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COLLEGE OF AGRICULTURE

SOIL SURVEY OF SULLIVAN LAKE SHEET

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F. A. WYATT AND J. D. NEWTON
(With Appendix by J. A. Allan)
University of Alberta

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Dominion Department of Agriculture
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The soil survey report of the Sullivan Lake sheet is the result of co-operation between the Dominion Department of Agriculture, the Soils Department of the University, and Dr. J. A. Allan, Professor of Geology.

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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.

This report describes the properties of the surface and subsoil of the various soil types, and gives the fertility invoice of the principal areas. It describes the topography, drainage, water supply, and alkali problems of the area. Methods of soil management and possible utilization of the area are discussed. It also contains a brief discussion of the climate and agricultural development of the area, together with the important farm crops and transportation facilities.

The soil map is an important part of this 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, railroads, streams and towns. The soil map serves as a reference by which the better land can be distinguished from the poorer land as well as indicating the best method of utilization. Two other maps accompany this report; one shows the distribution of the cultivated, abandoned, and virgin lands in the area, and the other shows the possible utilization of the area.

During the last fifteen years there has been some re-location of farmers within the Sullivan Lake area, as well as some movement to other parts of the province. It would have been a kindness to these settlers if this survey had been made previous to settlement, as these settlers have abandoned their farms after wasting much money and many years of their lives in an attempt to build up homes on submarginal land. However, such soil reports are of value today to determine those areas that might still be cultivated in the "drought area," and to aid in re-locating those settlers that it is desirable to move. Such a transferring of settlers from one community to another cannot be done without great expense, first in the actual cost of moving; secondly in the loss of the investment in the original home, and thirdly in the loss in production while these settlers are being established in their new homes. It is necessary that all possible information be available to aid in this re-location.

It is true that particularly in southeastern Alberta rainfall is the main limiting factor in crop production, but, in a given district, with a given rainfall different soil types differ greatly in their crop producing powers or their ability to resist drought. The better soil types of these areas should be profitable under a planned system of agriculture.

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. Similarly, results from local illustration stations apply particularly to the soil types similar to the one at the station. When planning 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 know whether a certain crop or treatment could be expected to bring results on their land 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 reports tend 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 more successful, he can observe what crops the more successful farmer is growing and what tillage methods he employs.

Our soils still form our greatest natural resource. However, if some of them continue to deteriorate at their present rate we will soon find that as a resource they cease to exist. It is quite apparent that soils of many areas are not as productive today as they were a decade ago even under similar climatic conditions. Soil conservation means a utilization of the soil in such a manner that it maintains a certain productive level. A program that will do this is imperative if we are still to have soil to cultivate for longer than one generation. A survey of our soil resources is the first step in any such program.

Soil Survey of Sullivan Lake Sheet, Alberta

BY

F. A. WYATT AND J. D. NEWTON
(With Appendix by J. A. Allan)
University of Alberta

W. E. BOWSER* AND W. ODYNSKY,*
Dominion Department of Agriculture
Experimental Farms Branch

DESCRIPTION OF THE AREA

The Sullivan Lake sheet is located in central eastern Alberta and comprises an area 84 miles east and west by 48 miles north and south. More exactly it consists of townships 33 to 40 inclusive within ranges 1 to 14 inclusive west of the fourth meridian.

The southern boundary of the surveyed area lies 192 miles north of the International boundary and the eastern edge lies along the Saskatchewan-Alberta boundary. The area extends on the east from a point about fifteen miles northeast of Provost to a point four miles south of Compeer, and on the west from a point about four miles west of Galahad to approximately six miles south of Sullivan Lake.

The soil map for the area described above represents 112 townships or 2,580,000 acres.

The area covered by this report lies partly in the brown soil zone of Alberta and partly within the dark brown soil zone. The line dividing these zones enters the Sullivan Lake sheet from the south at a point in range 12, runs north to Coronation, and then generally east to a point on the eastern edge between townships 36 and 37. That is, the portion south of this line is in the brown soil zone and forms a part of the treeless or bald prairie of southern Alberta and the portion north of this line is in the dark brown soil zone and forms a portion of the transition zone between the bald prairie and the tree park lands of Alberta.

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*Soil Specialist, Prairie Farm Rehabilitation Act, attached to Soils Department, University of Alberta.

Messrs. J. A. MacGregor, H. M. Thompson, R. L. Erdman, G. Richards, and R. E. Carlyle assisted with the field and analytical work during the course of the preparation of this report.

The backbone of the Neutral hills runs in an easterly direction from township 37, range 9, to township 35, range 1, and then into Saskatchewan. Nose hill in township 37, range 9, is about 3,000 feet high, but the altitude of the range becomes generally lower as it runs east. A fairly wide area south and north of this ridge is quite rough and broken and is mapped as rolling or hilly. There is a small area of rolling topography outlined in township 33, range 14, at the south end of Sullivan lake. Apart from this the sheet is principally undulating to gently rolling. There is very little really level land. The rolling and hilly areas are outlined on the map by hatching. There are 342,000 acres of rolling land and 142,000 acres of hilly land; that is 19 per cent. of the sheet is topographically unsuited for cultivation or is of marginal suitability.

There is a gradual slope or drop in elevation from the southwest to the east and northeast. Castor and Sullivan Lake on the west side of the sheet have elevations of 2,681 and 2,651 feet respectively, and Compeer and Provost on the east side have elevations of 2,363 and 2,186 feet respectively. Nose Hill, north of Veteran, is the high point of the area with an elevation of slightly over 3,000 feet. Battle river flows out of the area in township 40, range 9, at an elevation of about 2,000 feet; this is the low point of the sheet.

Practically the entire area belongs to the North Saskatchewan drainage system by way of Battle river. Battle river enters the area in township 40, range 14, then loops south before turning northeast to leave the area in township 40, range 9. Paintearth, Castor and Young creeks flow into Battle river from the south. They drain the area from Castor to Federal. Ribstone creek, which in the dry years becomes a seasonal stream, has its head waters around Coronation. It has cut a wide valley, much of which floods in the spring run-off. It flows northeast to leave the area in township 40, range 6, about five miles northeast of Czar, and joins Battle river in township 45, range 1. The many meadows and draws south of Coronation are the headwaters of Sounding creek. This creek, at present almost entirely seasonal, flows south into the Sounding Creek sheet, makes a large loop, and re-enters the Sullivan Lake sheet in township 33, range 2, at Grassy Island lake. From here it flows north to be joined at Pemukan by Monitor creek, which drains the area from Veteran to Monitor, and thence north into Sounding lake, located in township 37, range 4. Sounding lake is drained to the east by Eyehill creek which leaves the sheet in township 38, range 1, and thence into Lake Manito in Saskatchewan. Sullivan lake has no outlet at present, but it would appear that at one time it may have drained south into Dowling lake, and then either into Red Deer river by way of Bullpound creek or east over to the headwaters of Sounding creek. In addition to these streams there are many small draws that carry the spring run-off. There is a number of springs particularly in the Neutral Hills area.

Gooseberry lake in township 36, range 6, which covers slightly less than two square miles, was the largest body of water in the area in 1937. It has a high water drainage outlet to Sounding lake, but generally it can be considered as the centre of a small inland drainage system. The water of this lake has a fairly high salt content. In 1937 Sounding lake, which covers about nine square miles, and Sullivan lake, which covers about one and one-half townships, were both dry. Some of the smaller lakes in the northern part of the sheet contained water in 1937, even after the long spell of drought, and these lakes showed considerable rise in water level after the fairly heavy late summer rains of that season.

Kirkpatrick lake in township 33, range, 10, Hamilton lake in township 35, range 10, and Grassy Island lake in township 33, range 3, are more in the nature of marshes and excepting for the very wet years are a source of meadow hay. Flats and small hay sloughs are fairly numerous in this area and supply considerable meadow hay for winter feed. The Ribstone Creek flat generally yields a large supply of hay. However, the extent of this crop varies with the nature of the spring run-off, that is with the amount of flooding these flats receive. Many of the sloughs, particularly in the more sandy soil areas, are very alkaline and do not support any vegetation of economic value.

The many small draws in the area afford excellent opportunities for the construction of artificial water reservoirs to be used as stock watering dams or for small irrigation projects. There are a few such dams at present constructed, but only three local irrigation projects were seen. All of these pumped water from a dam to irrigate an upper bench. One on Castor creek is used to irrigate a truck garden.

The soil on the eastern half of the area consists mainly of glacial drift. This till varies greatly in depth; in some places the underlying parent material comes practically to the surface, and in the hilly morainal area it may be hundreds of feet thick. Some of this drift has been brought in by the glaciers from Hudson's Bay region, but some of it originated from the underlying sandstones and shales in the vicinity. Glacial stones, of Hudson's Bay origin are fairly numerous in the rolling and hilly areas of this sheet. They are most noticeable on the weathered ridges and slopes. Considerable sorting due to glacial streams appears evident. In the western half of the sheet the bed rock is generally much closer to the surface. There are glacial stones over most of this area, but they are found principally on the surface and it appears as if the glacial till deposit has been mostly washed or eroded away. For a more detailed statement of the geology of the sheet the reader is referred to the appendix by Dr. J. A. Allan.

