium content, which varies from 1.4 to 2 per cent potassium. It would appear that the high potassium content in some of the soils in this district may be explained as having been derived from rocks belonging chiefly to the *Edmonton* formation in which kaolinized potash feldspars are abundant.

The *Paskapoo* formation underlies the southwestern third of the map area and southwest of the line of contact between the *Paskapoo* and *Edmonton* formations as defined above. The name *Paskapoo* was first given to these rocks by Tyrrell[5] for beds occurring on Blindman river near its confluence with the Red Deer a few miles east of the town of Red Deer. The thickness of this formation is considerably greater than that reported for the rocks belonging to this formation in this area. It is only the basal beds of the *Paskapoo* formation that occur in the southwest part of the Lake St. Ann district. The thickness of these beds would probably in no place exceed 500 feet. Rutherford describes the basal members of the *Paskapoo* formation as follows:

"The basal *Paskapoo* in its eastern development is usually characterized by massive sandstones, which are readily differentiated from the *Edmonton* formation that is largely clays and shales. These sandstone beds are often over 50 feet thick and usually highly cross-bedded. Lenses of clay shale frequently occur within the sandstones. These massive sandstones are well exposed in several places, for example on the Saskatchewan at Berrymoor ferry (township 50, range 5); around the west end of Lake Wabamun at Fallis and north of Seba Beach; along the Pembina at Evansburg and on the McLeod in townships 57 and 58. The first appearance of these sandstones above the typical *Edmonton* beds has been taken to represent the base of the Paskapoo by most investigators. Tyrrell placed the base of the *Paskapoo* on the Saskatchewan at the first appearance of

[4]Sanderson, J. O. G., Analyses of Cretaceous and Tertiary sediments and their stratigraphic relationships, prepared for Nat. Res. Coun. of Canada, 1924.

[5]Tyrrell, J. B., Geol. Surv., Can., Summ. Rept., New Series, Vol. 2, 1887, p. 135E.

these massive sandstones. McEvoy[6] assigned a *Paskapoo* age to similar beds near Evansburg, although he grouped the *Edmonton* and *Paskapoo* together under the *Laramie*."

The lime content in the *Paskapoo* strata is somewhat higher than it is in the underlying *Edmonton* strata. Immediately above the massive sandstone that usually occurs close to the base of the *Paskapoo* is a series of clays, more or less indurated, in which the lime content is also high. The disintegration of these beds results in the development of heavy clay soils. This is particularly well shown in the 6271 type in the southwestern part of the map. It might also explain the 8151 type that occurs east of Rocky Rapids and again in the vicinity of Low Water lake, although in the latter district the material has been transported and sorted to a certain degree.

ORIGIN OF SURFICIAL DEPOSITS.

The soil types in this area have been grouped into three soil types, namely:

(1) Black Soil Belt,
(2) Incipient Podsolic Soil Belt,
(3) Wooded Podsolic Soil Belt.

The two factors that have to be considered are the age of the soil, that is, the time to which it has been subjected to weathering agents, and the origin or source of the material making up the soil. It would seem that the wooded soils may be classed as the oldest or most mature, as they have been more thoroughly drained and forest growth has resulted. This type in this area represents about 40 per cent of the total area mapped. The black soils and peats represent the least mature or youngest type, high in organic material, and in the case of peat, high in water content. The incipient podsolic type is intermediate between the other two, less mature than the wooded and more mature than the black soils. In fact, specific examples of the development of one type into the other can be observed in this part of Alberta. At least some of the incipient soil types were formerly black soils, and with time will pass into the wooded type. Of course, besides the age factor, the original composition or origin factor must also be considered.

The soil differs from the underlying deposits upon which it is developed in that weathering agents have changed its

[6]McEvoy, J., Geol. Surv., Can., Summ. Rept., 1898, Pt. D, p. 24.

original texture, color and composition. In some soils, particularly the black soil types, the accumulation of organic material, largely vegetal, has caused the soil, particularly the surface soil, to assume a dark color. In many cases surface leaching has deprived the soils of certain mineral, and often the mineral content of the subsoil has been changed. It would appear, from the report of this area, that the podsolic soils show the greatest amount of leaching.

The unconsolidated deposits in the Lake St. Ann district can be classified into four types:

(1) Residual deposits,
(2) Glacial moraine, unsorted,
(3) Resorted glacial deposits,
(4) Transported deposits of alluvial, lacustrine and dune origin.

The first type of soil includes the *residual deposits* that have been formed by erosion processes from the underlying strata. Soils formed in this way will have a composition somewhat similar to the composition of the underlying rock from which they have been formed. For example, certain areas of sandy loam indicate the occurrence of clayey sandstone below, while silt loam and clay loam suggest the presence of shale formations in the underlying rocks.