A branch line of the Canadian Pacific Railway from Red Deer to Kerrobert, Saskatchewan, traverses the sheet from west to east. Castor and Coronation, each with a population of approximately 600, are on this railway. Consort, with a population of about 250, and the villages of Veteran, Monitor and Compeer are also situated along this line. The Edmonton to Winnipeg line of the Canadian Pacific Railway cuts through the northeast portion of the sheet. Provost, with a population of about 500, and the villages of Czar and Cadogan are on this railway. A branch line of the Canadian National Railways from Camrose enters the sheet in the northwest corner and terminates at Alliance, a town with a population of about 260. A branch line operated by the Canadian Pacific Railway runs north from Coronation as far as Bulwark. Grading on this line is completed through to link with the Camrose to Alliance line. A branch line from Unity, Saskatchewan, enters the sheet from the east in township 37, range 1, and terminates at Bodo. A branch line of the Canadian National Railways from Alex to Hanna cuts through the southwest corner of the sheet. Scapa, at the south end of Sullivan lake, is on this line. Rails are laid on a line running east from Scapa to Hemaruka in township 32, range 8, and rails are also laid on a line from Coronation south to this line. Railroad grade is built from Bulwark east to Ribstone creek near Lakesend. Transportation facilities are, therefore, good. Very few places on the sheet are over eighteen miles from the railway, and, in general, most of the farmers are within easy reach of railway towns.

The area is fairly well supplied with dirt highways that are for the most part in a good state of repair. The side roads in some of the badly deserted areas are deteriorating, but here the through roads are in good condition. Battle river is crossed by bridges at four points on the sheet.

There is a considerable amount of abandoned land in the brown soil zone south of the C.P.R. line from Coronation to Compeer. The greatest desertion has taken place south of Coronation and south of Monitor. In these two areas there was considerable abandonment during the period 1920 to 1925 as well as since 1930. The 1930 Dominion census showed that the 1925-1930 period saw the peak of cultivation in the entire sheet. In most of the sheet there has only been a slight drop in total cultivated acres as shown by the 1935 census as compared to the 1930 census, excepting in the two above mentioned areas and in these the 1935 cultivated acreage was lower even than the 1920 acreage (see Plate 5). Most of the early desertion was off sandy soil areas which since that time have drifted badly (see Plate 6). The recent desertion has been more general, but is restricted principally to the poorer soil types. These areas are now covered with weed growth.

Gooseberry lake, north of Consort, and Shorncliffe lake at Czar, are local pleasure resorts. The parkland area of the northwest portion of the sheet which is frequently cut by deep coulees exposing brightly colored country rocks affords many scenic and attractive spots.

CLIMATE

The climate of the Sullivan Lake sheet is 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 winter weather. There are, in general, fewer high winds in this area than in the chinook belt farther to the south, but very few days are wind free. Wind direction records have been kept at Halkirk, which is situated on the western edge of the sheet, from 1911 to 1929 inclusive, the readings being taken twice daily. Over this period of years the largest percentage of the winds were either from the northwest or the south, with the fewest winds from the east; 23 per cent. were from the northwest, 22 per cent. from the south and slightly less than 4 per cent. from the east.

The following summary gives approximately the relative wind direction frequency at Halkirk from 1911 to 1929:

North	45	South	159
Northeast	52	Southwest	104
East	28	West	57
Southeast	102	Northwest	165

The distribution of the winds during the growing season is the same as for the full year. Although no wind velocities were given in the records, observations of drifted fields would indicate that the strong winds and gales were from a west to a northwest direction.

Edmonton receives about 2,200 hours of sunshine per year and Medicine Hat about 2,350 hours per year; so that the total annual sunshine of the Sullivan Lake sheet should be somewhere between these two figures.

All the meteorological data given in this report are compiled from the Dominion Meteorological Records. There are no long term records from the Sullivan Lake sheet so that records from stations near the sheet have been used. These stations were selected to give as complete a picture of the climate of that area as possible.

Alix, which is situated fifty miles west of the sheet, has complete data for the thirty-two year period, 1906 to 1937. Halkirk on the western edge of the sheet has records for nineteen years. Both of these stations, however, are in a darker soil zone than is found in the southeastern portion of the Sullivan Lake sheet. These records should give a fairly accurate statement of temperature and rainfall conditions of the area around Castor, Alliance and Provost, but the soil profile definitely indicates that the area centering on Coronation, Monitor and Compeer has received over a long period of years a lower annual precipitation than the rest of the sheet. To give some indication of this, a ten-year record from Pemukan, which is situated seven miles east of Monitor, is included in the tables. For additional comparisons records from such points as Vermilion, Endiang, Medicine Hat, Lethbridge and Edmonton are also tabulated.

Table I shows the monthly distribution of the rainfall over a thirty-two year period at Alix. Included in this table is the rainfall at Pemukan for 1929 so that it might be compared with the dry year of 1929 at Alix. The year, in this table, is divided into three sections, namely: the previous fall, winter, and the growing season, because it is thought that the previous fall's moisture plus the growing season's moisture is most closely related to the crop yield. Snowfall is also included in this table.

The precipitation records from such points as Alix, Halkirk, Vermilion, Endiang and Pemukan for various terms of years are given in Table II. These are averaged at three places in the table to give comparable figures. For example, the first set of averages shows the annual precipitation at Alix, Halkirk, and Endiang for the years 1911 to 1917. Also included in this table is the seasonal distribution of the previous fall and growing season's precipitation for Alix, Halkirk, Endiang, Vermilion and Pemukan. At the bottom of this table are given the average annual precipitations for Medicine Hat, Lethbridge and Edmonton for the years 1904 to 1935. This is taken from the Rainy Hills Soil Survey report.

From Table I it is seen that the average yearly precipitation at Alix is 16.22 inches. This is about two inches less than the

TABLE I.—Seasonal distribution at Alix and for dryest year at Pemukan. Precipitation in inches—1905-1937.

Month	Average monthly precipitation	Greatest amount in one year	Total amount in dryest year 1929	Pemukan 1929	Total amount in wettest year 1916	Average monthly snowfall
August	2.02	5.29	1.02	.18	5.29	.00
September	1.35	3.82	.42	.98	2.39	.06
October	.80	2.01	.05	.20	1.26	.33
Previous fall	4.17	......	1.49	1.36	8.94	.39
November	.77	2.40	1.47	1.18	.78	.69
December	.72	2.35	1.13	.88	1.32	.53
January	.85	2.05	1.12	.78	1.10	.85
February	.44	1.39	.90	.80	.86	.52
March	.78	2.43	.34	1.15	.59	.78
Winter	3.56	......	4.96	4.79	4.65	3.37
April	1.10	2.97	1.31	.95	.95	.72
May	1.88	4.00	1.37	1.49	2.24	.13
June	2.93	8.46	1.29	.44	3.52	.00
July	2.58	6.07	.79	.87	6.07	.00
Growing season	8.49	......	4.76	3.75	12.78	.85
Total	16.22	......	11.21	9.90	26.37	4.61

long term average for Edmonton. Of this 16.22 inches of precipitation, 12.66 inches fell during the previous fall and during the growing season, or in other words 78 per cent. of the total annual rainfall came during the effective period. This is typical of Alberta's precipitation distribution. At Medicine Hat during the period 1916 to 1935, 76 per cent. of the annual precipitation fell during the growing season plus the previous fall. During the thirty-two year period at Alix the effective rainfall was below 12.66 inches in seventeen years, and was above 12.66 inches in fifteen years. If from nine to ten inches of rainfall during the previous fall and growing season be roughly considered the border line between those years that are considered drought years and those that are not, then during the past thirty-two years at Alix there have been seven drought years and three borderline years. That is, approximately one year out of three or four has been a drought year.

During the important growing months of May, June and July, there was an average of 7.39 inches of rain or 45.6 per cent. of the total annual fall. Such a distribution of moisture is much more effective than it would be if it were evenly distributed over the twelve month period. However, of these three months May has a much lower average rainfall than either June or July, and since it is an important growing month, conservation of the previous fall's moisture and of the spring run-off, is important. Out of the thirty-two years recorded there were nineteen Aprils and eight Mays that received less than one inch of precipitation, and twenty-nine Aprils and eighteen Mays that received less than two inches. Any method of conservation that would prevent some of the spring run-off loss should be favorably reflected in the crop yield. There were twenty-two Junes and eighteen Julys out of the thirty-two that received over two inches of rain.

The average snowfall at Alix is forty-six inches, that is a total of 4.61 inches of precipitation. Most of the snow (equal to 3.37 inches of rain) falls between November and March and thus cannot enter the soil. Consequently it is lost by evaporation and run-off. The total snowfall amounts to almost 83,000 tons of water per quarter section of land. Much of the run-off might be stored in reservoirs for stock and future crop use.

Table II is given to show the annual variation in the total rainfall and to give comparisons of various stations in and around the Sullivan Lake sheet. The extreme variation at Alix is from 26.37 inches in 1916 to 11.21 inches in 1929. The year 1913 may have had a lower annual fall, but one month was missing from the records of that year. The extreme variation at Halkirk is from 28.57 inches to 10.30 inches and at Pemukan for the period 1927 to 1936 is from 23.72 inches to 9.83 inches.

During the period 1927 to 1936 Alix received an average annual rainfall of 16.78 inches and Pemukan received only 13.09 inches; that is, over twenty per cent. less moisture fell in the southeast portion of the sheet than fell along the western side. A study of the precipitation map for western Canada published by the Dominion Meteorological Service shows that there is a decrease in rainfall from Alix to Compeer in the southeast corner of the sheet. The drop in total rainfall for the growing season, as shown on this map, is approximately sixteen per cent. This would mean that possibly in this portion of the Sullivan Lake sheet one year out of two or three is a drought year. It was stated previously that in the darker soil zone in the north and west portions of this sheet one year out of three or four is a drought year. Although in general it may be stated that below a certain minimum rainfall it is impossible to produce a crop, and that what little rainfall does come will have a very low efficiency factor, it should be remembered that many factors influence rainfall efficiency: the distribution of the rainfall, the amount of evaporation, the soil type, and the type of farm management, are some of these factors.

Meteorological records have shown that the evaporation from a free water surface is much greater on the bald prairie at Claresholm than in the park belt at Edmonton. Evaporation,

TABLE II.—Precipitation record for stations on and near the Sullivan Lake sheet together with stations at Medicine Hat, Lethbridge, Alix, Edmonton and Vermilion.

	Alix		Halkirk		Vermilion		
	Previous fall and growing season	Total precipi-tation	Previous fall and growing season	Total precipi-tation	Previous fall and growing season	Previous fall and growing season	Total precipi-tation
1906	11.69	12.30	....	....	....	....	....
1907	7.84	12.73	....	....	....	....	....
1908	14.14	14.16	....	....	....	....	....
1909	12.03	14.42	....	....	....	....	....
1910	9.41	16.61	....	....	....	Endiang	
1911	19.67	22.43	....	20.97	....	....	16.07
1912	17.02	18.98	17.24	21.63	....	14.31	17.78
1913	11.97	9.53	15.59	12.64	....	15.91	13.09
1914	8.41	13.94	12.88	20.11	....	11.27	19.11
1915	16.60	18.02	21.59	18.75	....	18.14	14.83
1916	16.20	26.37	16.27	28.57	....	17.81	23.83
1917	16.27	16.16	15.56	10.30	....	13.24	11.68
Average 1911-17		17.92		18.99			16.63
1918	9.47	12.51	8.77	8.07	....	....	....
1919	12.31	16.88	9.75	14.52	....	....	....
1920	12.78	13.75	14.53	13.13	16.29	....	....
1921	8.61	13.94	8.35	11.43	13.15	....	....
1922	8.43	11.95	8.04	9.34	11.91	....	....
1923	12.94	15.99	17.90	22.38	16.84	....	....
1924	8.59	13.98	13.04	15.23	14.26	....	....
1925	10.62	18.24	14.85	14.79	14.48	....	....
1926	14.81	21.86	11.87	16.86	15.79	Pemukan	
1927	17.32	21.62	18.99	23.98	18.35	16.61	23.72
1928	11.28	13.55	15.28	14.53	16.83	14.61	15.94
Average 1911-28		16.98		16.51			
1929	8.82	11.21	7.29	....	7.47	6.90	9.90
1930	7.99	12.36	....	....	12.46	11.83	16.42
1931	17.60	20.90	....	....	19.00	8.02	9.83
1932	13.27	18.67	....	....	12.10	8.27	10.02
1933	15.00	20.34	....	....	....	9.40	11.86
1934	9.91	11.72	....	....	....	8.90	8.93
1935	12.64	20.24	....	....	12.19	10.21	13.43
1936	13.00	17.23	....	....	11.04	7.38	10.84
Average 1927-36		16.78					13.09
1937	13.51	....	....	....	12.28	6.42	....
Average	12.50	16.21	13.77	16.51	14.03	....	....

Average precipitation for the years 1904-1935

Medicine Hat	12.04
Lethbridge	15.53
Edmonton	18.08

then, in the treed portion to the north and west should be slightly less than on the open prairie to the southeast. The greater evaporation means that less of the annual precipitation is available to the plant.

The frost free period has a considerable bearing on the risk of producing certain crops and on the variety of crops grown. It must be noted that the frost free period is ended by one degree of frost, and in many cases this slight amount of frost would not harm many of the farm crops. Thus, the frost free period is seldom as long as the growing season. It should also be noted that the amount of frost will vary locally with changes in relief or topography.

The average length of the frost free period at Edmonton for the period 1902 to 1933 was 95 days, with a variation of from 52 days to 134 days. The average frost free period for Alix from 1921 to 1935 was 90 days. Brooks, which is situated eighty miles south of the Sullivan Lake sheet, had a free period of 115 days during the period 1925 to 1935. During this same period Vermilion and Lloydminster, which lie about sixty miles north of the sheet, had a free period of 100 days and 95 days respectively. From these figures it would seem that the frost free period for the Sullivan Lake sheet lies somewhere between 90 and 100 days. This period is short and the frost hazard must be considered in planning the farming practice.

TABLE III.—Monthly, seasonal, and annual means and extremes at Alix, Alberta, 1906-1936.

	Mean	Mean maximum	Mean minimum	Highest monthly mean	Lowest nonthly nean	Extreme highest	Extreme lowest	Mean of Sullivan Lake sheet*
August	59.3	74.1	44.6	67	53.1	100	21	58
September	49.7	64.4	35.1	54	41.4	95	10	48
October	39.2	53.1	25.4	48	29.0	91	—15	38
Previous fall	49.4	63.8	35.0	......	......	100	—15	....
November	25.7	38.3	13.1	39	12	74	—32	19
December	13.2	25.3	1.1	25	— 2	65	—64	10
January	6.3	19.5	— 6.9	24	—15	63	—56	1
February	13.5	28.2	— 1.1	30	—12	67	—58	1
March	24.1	38.5	9.7	33.1	13	70	—39	14
Winter	16.6	29.9	3.2	......	......	74	—64	....
April	39.2	53.3	25.1	48.3	30.3	88	—25	36
May	50.8	63.2	38.5	57	41.3	95	13	48
June	56.3	69.2	43.4	62	51	95	23	56
July	61.9	76.9	47.0	68	57.2	103	28	60
Growing season	52.0	65.7	38.5	......	......	103	—25	....
Year	36.6	50.3	22.9	......	......	103	—64	....

*Average temperatures compiled from meteorological map.

As it was previously stated the climate of the Sullivan Lake sheet is characterized by warm summers and dry cold winters. Table III gives the temperature variations at Alix for the period 1906 to 1936.

In order to clarify the column headings the August figures may be considered.

The first column, first line, gives the mean, or average August temperature over the thirty-one year period.

Column two, first line, gives the mean or average maximum temperature for August over the same period. It is obtained by adding the daily maximums for that period and finding the average. The mean minimum is found in a like manner.

In the fourth column is given the highest monthly mean, which in this case represents the average temperature of the warmest August during the period, and the fifth column gives the average temperature of the coldest August during the period.

The sixth and seventh columns give respectively the warmest and coldest August temperatures recorded.

In column eight is given the average mean temperature for the Sullivan Lake sheet. This is compiled from the weather maps issued by the Dominion Meteorological Service and is an approximate figure.

The yearly mean or average temperature for Alix for the period 1906 to 1936 is about 37 degrees Fahrenheit. This mean is about 6 degrees colder than the mean for Medicine Hat, in the southeast corner of the province, for the same period. The mean maximum temperature is 50 degrees. This is an average of the highest daily temperatures throughout the thirty-one year period. The mean minimum for the same period is about 23 degrees. The highest temperature, 103 degrees, was recorded in 1933 and the lowest, —64 degrees, was recorded in 1924. However, a better idea of temperature variations is obtained from the mean maximum and mean minimum readings. For the previous fall months the mean maximum was 63.8 degrees above zero and the mean minimum was 35 degrees above. For the winter months of November to March the mean maximum temperature was 29.9 degrees above zero, and the mean minimum 3.2 degrees above. During the growing season the mean maximum was 65.7 degrees above and the mean minimum 38.5 above. In general, the summers are warm and permit of rapid growth. The temperature usually drops very soon after sunset, making the nights cool.

AGRICULTURE

The Sullivan Lake sheet was sparsely settled prior to 1900. The first settlers in the area were ranchers who settled along Ribstone and Sounding creeks. These creek flats afforded a source of meadow hay (Plate 2, Fig. 3) and the adjoining Neutral Hills area an excellent summer pasture ground. The Royal Northwest Mounted Police maintained a barracks in the

Neutral Hills in the early nineties. It is reported that this barracks was for the purpose of intercepting horse thieves who used the frog in the south end of Sounding lake as a resting ground during their trek south.

General settlement started in the Provost area just after the turn of the century, it started around Castor in 1908 and in the rest of the sheet between 1909 and 1912. Most of the early settlers were from Ontario and United States; most of the European settlers came in after the first general influx.

The railway which came from the east to Provost about 1907, was the first railway line in the area. Camrose, about 60 miles northwest of the sheet, was the trading centre for the early settlers in the western portion of the area. The railway line from Lacombe entered Stettler in 1908 and moved on to Castor in 1909. Castor was end of steel for two years, and boasted of a population in 1911 of 1,600. The line was built east from Castor and west from Kerrobert, Saskatchewan, and joined in 1914. Rails were completed from Camrose to Alliance in 1915. Statistics indicate that the sheet was quite extensively settled in 1920, and although there was approximately 50 per cent. more land cultivated in 1930 than in 1920 this is probably due more to increased holdings than to an increase in number of land owners.

It was seen under the discussion of climate that the rainfall, particularly in that portion of the sheet within the brown soil zone, is limited, and as a result there have been cycles of good and of poor crop years. Abandonment has followed the poorer years. The largest mass departures, as stated previously, were from the area south of Monitor and south of Coronation. Most of this abandonment took place between 1920 and 1925. The abandonment that has taken place since 1930, and particularly since 1934, has been more general, but has been particularly from the south half of the sheet and from the lighter soil areas in the north portion (see map, Plate 5). It is estimated that approximately 1,260 quarter sections once cultivated have been abandoned, 630 in the dark brown soil zone and 630 in the brown soil zone. It should be noted here that the dark brown soil zone covers approximately two-thirds of the sheet. It is found that 23 per cent. of the abandoned land is in sand and sandy loam areas, 12 per cent. in fine sandy loam, 55 per cent. in blow-out (solonized) and hilly loam, and 10 per cent. in all of the other soil classes. Most of the abandoned silt loam and clay loam parcels, as well as some of the sandy loams, are solonized soils. In general the abandonment has been of such a recent date that the land has as yet a very meagre grass growth, and is therefore of little pasture value. Much of it might respond to re-seeding during wet years.