In the Lake St. Ann district residual soils are believed to have a wide distribution, especially in the southeastern part of the area mapped, especially from Duffield east to Stony Plain and south to include the area south of the Saskatchewan valley. These soils have in large part been derived from the *Edmonton* formation. As mentioned above, Rutherford has pointed out that the *Edmonton* beds were extensively eroded, and a pronounced topography developed in Tertiary time. This topography therefore is of pre-glacial date and long before the advance of the ice sheet. No doubt some of this eroded material was worked over by glacial action, but nevertheless it may be regarded in part as residual. Soils at least of partial residual origin occur in the southwest part of the area mapped, especially south of Tomahawk.

The second type, namely, *unsorted glacial moraine*, is not very widespread in this area, except in the northeast corner of the map. There is a morainal belt extending into this map area largely in the area between Lake Nakamun and the vicinity of Onoway. The rolling character of the surface topography is due largely to morainal deposits. Precambrian boulders are common with the gravel and sandy clay, but these became fewer to the southwest. In the vicinity of Nakamun there are also boulders of bituminous sand transported by the glaciers from the McMurray district, over 200 miles to the northeast.[7]

In the morainal covered areas, local depressions are common. These depressions are often circular in outline and even conical in shape, sometimes more irregular. These depressions are called "kettle holes" and are formed by entrapped blocks of ice melting after the glacier left that surface, with the result that the moraine settled to form such depressions. In some of these there may be soft ground or slough conditions, or the depressions may be sufficiently drained to form a firm surface. There are a number of these kettle holes in the vicinity of Onoway. In a few cases observed, a few trees are growing in a circular line about the depression. This is due to the growth that resulted while the central part of the depression was covered with water or while slough conditions existed. Such surface conditions are unmistakeable evidence of the presence of morainal material in that area. No large morainal deposits have been observed in other parts of the area mapped.

The third type of soil is that resulting from *glacial drift* that has been *resorted* and deposited along old glacial drainage courses or in ponds and lakes close to or near the front of the retreating ice sheet. In some cases *outwash plains* have been formed from deposits carried out by streams coming from under the ice sheet around its margin.

It would appear that the large area in the central part of the map, and especially that lying north of Lake St. Ann and Isle lake, have been in large part formed from the resorting of glacial deposits that occur north and east of this area mapped. These have been derived chiefly from the underlying rock formations over which the ice passed, and to a lesser extent from the Precambrian rocks beyond the northeastern part of Alberta.

It is not always possible to separate this type from the transported type, but in any district where there are glacial boulders or coarse gravels with a large number of pebbles of

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[7]Rutherford, R. L., Two interesting boulders in the glacial deposits of Alberta, Jour. of Geol., Vol. XXXVI, No. 6, 1928, p. 558.

igneous rock or other rock foreign to this area, those deposits are very likely to be of glacial origin.

The last type of surficial material includes the *transported deposits.* The transporting agents are running water and wind. The former gives rise to alluvial and lacustrine deposits, the latter to sand dunes. All transported deposits are bedded in character, due to the sorting action of the transporting agents. The sand and clay may occur in separate beds, forming a sandy soil or a clay soil. These deposits may also be a mixture of sand and clay with varying proportions of each, giving rise to a sandy clay or a clay loam soil.

Alluvial material occurs along the bottoms of valleys where there are streams at the present time, or along old drainage courses where there is no apparent drainage today. The lacustrine deposits include those clays and sands deposited on lake basins, sometimes small, sometimes large in area. There may be a small lake remaining or there may not be any surface evidence of such a lake at the present time except a broad, plain surface. In this type of deposit the character and composition of the soils are usually quite uniform.

The larger lakes in the Lake St. Ann district are remnants of much larger bodies of water. The soils between Lake Wabamun and Low Water lake indicate that these two lakes were formrly connected. There are indications that the former drainage of these basins was northeast into Sturgeon river. Wabamun lake and Isle lake and also Lake St. Ann were at one time connected, so that the soil types in the central part of the map consist in part of transported material and in part of resorted glacial debris, and possibly some residual material from the underlying formations. The soils about many of the smaller lakes have been formed when these lakes were larger than at present. Some of the earlier lakes have become filled up and their basins are yet apparent, others consist of peat deposits or muskegs. The transporting agents are still at work. Beaches, mud flats and swamps are being developed and the land surfaces are being extended into some of the lakes.

There is no doubt that more detailed field investigations on the surface geology of this Lake St. Ann district would add much data to that recorded in this appendix, and the origin of the material in particular soil areas could be more correctly explained.

GLACIAL HISTORY OF THE LAKE ST. ANN DISTRICT.