In general the farm buildings are fair to good. Some very good farmsteads are found in the Provost area, in the southeast corner of the sheet, and on some of the better established farms in the north and west portion of the sheet. Some of the deserted buildings have been moved away or torn down, but some still remain, uncared for, and in varying degrees of dilapidation. Some of the farmers who remain in the drier portions of the area are making adjustments in their agricultural practices. They have realized that in this area cycles of good and poor years must both be expected.

The data in Table IV were obtained from the records of the Provincial Statistician and were taken from the Dominion Government census returns by municipal units. Since many of these municipal units only fall partially within the Sullivan Lake sheet it is understood that the figures are estimations. The total cultivation column was obtained by assuming that one-third of the cultivated land was in fallow.

Certain facts are apparent from this table. The decline in cultivation on the brown soil zone has been much greater than in the dark brown soil zone. There was actually less land cultivated in 1935 in the brown soil zone than there was in 1920. Cultivation on the sheet reached its peak about 1930 when a total of approximately 1,141,350 acres were cultivated. This represents about 50 per cent. of the total area of the sheet. Of this cultivated area about 78 to 80 per cent. of the cropped land was in wheat. In the brown soil zone about 15 per cent. was sown to oats and in the dark brown zone about 17 per cent. A slightly higher percentage of barley was grown in the dark brown soil zone and a higher percentage of rye was grown in the brown soil zone.

TABLE IV.—Acreages of crops in the Sullivan Lake sheet.

	Wheat	Oats	Barley	Rye	Total cropped	Total cultivated
		Brown soil zone				
1920 acres	109,900	54,500	2,025	1,975		
% total crop	65.3	32.3	1.2	1.2	168,400	252,600
1925 acres	133,700	30,600	1,150	4,050		
% total crop	78.8	18.1	0.7	2.4	169,500	254,250
1930 acres	182,000	30,300	1,650	12,200		
% total crop	80.5	13.4	0.7	5.4	226,150	339,225
1935 acres	132,000	26,700	1,140	4,910		
% total crop	80.1	16.2	0.7	3.0	164,750	247,125
		Dark brown soil zone				
1920 acres	211,500	124,800	6,450	3,150		
% total crop	61.1	36.1	1.9	0.9	345,900	518,850
1925 acres	310,900	66,200	5,550	5,250		
% total crop	80.2	17.1	1.4	1.3	387,900	581,850
1930 acres	424,000	84,900	10,180	15,670		
% total crop	79.3	15.9	1.9	2.9	534,750	802,125
1935 acres	371,700	90,950	6,540	8,210		
% total crop	77.8	19.1	1.4	1.7	477,400	716,100

Total cultivated acres on the sheet

1920	771,450	1930	1,141,350
1925	836,100	1935	963,225

The cultivation in the dark brown soil zone is, in general, patchy. This patchiness is largely due to the presence of small meadows and clumps of poplar and willow growth (see Plate 3, Fig. 2). These groves of trees, besides giving a limited wood supply, hold the winter snows and materially lessen the amount of soil drifting. In the Provost area, as in portions of the prairie section in the southeast portion of the sheet before abandonment, there are more solid blocks of cultivation.

The Neutral Hills area in the central southeast portion of the sheet and the large sandy area north and west of Sounding lake are the only relatively large sections of the sheet that are still uncultivated. They are both good grazing areas, but are at present much reduced in their carrying capacity.

TABLE V.—Comparative wheat yields in Alberta.

Area	Yield of Wheat
Edson-Better wooded soil	19.0
Edmonton-Black soil	23.2
Sullivan Lake—Dark brown	15.8
Sullivan Lake—Brown	12.9
Average for Sullivan Lake sheet	14.8
Average for Province	17.1

Table V gives the wheat yields of the two zones in the Sullivan Lake sheet, as well as comparable figures for other representative soil areas of the province. The figures for Edson and Edmonton are taken from the records of the Provincial Government and represent a fifteen-year average for 1921 to 1935. The figures for the Sullivan Lake sheet are estimated yields, and are computed from census division, station, and municipal unit yields, and cover most of the years from 1913 to 1935. It is seen that the yields given for the Sullivan Lake sheet are lower than the yields given for areas representative of the two other major soil zones of the province. The yield of 12.9 bushels for the brown soil zone is, however, higher than the yield of 9.5 bushels given in the Rainy Hills survey bulletin No. 28 as representative of the brown soil zone from Empress to Brooks.

It was seen in the discussion on climate that the rainfall for the brown soil zone of the Sullivan Lake sheet is relatively low, and for the dark brown zone, although higher, is still a vital limiting factor in crop production. Figures indicate that one inch of total rainfall produced about one bushel of wheat per acre. During the wet years the efficiency of a unit of rainfall is much higher, up to two bushels per inch, and in a very dry year it may be as low as one-half bushel per inch of rainfall. By way of comparison one inch of rainfall in the Edmonton district produces approximately an average of 1.3 bushels of wheat per acre.

Since the efficiency of a unit of rainfall in the Sullivan Lake sheet is relatively low every effort should be made to best utilize the rainfall. A lessening of the transpiration and evaporation losses through better control of weeds, etc., and a conservation of the spring run-off should raise the rainfall efficiency. From a study of soil moisture conditions, the soil types, and the trend of settlement on the sheet it would seem evident that all the areas should not be subjected to the same utilization. Some areas are strictly pasture lands, some areas should remain as grain producing lands, and other areas could be utilized on a farm-ranch basis. Wholesale abandonment of the cultivated lands, which, during the last dry period seemed submarginal, offers many difficulties. A strictly ranching population would not be of sufficient number to maintain the social services intact, or maintain the transportation facilities already in the area, facilities which represent a large capital outlay. The building of water reservoirs and the installation of small irrigation projects would add materially to the security of the individual farmer. This question will be more fully discussed under farming practices.

SYSTEM OF SOIL CLASSIFICATION

The soils of Alberta are divided into broad soil zones. These zonal divisions are based principally on the color of the soil profile; these color differences have developed as the result of certain soil moisture and vegetation conditions over a long period of time. The soils of the respective zones are again divided on the following bases: (1) the texture of the surface soil, generally of the A horizon; (2) the dominant characteristics of the soil profile; (3) the mode of deposition of the parent material, that is its geological deposition. Such factors as topography, stoniness, alkali accumulation, grass or tree growth and degree of erosion all influence the soil type finally designated. The combination of all the factors that characterize a given soil, other than its surface texture gives that soil its series designation. The soils of the Sullivan Lake sheet belong partly to the brown soil zone and partly to the dark brown soil zone. On the map accompanying this report the soil classes, determined by the surface texture, are shown in different colors. Each textural class, however, may be subdivided into smaller areas, and each of these areas carries a three digit number. This number determines its series. Although the complete legend for the classification of the soils of this sheet appears on the map, an explanation of that legend is in order here to facilitate the interpretation of the next section in this report, namely, the soils of the Sullivan Lake sheet.

Soil Zone.

The 1.0.0 soils are those in the brown soil zone. This zone corresponds to the bald prairie of southeastern Alberta. These soils are relatively low in nitrogen and have a shallow profile. They have developed under low annual rainfall and a high evaporation.

The 2.0.0 soils are those in the dark brown soil zone. This zone forms a broad transition belt between the brown and black or parkland soils of the province. It averages about 50 to 75 miles in width. This area has developed under somewhat more humid conditions than prevail in the brown zone.

Mode of Deposition of Parent Material.

This column deals with the parent material on which the soil profile developed. Glaciers, wind and water all played a part in the transporting and sorting of this parent material. In many cases it is impossible to determine what agency has been most active. In this classification certain type profiles most characteristic of the mode of deposition were set up. It is possible that in some cases the geological agency indicated in the legend may not have been solely responsible for the deposition of the parent material.

0.0—These soils are residual soils, that is soils formed in situ from the weathering of the underlying rock formations. Since most of the consolidated rock formations of Alberta were formed in the beds of large bodies of water, this material is relatively stone free and the soil that has formed from their weathering is also stone free. In most cases the topography is uniform, level to undulating, and the unweathered parent rock is fairly close to the surface.

1.0—These soils are termed sorted residual. They are formed principally from the weathered material of the underlying parent rock that has undergone some surface sorting. Many of these soils may have been glaciated at one time, but the glacial till has all eroded off, leaving only the transported stones on the surface. The depth of unconsolidated material over the parent rock varies greatly, but in these areas exposures of the underlying formation are quite numerous.

2.0—These soils are unsorted glacial soils, that is soils which have developed on the unsorted till just as the receding ice left it. These soils are characterized by a rough topography and few to many stones scattered throughout the profile. Due to the broken nature of the topography and the absence of gravel and sand lenses the areas often contain numerous sloughs and meadows. The till or glacial drift in this area was all transported by the Keewatin glaciations. Some of the material naturally is of local origin, but some has been transported long distances. Because of the variety of sources of this material the texture of these soils is often quite variable.

3.0—These soils are termed resorted glacial. They have developed on glacial till that has undergone a surface sorting. Generally these areas are on level to undulating topography, that is on ground moraine. There are glacial stones throughout the profile, particularly in the unsorted subsoil, and the surface material may contain some water worn gravel and stones. Wind, as well as water, may have been responsible for the formation of this surface layer. Generally these soils are of a more uniform surface texture than the glacial soils and agriculturally are generally good soils.

4.0—These soils are a grouping under the title, gravelly outwash. They are characterized by being very gravelly and often stony. In most cases they are non-arable. The gravelly nature may be due to an alluvial deposition or to the removal of the finer particles from glacial dumps. In either case the coarser gravel and stones predominate due to the washing out of the finer material. They are generally light textured soils on level to undulating topography.

5.0—These soils are of alluvial origin. They are characterized by the presence of some water worn stones in the profile and by the presence of gravel and sand lenses throughout the profile. The variable deposition is the result of water moving at different speeds or carrying loads of varying materials. These soils vary in their utility with the percentage of gravel and the frequency of sand lenses. These sandy lenses affect the drainage and the water holding capacity of the soil.

6.0—These soils may be alluvial or eolian. In this class are put the uniformly deposited light textured soils. In many cases these soils are of alluvial origin, but have been subsequently moved by wind. Generally they are pasture lands. Where they overlie a heavy textured subsoil or impervious strata they may have arable possibilities. They are generally stone free and on undulating to gently rolling topography.

7.0—These soils may be lacustrine or eolian. In this class are put the uniform medium to heavy textured soils. Most of the soils of this class are of lacustrine formation, that is they have formed on the material that settled out of still water. As a result the texture of these soils is fairly uniform throughout the profile. They are practically stone free and generally on level to undulating topography. Post glacial winds may have been responsible for deep silt deposits, particularly in the glaciated areas. In general this eolian deposition is shallower than the average lacustrine deposition.

Profile Variation.

This column deals with the variations that are found in profile development as well as the degree of salinization of the soil. Chemical and physical weathering of the parent material, the movement of soluble substances throughout the soil profile by the percolating rain water, the addition of organic matter due to vegetative growth, and the activity of soil microorganisms are some of the important agencies that have created the soil profile.

0—These soils have very little profile development. The sands, recently flooded river bottoms, and areas that have recently been severely drifted lack profile development. They may be considered as raw or undeveloped, and in general have a single grained structure.

1—These soils are hillside soils. As a result of loss of run-off water these soils are locally more arid than the surrounding soils and generally they are of a lighter color and have a shallower profile. The run-off water carries with it much of the surface soil from the slopes.

2—These soils are non-saline and have a normal profile development; that is they are normal for their texture and the amount of rainfall they receive. The structure is commonly cloddy to columnar. They are generally the good arable soils.

3—Soils of profile 3 are non-saline, but are developed in local depressions. Due to a lower position they receive run-off from the higher soils near by and as a result may develop a deeper and darker profile than the normal soils of the area. If these soils do not have a drainage problem they are among the best arable soils.

4—These soils are characterized by a weak solonetz development. They have a well developed columnar B_1 horizon, but the white rounded tops and the break between the A_2 and B_1 is not so clearly defined as in 6. They are intermediate in character and utilization between soils 6 and 2.

5—These soils are slightly saline and are generally found in areas that have poor to fair drainage. Due to the poor drainage a normal soil profile does not develop and the profile has very little differentiation from the surface down. They are often of quite a heavy texture. The alkali salts move up and down in the soil depending on the direction of the movement of the water in the soil. Many of these grow good meadow hay and some might produce certain cultivated crops if properly drained.

6—These soils are slightly saline, but generally less so than the soils of 5. They are characterized by a hard impervious subsurface layer—a solonized B_1 horizon. The hard B_1 horizon has a well developed columnar structure and the surface of this horizon often looks much like a cauliflower head; the A_2 horizon that lies immediately above this layer is often very light in color and of a layered or platy structure. Mechanical analyses of these profiles suggest that there has been a movement of fine clay particles from the A horizon into the B_1 horizon. These fine particles, mostly colloidal, help to bind the grains of this B_1 horizon together into hard cubes very difficult to break. Although there are exceptions, most of the solonized profiles are found on level to undulating areas where possibly at one time drainage was not adequate. The areas are characterized by a patchy micro-relief due to the erosion of the A horizon (see Plate 4, Fig. 3). If the hard layer is close to the surface they are generally inferior soils, partly because of the limited depth of water and root penetration.

Each soil area outlined or described, then, carries a three digit number. Each of the digits is separated by a dot, for example, 1.2.1. This number represents a brown, glacial soil profile developed on sloping ground. It is quite possible that two modes of deposition may be found, one over the other, within the profile depth; for example, an 18-inch eolian silt may be deposited over an unsorted glacial moraine. The second digit representing the mode of deposition, in this case would be 7/2. It should also be recognized that the profile development in a given soil area is not entirely uniform. If one form of development is quite dominate a single number is used in the units column. However, if there are two distinct forms of profile development so intermixed that separation is not practical a fraction may be used in this column. For example, the complex 2/6 would indicate a normal soil profile over most of the area with patches of solonized soils scattered throughout the area. Such a soil area might carry the number 2.1.2/6. This indicates a dark brown soil formed on sorted residual parent material having generally a normal profile development, but containing patches of solonetz soils within the area.

There are eight main texture classes mapped. These are, going from the lightest to the heaviest, sand, sandy loam, fine sandy loam, very fine sandy loam, loam, silt loam, clay loam and clay. There is also a mixed class that is used where the surface is so badly mixed that separation is not practical. These are subdivided into light, medium and heavy phases of each class. On the map Lt. refers to the light phase, H to the heavy phase, and the absence of any such prefix signifies a medium texture of that class.

Topography, stones, and the presence of eroded surface patches in the solonized soils are indicated on the soil map by symbols.

SOILS

Although the entire Sullivan Lake sheet appears to have been glaciated at one time the till covering is eroded away in many places leaving glacial erratics scattered over the soil surface. In these areas consolidated parent rock is relatively close to the surface. Neutral Hills, in the eastern portion of the sheet, is a glacial moraine and in this area there are great depths of unsorted till. Some of the lower ridges in the west to southwest portion of the sheet also appear to be of glacial till.

There has been local post glacial water sorting on this sheet. This is shown by the presence of water worn stones on the leveler areas and of many silty basins. Post glacial winds may have been responsible for the spreading of a silty loess covering on some of the rougher topography areas. The large sandy areas on the sheet are possibly of alluvial origin, although some of them have since been subjected to wind action. Judging by the size and frequence of the drainage courses large volumes of water have been carried from the sheet, and this undoubtedly has been responsible for sorting the surface material and carrying away much of the finer portions of it.

The data in part one of Table VI give the acreage and percentage distribution of the main topographical types on the Sullivan Lake sheet. From these figures it is seen that over 40 per cent. of the sheet is composed of level to undulating topography. In general most of the land lying west of a line drawn from the east side of township 40, range 12, to the west side of township 33, range 5, has generally a fairly level topography. It is, however, cut by many draws, particularly in the northwest portion and between Coronation and Nose hill. These draws are tributaries of Battle river and Ribstone creek respectively. The large flat south of Monitor and much of the area in the northeast corner of the sheet, north and south of Provost, is relatively level land. Smaller areas of level to undulating land are found scattered throughout the rolling and hilly areas; the largest of these are the silt loam area at Compeer, the alluvial loam north and west of Consort, and some of the sandy loams north of Metiskow.

Hilly and rolling areas make up respectively 5 and 13 per cent. of the total area. Hilly land is recognized as definitely too steep and rough to cultivate. These areas are concentrated along the main Neutral Hills moraine from Compeer to Sounding lake, and then in more scattered portions north to Czar and northwest to township 40, range 10. These topography divisions are shown on the soil map by hatched lines. This long range of hills forms a height of land running diagonally across the sheet. It is cut by the drainage course of Sounding creek, Ribstone creek, and a smaller course at the Little Gap in township 37, range 6.

Midway in roughness between undulating and rolling is the topography division, gently rolling. Approximately 30 per cent. of the Sullivan Lake sheet is mapped as gently rolling. The gently rolling areas are found mixed with the rolling and hilly along the moraine and skirting its edges. There is an area in range 12, township 34 to township 38, which is composed of a series of low ridges. Skirting the level to undulating areas in the northeast corner are fairly large areas of gently rolling topography. Erosion, lakes and marshes are discussed under a separate heading on page 69.

The data in part two of Table VI show the acres and percentage distribution of the textural soil classes on the Sullivan Lake sheet. From this table it is seen that the loam textured soils make up the largest percentage of the soils, approximately 60 per cent. Loam soils are medium textured soils generally underlain by a subsoil heavier than the surface soil. A true loam soil has the three fractions, sand, silt, and clay, mixed in such proportions that no one fraction dominates. Light loams have less clay and more sand, and heavy loams in general more silt and clay than the medium loams. Loam soils do not drift

TABLE VI.—Extent of topography divisions and soil classes in Sullivan Lake sheet.

Part 1—Topography Divisions.

Division.	Acres.	Per Cent.
Hilly	141,600	5.5
Rolling	342,500	13.2
Gently Rolling	761,000	29.4
Level to Undulating	1,101,000	42.6
Erosion	109,800	4.3
Lakes and Marshes	123,500	4.8
Total	2,579,400	99.8

Part 2—Soil Classes.

Soil Class	Acres.	Per Cent.
Sand	80,000	3.1
Sandy Loam	145,000	5.6
Fine Sandy Loam	195,000	7.5
Loam	1,542,000	59.7
Silt Loam	225,000	8.7
Clay Loam	68,000	2.6
Clay	11,200	0.4
Mix	61,000	2.4
Eroded Lands	109,800	4.3
Lakes and Marshes	123,500	4.8
Total	2,560,500	99.1

as readily as do the soils of either lighter or heavier texture, they are relatively fertile and in areas other than those of restricted rainfall are often good, arable soils.

Silt loam forms approximately 9 per cent. of the total area, most of it being located around Provost in the northeast corner of the sheet. Silt loam soils have a predominance of silt particles in their mechanical composition, usually over 50 per cent. The light silt loam soils contain considerable fine sand and are quite similar to loams in utilization. The medium and heavy silt loam soils may contain considerable clay, and they are often termed heavy soils. Silt loam is generally associated with water deposition or water sorting, although many silt loam soils are the result of post glacial wind deposition. Most of them have few to no stones. They are not as heavy to cultivate as the clay soils, but they have a high water retention power and are usually well supplied with the plant food elements; as a result of these factors they are generally among the best arable soils.