A study of the surface deposits and the present physiography of the Lake St. Ann district involves to a certain extent the glacial history of this part of Alberta. The glacial history of this sheet, in so far as it is related to soil types, is so intimately connected with the glaciology over a large part of Alberta that it is in order to include a few general notes on the subject.

The glaciers that affected this part of Alberta by advancing over the surface and leaving deposits when the ice melted belonged to the Keewatin ice sheet. The drift deposits left by this ice advance are characterized by the presence of boulders and gravel of Precambrian rocks, largely gneisses, schists and granites. The western limit of this Keewatin drift occurs beyond the limit of this map. Rutherford records the western limit as occurring on McLeod river at the west side of range 16.

During late Tertiary time and after the deposition of the *Paskapoo* strata, and long before the southern advance of the Continental ice sheet from the west side of Hudson bay, there was a pronounced topography throughout much of Alberta, including this area. Prolonged erosion prior to the advance of the Keewatin glaciers produced an erosion surface with hills, valleys and inter-valley ridges. These physiographical features became more pronounced by erosion with the approach of Pleistocene glaciation. Prior to the glacial period, erosional features were developed in no small way by drainage related to the uplift of the Rocky mountains. It was towards the close of the Cretaceous period in the Mesozoic era that the initial uplift of the Rocky mountains occurred. As this uplift continued, drainage channels were formed on the eastern slope. Ultimately a pronounced system of drainage was developed, with major streams having a general easterly direction. This pre-glacial drainage down the east slope of the Canadian Rocky mountains is today represented in general by such rivers as the Red Deer, North Saskatchewan, Athabaska, Peace and many other smaller rivers.

It is not necessary in this report to discuss details regarding pre-glacial topography. It is apparent, however, that the general surface of this part of Alberta at the close of the Tertiary was a rolling plain, deeply incised with many valleys. The elevation of this plain was considerably above the present elevation—at least as high as the top of the Swan hills, which occur north of this area and south of Lesser Slave lake. These hills rise to an elevation of over 4,200 feet above sea level, or over 1,400 feet above the present highest part of the Lake St. Ann district. When the glacier advanced this part of the province was covered with what is known as the Keewatin ice sheet, which originated in the snow fields west of Hudson bay. This ice sheet advanced beyond the southern boundary of Alberta. The advancing sheet brought with it Precambrian boulders and finer rock debris from the northeast, but the largest part of the load of the ice consisted of rock debris from the younger Cretaceous and Tertiary formations over which the ice passed. There is no way of determining the exact amount of material that has been removed by erosion from this district, but when the position of the Swan hills is considered and also the high land known as Whitecourt hill south of Whitecourt, about 30 miles west of Sangudo, which is at the northwest corner of this map, it would appear probable that over 1,500 feet of beds have been eroded from the upland. This erosion occurred in pre-glacial time and after the deposition of the *Paskapoo* beds. There is no exact data on how thick the ice was in this part of Alberta. It was possibly quite thin in some places and possibly absent from other areas, because there are local driftless areas; that is, areas where there are no glacial deposits today.

With a more moderate climate, the ice sheet melted and the enclosed rock debris was left as glacial drift. It is important to bear in mind that this drift was made up of heterogeneous rock debris consisting in large part of silica-, alumina-, potash- and magnesia-rich debris from the Precambrian rocks to the northeast, and silica-, lime-, and alumina-rich sand and clay from the Cretaceous and younger rocks at the surface northeast of the Lake St. Ann sheet, which were ground up by the advancing ice sheet. There is no debris in the map-area that has been derived from the Rocky mountains, except that along the river channels.

Glacial erosion is always caused by the forward movement of the ice. During the retreat of the ice shee the ice does not move backward, but the front of the ice sheet is melted more rapidly than the forward movement of the ice. The front of any ice sheet is irregular and lobate in outline. Tongues of ice project farther forward than other parts of the ice mass. This applies to the Pleistocene ice sheets as well as to modern glaciers. As the ice-front retreated, the water from the melting ice became impounded where drainage courses from the ice became blocked by debris from the ice. In many places in Alberta drainage courses were developed sub-parallel to the ice-front. This type of drainage is not much in evidence in the Lake St. Ann sheet, but the former extensions of Low Water, Wabamun and Isle lakes, and Lake St. Ann have been related to glacial and post-glacial drainage.

Post-glacial erosion has, to a considerable extent, developed Pembina valley and has deepened many of the depressions that were present when the ice retreated. The smaller streams tributary to the North Saskatchewan, to the Pembina and to the various lakes, are of post-glacial age and have been developed in comparatively recent time. The details on the glaciology of Alberta have not yet been worked out, and no doubt many interesting features on the glacial history of this province are not yet known.