Fine sandy loam soils form between 7 and 8 per cent. of the total area of the sheet. The fine sandy loam soils mapped on this sheet contain about 65 to 75 per cent. sand. This leaves enough silt and clay in the mechanical composition to give some structure to the profile. Although this structure, described as a massive cloddy type, does not clearly differentiate the horizons, it does give a distinct firmness to the profile, a firmness that is not evident in the lighter soil types. Most of the fine sandy loam areas are in close proximity to the sands and the sandy loams and often form transition areas between these and the adjoining loam areas. In general fine sandy loam soils in an area of limited rainfall are of questionable arable value. However, the value varies with the type of profile development and will be discussed under the series heading.

Sandy loam forms between 5 and 6 per cent. of the total area of the sheet. The sandy loam soils of the Sullivan Lake sheet have, in general, a high sand content. Mechanical analyses show that they contain about 80 to 85 per cent. of sand particles. In the uncultivated state they are stable, that is they lack dune formation. Agriculturally most of them are non-arable, and areas that have been cultivated are now abandoned and often badly drifted (see Plate 6). Most of the sandy loam soils of the Sullivan Lake sheet are probably of alluvial formation, that is they have been deposited from moving water. This at least partially accounts for their lack of finer soil particles. Most of them are on level to gently rolling topography and normally support a fair growth of grass; much of it is, however, of coarser varieties and not as readily eaten by stock as the grass native to the loam soils. The sandy loam areas of this sheet are located principally between Czar and Sounding lake, south of Monitor, around Hamilton and Kirkpatrick lakes and around Sullivan lake.

The sands of the sheet form about 3 per cent. of the total area. The sand areas are characterized by the presence of dunes and in most of the areas these dunes are at present open and shifting. Mechanical analyses of these soils show that they contain, on the average, about 95 per cent. of sand particles. Agriculturally they are non-arable and are poor to fair pasture lands.

Clay loam forms less than 3 per cent. of the total area of the sheet and clay about one-half of 1 per cent. of the total area. Clay loam soils average between 20 and 30 per cent. clay particles; clay soils have a still higher percentage of clay particles. In both these soils the clay particles make up a high enough percentage to dominate and to label the soils as distinctly heavy. Soils of this texture with normal profile development are good dry land soils. However, only three small areas with normal profile development are outlined. The remainder of the clay and clay loam areas are in the nature of poorly drained flats and are alkaline.

Slightly over 2 per cent. of the area of the Sullivan Lake sheet is mapped as mixed soils. These soils are all very gravelly in nature and generally are light textured, a mixture of sandy loams and fine sandy loams. In general they are non-arable soils.

On the soil map that accompanies this report the soil textures are designated by different colors. Each soil area on the map carries a three digit number; this number indicates the soil series to which the area belongs. The first or hundreds digit refers to the color zone, the second or tens digit refers to the way the parent material, upon which the soil profile has formed, was deposited and the third or unit digit indicates the form of profile that has developed. In the section on "System of Soil Classification" these factors were broadly defined and the method of using them indicated; however, before describing the soil areas as they appear on the soil map a more specific and local description of some of these factors is in order.

One hundred number and two hundred number soils are mapped on the Sullivan Lake sheet; it has been stated before that the line dividing the brown and dark brown soil color zones of Alberta cuts through the sheet. This line enters the sheet in township 33, range 12, travels in a north by northeast direction to a point about four miles northwest of Coronation, and then swings southeast to a point just north of Loyalist.

From here the line turns north to Gooseberry lake, then east to the south side of Sounding lake and then continues east to the Saskatchewan border in township 36, range 1. The area lying south and east of this line is considered to be within the brown soil zone. This zone corresponds to the semi-arid or bald prairie of southeastern Alberta. The area north of this line is within the dark brown soil zone. This zone forms a fairly broad transition belt between the brown and the black soils of the province. It must be recognized that any such color line represents actually a fairly broad strip of land; that is, there is a gradual change from the brown to the dark brown soils. It must also be recognized that due to differences in soil types, relief, as well as local precipitation differences, islands of darker soil may be found within the brown soil zone and conversely islands of brown soil may be found within the dark brown soil zone.

The soils of these color zones have developed as a result of differing soil moisture relationships. The lighter color of the brown soil is the result of a lower rainfall, a higher temperature or greater evaporation, or possibly a combination of all three factors, and, consequently, a shorter growth of grasses and other plants. Further discussion of these color zones will be found under the description of the soil areas.

It has been stated previously that in the western half of the sheet bed rock is very close to the surface. However, in no place were there any residual soils mapped, but much of the area is mapped as sorted residual. These areas are characterized by the nearness of the consolidated bed rock to the surface. This bed rock is partly Edmonton and partly Bearpaw (see map, Plate 9). The presence of scattered glacial erratics on the surface indicates that the area has at one time been glaciated and the presence of some water worn stones in the profile, as well as occasional gravel lenses, indicate that the surface material has undergone some sorting; in other words, the soil profile is not formed from the undisturbed weathering of bed rock. The sorted residual soils are in general on level to undulating topography with the general slope of the land downwards to the east and north.

The Neutral Hills moraine runs diagonally across the eastern two-thirds of the sheet. Most of the soils on this moraine are mapped as glacial. The glacial till is more or less as the glaciers left it, that is, in an unconsolidated and unsorted dump. In general the till of this region is of a buff color and has glacier erratics scattered throughout its depth. Due to the many formations of bed rock over which the glacier passed in its southwesterly thrust a variety of materials is mixed into its hetereogeneous composition.

The glacial till along the edges of this moraine, in the country from Talbot to Alliance, south of Federal, and the higher land around Provost, is more of the order of ground moraine, and, being generally of undulating to gently rolling topography, has been subjected to some post glacial sorting. These soils are mapped as resorted glacial. The surface texture is generally more uniform than that of the glacial soils and often contains a higher percentage of silt particles.

Indications are that large volumes of water have moved across the Sullivan Lake sheet in immediate post glacial times and this has been responsible for considerable washing and sorting of the surface materials. A few small areas of very gravelly soils, from which much of the finer materials has been washed, either by the post glacial waters, or by local streams, are mapped as gravelly outwash. Most of these areas are generally of a sandy texture and are quite mixed.

Most of the alluvial soils of this sheet contain gravel often in the form of lenses throughout the profile. They have been deposited by water moving at varying speeds. They are found on level to gently rolling topography and often in basin-like areas. There is considerable variation between areas in the amount of gravel and sand in the profile, which consequently affects the value of respective areas. This will be indicated in the discussion of the individual areas.

The outwash and alluvial soils described above are generally of variable deposition; the latter particularly shows variations of deposition. The next two groups, consisting of alluvial or eolian and lacustrine or eolian, are characterized by a more uniform deposition throughout the profile. The uniform light textured soils of alluvial or eolian deposition consist mostly of the sands, sandy loams and some of the fine sandy loams of this sheet. The large area north of Sounding lake is composed of a deep deposition of sand; in some places it remains as the moving waters have deposited it; in other places subsequent winds have moved it and continued its sortation. The sandy areas near Sullivan lake, although conforming to the profile definition of this group, may be more lacustrine in deposition. They possibly form the outer rim of the lake basin. The sandy area south of Throne is topographically lacustrine, but the general area forms the head waters of the Sounding Creek drainage system.

A small percentage of the soils of the Sullivan Lake sheet are medium to heavy textured lacustrine or eolian soils. There are some lacustrine settling basins on this sheet; the heavy silt loam area directly north of Provost is possibly the largest area of true lacustrine soil. Soils of this group are practically stone free and of uniform deposition for considerable depth. Many small more recent lake beds are found in the area. These are usually clay and clay loam in texture, and often quite alkaline.

Since the mode of deposition of the parent material upon which the profile has developed is an indication of such things as soil variability, presence of stones, plant feeding range, and to an extent topography, it is an important factor in the series number of the soil area. However, the type of profile that has developed on this material so deposited is, at times, even more important than the deposition factors and something now must be said of the types of profiles mapped on the Sullivan Lake sheet.

It has been stated under "System of Soil Classification" that the third or units digit of the series number refers to profile development. Seven different profile developments have been mapped numbering from zero to six inclusive.

Variation 0 is described as a profile having from weak to no horizon development. All the sands and most of the sandy loam soils of this area are mapped as zero, that is they lack horizon differentiation and structure. In a few places at considerable depth it was possible to find a weak indication of the B_2 or lime concentration horizon. There are a few patches of abandoned cultivation in which so much of the surface soil has blown away that very little of the original profile remains (see Plate 6, Fig. 3). These drifted areas were not large enough to be placed in a separate series.

Soils of profile variation 1 are typically more shallow due to locally arid conditions. They are hillside soils and as a result there is considerable run-off, particularly in the spring and during heavy rains. This run-off carries with it considerable surface soil, thus removing much of the available plant food which is concentrated in the surface horizons. The normal process of soil formation liberates plant food, but it should be remembered that the process is very slow. In a survey such as was conducted in the Sullivan Lake sheet the individual slopes could not be separated out and mapped, so that only the hilly areas in which steep slopes predominate are mapped as 1 soils. With one exception all the soils of this profile are along the Neutral Hills moraine.

The soils that carry the unit digit 2 are considered to have normal profile development; that is the soils are non-saline, they are of a depth commensurate with the texture and average rainfall, and they have a normal horizon differentiation. For this area the profile varies from two to four feet in depth and is generally of a cloddy to columnar structure. Most of the loams of undulating to rolling topography on glacial moraine have normal profile development as well as most of the fine sandy loam soils and the silt loams, particularly in the eastern half of the sheet.

A small percentage of the soils of the Sullivan Lake sheet has been given the profile designation 3. They are the soils in local depressions that are more humid than the normal soils. As a result of this the profile is generally deeper and darker than the surrounding soils of normal profile development. If these soils do not have a drainage problem, and most of them will not under the limited rainfall for this area, they are among the most productive soils of the area. Small patches of these soils occur particularly in the hilly areas, but they were too small to be shown on the soil map. However, it should be noted that they are of considerable value to grow forage for the stock that pasture the neighboring hills. Some of them are irrigable.

The four profile types that have been described above are all non-saline; the remaining three are generally known as saline soils. The discussion of these types can be more logically presented if profile 6, that is the solonetz profile, is described next. Most of the soils lying west of a line from township 40, range 10, to township 33, range 5, have a solonized profile in varying degrees of intensity and varying degrees of development. Some areas of solonized soils are found elsewhere in the sheet, particularly in the northeast corner.

The solonetz soils as described on page 25 have a very hard columnar B_1 horizon underlying a leached A_2 horizon. In this sheet the depth of the A or surface soil horizon varies from about three feet in some of the light textured soils to less than three inches in the heavy textured soils. The depth of A horizon seems to vary directly with increasing coarseness of texture and the amount of the rainfall. The main area of this type follows the trough of fairly level land from south of Consort to Alliance. Towards the northwest end of this area precipitation is greater and the A horizon is deeper, and as the A horizon gets deeper the characteristic eroded pits are less frequent. Symbols are used on the map to indicate areas where over 10 per cent. of the surface soils has been eroded off exposing the hard B_1 horizon. Where the hard impervious B_1 horizon occurs close to the surface in the section of limited rainfall the soils are generally inferior, principally because of the lack of water and root penetration.

Variation 4 is a profile with weak solonetz characteristics. The hard rounded tops of the B_1 are absent in this soil. The main areas of this group are found as transition soils between those of strong solonetz development and those of normal profiles. Generally speaking, they are better drained, less saline and more penetrable by water and roots than the soils of profile 6. In other words, in character and utilization, they are between soils of profile 6 and profile 2.

The soils of the profile 5 have a salt content between those of profile 6 and the marshes and sloughs. Generally speaking on this sheet they are low areas with poor to only fair drainage and total only about 2 per cent. of the area of the sheet. Many of them have the characteristic hard rounded top B_1 of the solonetz morphology, but below this there is very little horizon differentiation. The water soluble salts in these areas are generally quite high, sometimes above the toxic limit for normal plant growth.

As has been previously stated, the color of the soil, the method of deposition of the parent material, and the type of profile all imprint certain characteristics on the final soil area; each factor contributing to the soils morphology and to its utilization. It must be recognized that natural objects, and soil is a natural object, commonly do not fall into hard and fast classifications. There are variations within any given series and within any given type, and one series or type gradually changes into another. Such variations must be expected in any soil area, but in general the variations are small and within any given soil boundary the profiles do not deviate far from the average for that particular area.

In the description of the soil areas of the Sullivan Lake sheet the followinig arrangement is made: The areas are first divided into their respective color zones, then grouped under the respective textural classes. A further division is made under the profile divisions and finally each type is described. This arrangement was used because it puts those soils together that are nearly alike in morphology and utilization.

Brown Soil Zone

In general the brown soils are characterized by a shallow profile and a light color. The lime carbonate horizon is found at from 9 to 24 inches and averages about 18 inches from the surface. The brown color of the A horizon carries to the surface and therefore the humus content of these soils is relatively low when compared with the soils of the more humid sections of the province. These soils are fairly well supplied with the mineral constituents, and in years of sufficient rainfall there has been enough available plant food to produce good growth. It has been stated that the brown soils of the Sullivan Lake sheet lie in the southeast portion of the area. This area, however, is the northern limit of the brown soils and therefore they are generally slightly darker in color than the soils farther south, nearer to the center of the brown soil zone.

Sand.

The sand areas of this zone are characterized by the presence of low dunes containing some little tree growth.

Profile 0. The sands in general have no profile development, that is, they have a single grained structure.

Series 1.6.0. There are approximately 35,000 acres of this type (1.6.0 sand) mapped. With the exception of the area in township 36, ranges 1, 2 and 3, which will be described with the dark brown sand areas, all the sands of this series lie in the Hamilton, Kirkpatrick lake district. This triangular area, having its three vertices at Hamilton lake, Kirkpatrick lake and Fitzgerald lake in township 33, range 8, is relatively level and very little higher in elevation than the lake beds. The sandy soils of this area may all have been of alluvial origin, but wave action and subsequent wind action has resulted in a later sorting of materials. The sands here are generally composed of fine sand. They are underlain by Bearpaw shale, but the Edmonton sandstone forms the uppermost strata not far to the west. Due to the relatively low elevation these areas have a fairly good pasture carrying capacity. They are non-arable.

Sandy Loam.

The sandy loam soils have slightly more fine particles than the sands and in the uncultivated state are stable. Areas are outlined around Compeer, south of Monitor and in the Kirkpatrick lake area.

Profile 0. Most of the sandy loams of this sheet have very little horizon differentiation, and they are therefore given the 0 profile designation. Below is a description of a sandy loam profile taken in section 27, township 33, range 10. It is a fairly typical profile:

0″-12″—A dark brown structureless horizon that contains many grass roots.

12″-24″—A brown loose horizon.

24″-36″—A light brown loose horizon.

at 40″—A light buff colored loose horizon spotted with lime.

Series 1.2.0. Three small areas of 1.2.0 sandy loam are outlined in township 35, range 1, comprising in all about 400 acres.

They are in the rolling topography area of the glacial moraine and contain some stones. Patches have drifted rather severely.

Series 1.6.0. There are approximately 60,000 acres of this type (1.6.0. sandy loam) mapped. Two areas of this type are outlined in township 33, range 1, and two in township 34, range 2. They are composed of coarse sand and have a fairly high lime content. These areas are slightly mixed in texture; the lower patches have considerable structure in the profile. Some sections have been cultivated but, in general, the area should be considered non-arable.

The areas around and north of Grassy Island lake, that is in township 33, range 3, and township 34, range 4, appear to be mostly of alluvial origin. The sand is generally coarse and contains some gravel. It contains a few patches of solonized soils and some clay spots. Grass growth is fairly sparse and it is only fair pasture.

Sandy loam areas are outlined in the Kirkpatrick Lake area. The sand of these areas is of a finer texture than the sand in the areas described above. Under sand, this area was described as being fairly level and of uniform elevation, and it is suggested that due to this, and the presence of the heavy underlying strata of Bearpaw shale, a fairly high water table exists. This fact was not definitely established by the soil survey; but the grass growth is very heavy for so light textured a soil and the nitrogen content of the surface foot of soil was 0.15 per cent., which is of a higher order than many of the medium textured soils of this sheet. These areas provide good pasture, but should not be cultivated. It should be stated, however, that the presence of a high water table in this sandy soil might make it profitable to grow grass or alfalfa. The sandy loams of township 36, ranges 1, 2 and 3, are described with the 2.6.0 areas.

The area of 1.6.0/6 sandy loam comprising about 5,000 acres in township 33, range 9, contains a considerable percentage of solonized soils. In general, this is a poorer soil than the other sandy loams in the area because the hard subsoil hinders deep root penetration. In some solonized sandy soils (see Plate 8, Fig. 1), however, the hard B_1 horizon is generally quite deep and acts as a reservoir in preventing loss of rainfall water by drainage.

Fine Sandy Loam.

Most of the areas of fine sandy loam lie in close proximity to the sand and sandy loam soils. Few of them are better than marginal arable lands.

Profile 2. In general the fine sandy loam soils contain enough of the finer soil particles to give some structure to the profile; a structure that can be described as massive cloddy.

Series 1.2.2. There are two areas of 1.2.2 fine sandy loam comprising about 6,000 acres. The area in township 35, range 2, is in rolling to hilly topography of glacial origin. Most of it is non-arable, although there is a small patch still cultivated in the level portion on the eastern side. The area in township 33, range 3, is on gently rolling to rolling topography; portions that have been cultivated have drifted badly, and until the area sets a new growth of grass it is only fair pasture.

Series 1.5.2. One area of this type (1.5.2. fine sandy loam) is mapped in township 36, range 6, comprising about 6,000 acres. It is quite gravelly in places and in general has a loose structured subsoil. The area is on undulating to rolling topography and is dotted with many small lakes, most of them quite alkaline. Patches of this area are still being cultivated. Most of the area, however, is from good pasture to only marginal arable land. The area in township 34, range 4, is rather mixed in surface texture, and contains a few stones. It is on sloping ground, and therefore relatively dry. The patches that have been cultivated have drifted rather badly, and in general the area is non-arable.

Series 1.6.2. There are approximately 24,000 acres of this type (1.6.2 fine sandy loam) outlined. A large area of fine sandy loam, principally of alluvial origin, is outlined in township 33, range 2. The soil is of medium to coarse sand, fairly high in lime, and has a light textured subsoil. The area is on undulating topography and situated in a shallow basin-like position. It may have arable possibilities within a certain crop range. This is particularly true of the eastern central portion.

In township 36, ranges 1, 2 and 3, there is a narrow strip of fine sandy loam between the sandy loam to the north and the loam to the south. The subsoil is fairly heavy and the surface soil is possibly a mixed alluvial and eolian deposition over the gently rolling rim of the Neutral Hills moraine. It is marginal arable land.

The area in townships 33 and 34, range 4, appears to be a true alluvial deposition, although there has been some subsequent wind sorting. The surface is mixed in texture and some patches are fairly stony, in addition to containing gravel bars. Because they are of a slightly higher elevation than the surrounding areas they will not hold much reserve moisture, and therefore become very dry. The areas that have been cultivated have drifted badly. A portion of the area centering on section 7, township 34, range 4, is of marginal arable value, and the rest is generally non-arable.

Profile 6. A profile description of a dark brown solonized fine sandy loam is given on page 52.

Series 1.6.6. About 15,000 acres of this type (1.6.6 fine sandy loam) are outlined on the map. The areas of fine sandy loam in the Kirkpatrick Lake district contain varying percentages of solonized soils. The small area just north of Kirkpatrick lake, that contains mostly soil with normal profile development, is mapped as 1.6.2/6, the rest is mapped as 1.6.6. The solonized soils are in the lower spots and in some of these places the B_1 comes practically to the surface. The B_2 in these spots carries a heavy concentration of salt and in general the low spots are fairly alkaline. What was said regarding the utilization of the sandy loam of this district applies to the more level areas of fine sandy loam; although the presence of the hard subsoil would make it more difficult for the roots to penetrate.

Loam.

Most of the soils of this zone are of loam texture, that is they are of intermediate weight. Loam soils generally have sufficient fine particles to give a well developed profile structure, but are not heavy soils to cultivate.

Profile 1. This profile is in general shallower than a normal profile. The hilly areas of this sheet are classed as profile 1.

Series 1.2.1. About 62,000 acres of this type (1.2.1 loam) are mapped, located principally along the backbone of the Neutral hills. The largest single block centers in township 35, range 2. This moraine extends up into the dark brown zone and the hilly sections of this zone will be described under the series 2.2.1.

Soils of this type are also outlined in township 36, range 5, as well as small areas in adjoining townships. There is also a small area in township 33, range 4, which is on the outer rim of Misty hills.

The following profile, taken in section 29, township 39, range 9, is from the dark brown zone, but is fairly typical of all the hillside soils of this sheet:

A —0″-4″. Very dark brown in color and of a gritty texture. This horizon has an elongated cloddy structure and there is some staining along the cleavage faces.

B_1—4″-11″. Brown color. There is no break in structure with the A horizon and there are no cleavage lines other than the clod edges.

B_2—11″-14″. Light brown color. The same cloddy structure as in the above horizons, but the clods are very hard. This horizon has a fairly heavy lime carbonate concentration.

C —A slate brown color. Structureless but packed quite firmly. There are salt inclusions in this horizon and numerous red flecks.

On many of the slopes, particularly in the brown zone, lime is found at six to nine inches from the surface and often it appeared that the lime horizon was closer to the surface on the western slope than on the eastern slope. As may be expected, the draws in these areas have a much deeper and a darker soil profile than the hill slopes. The surface soils in these low spots are often silty and because they receive considerable run-off water support a heavy grass growth.

There are stones throughout all these areas; on the surface, due to surface erosion, and through the profile. These stones are all of Hudson Bay origin. Although a few ridges are quite stony, in general, the stones are not numerous enough to materially curtail the grazing capacity of the area.

These areas are useful principally for grazing. The grasses are of good varieties (see Vegetation, page 83), and if systematically grazed the areas should have a fairly high carrying capacity. During 1937 fields that had been carefully grazed had a deep thick growth of grass. Because of this deep growth run-off loss will be limited and the annual growth of grass should be much greater than on the barer slopes. The areas are fairly well dotted with sloughs which form parts of small inland drainage systems. Some of these sloughs are quite alkaline and void of vegetation, others grow good meadow hay. There are some running springs in the area. Scattered throughout these areas are small valley-like flats that belong to the series 1.3.3, but because of their small size, 25 to 100 acres in extent, are not shown on the soil map. They are often good arable land and should be valuable in a ranching area. Some could possibly be irrigated from a coulee dam. A few of these level draws are strongly solonized. These are not as valuable, agriculturally, but under irrigation the hardpan tends to soften and becomes much less objectionable. The surface texture of the 1.2.1 loams is very variable and patchy, but they are all graded a medium loam. Due to erosion, which brings the subsoil close to the surface, the surface soil is often quite heavy, that is the clay content may be almost high enough to put the soil in the clay loam class. However, since these soils are all very gritty and are non-arable, the medium loam designation is used.

Profile 2. In general the loams of the Sullivan Lake sheet with a normal profile development have a cloddy prismatic structure and become heavier textured with depth.

Series 1.2.2. *Rolling phase.* There are about 140,000 acres of this type (1.2.2 loam) mapped. From Gooseberry lake to Compeer the rolling 1.2.2 loam areas lie beside the hilly areas, but they also carry farther north and south along the edge of

Neutral hills. A fairly large area is also outlined in township 33, range 5. The general description that applied to the 1.2.1 loam applies to this series, including the profile description. The difference lies in one direction only; the slopes are not as steep, the profile is therefore slightly deeper on the average, and there is a higher percentage of valley soils. As a result there is more arable land in these areas and their grazing capacity is slightly higher.

Series 1.2.2. *Level to gently rolling phase.* There are about 22,000 acres of this type mapped. This phase of the 1.2.2 series is composed of the more level areas of glacial loam. They are the areas large enough to map. The profile is from 12 to 24 inches deep, contains stones, and is often in the form of a large basin surrounded by hills. In some of these the profile development is between 2 and 3. Some are fair arable land and are at present cultivated. Areas are outlined in township 34, range 2, township 35, range 2, and township 35, range 5, as well as some other smaller ones. The largest area is found on the east side of Sounding creek, east of Pemukan. This area is on gently rolling topography and the presence of some gravel indicates that the soil has had a little post glacial sorting. The Pemukan area and the smaller area southeast of Kirriemuir are of a darker color than the surrounding soils. Both of these areas are practically all cultivated and are considered to be fairly good arable land.

On the eastern rim of the strongly solonized loam are two areas of 1.2.2/6 loam on gently rolling topography; one centering in township 34, range 6, and one in township 33, range 4, comprising about 35,000 acres. They have only isolated patches of solonized soil within their boundaries, generally in the lower spots, and for the most part the profiles are of a prismatic cloddy structure. In general the profile is shallow. Most of the area has been cultivated; however, some is now abandoned. This type is from marginal to fair arable land.

Series 1.3.2. There is one area of 1.3.2 light loam comprising about 2,000 acres, outlined in township 33, range 1. The area is quite stony, but is of a lower elevation than the 1.2.2 loams to the north. The southern portion of the area is fair arable land, but the northern portion is only marginal arable land.

In township 33, range 9, there is outlined an area of 1.3.2/6 light loam comprising about 3,500 acres. Patches of solonized soils occur throughout the area. The sections that have been cultivated have drifted badly. It may be considered as marginal arable land.

Series 1.5.2. There are about 4,500 acres of this soil type (light loam) mapped. The two areas south of Monitor are on high land, and of a coarse texture. They have drifted badly where cultivated. The one centering in section 26, township 34, range 5, might have some arable value. The two areas along Sounding creek in township 35, range 4, appear like alluvial fans. They receive considerable drainage from the surrounding hills. These two areas are cultivated at present and portions of them might be irrigable.

The large area of 1.5.2/6 light loam in township 33, range 7, comprising about 12,000 acres, contains patches of solonized soils. Where these occur, however, the A horizon is 10 to 12 inches deep. There is considerable gravel in the subsoil and the surface has drifted quite badly. Practically the entire cultivated portion is now abandoned. The area in township 33, range 5, is on the Monitor flat. It is fair arable land.

Profile 3. The soils of the brown zone of the Sullivan Lake sheet in relatively low positions are generally darker in color than the upland soils, are more humid and if sufficiently drained are often more productive. It has been stated before that numerous areas of this type too small to map are scattered throughout the hilly section. Where these areas are in such a location that they can be cultivated they should be quite valuable.

Series 1.5.3. An area comprising about 4,000 acres of this soil type (1.5.3 loam) in township 35, range 6, lies on the transition between the brown and dark brown soil zones. The soil is somewhat silty and the profile is deep and of a red brown color. There is gravel throughout the area and in places sandy clay in the subsoil. The entire area is cultivated. It is good arable soil.

Profile 6. The large area of loam soil stretching from township 33, range 6, to the northwestern corner of the brown soil zone west of Coronation has a strongly solonized profile. In the brown zone slick spots are very numerous due to the relative shallowness of the A horizon. In general these soils are on level to undulating topography. A description of a solonized loam profile for the dark brown zone is given on page 61. In the brown zone the A or surface horizon is in general not quite as dark and not quite as deep.

Series 1.1.6. There are between 75,000 and 80,000 acres of this soil type. An area of 1.1.6 loam stretching from township 35, range 9, to township 36, range 11, centering on Coronation, is outlined. This area of level to undulating topography lies between the Ribstone drainage to the north and the Sounding creek drainage to the south. Surface stones are found throughout the area, but the relatively unweathered underlying bed rock, mostly Bearpaw shale, comes very close to the surface. In general the A horizon is quite shallow and throughout the area slick spots are quite numerous. The A horizon gets deeper towards the north and consequently the eroded slick spots are less numerous. These slick spots, most of them devoid of vegetation, contain many small gravelly stones. The area is of marginal arable value under dry land conditions, and in the native state the presence of slick spots reduces the pasture carrying capacity.

Series 1.2.6. A small area of 1.2.6 loam comprising about 2,000 acres is outlined in townships 33 and 34, range 8. This area is in strongly undulating topography and is very stony. It is generally non-arable.

A large area of 1.2.6/2 loam on gently rolling topography, principally in the form of low ridges stretching from Veteran to south of Consort, forms a transition between the 2.2.2 to the north and the 1.3.6 to the south. Most of the soils have solonetz development, but the A horizon is generally 10 to 14 inches deep, consequently there are relatively few slick spots. Most of the area is cultivated and there is very little abandonment. It is fair arable land. Another area is outlined in township 33, range 5. It is marginal arable land. There are about 4,500 acres of this soil type.

Series 1.3.6. There are about 90,000 acres of this soil type (1.3.6 loam) mapped. The main area of 1.3.6 follows southeast from the end of the Coronation 1.1.6 area to township 33, range 6, and south to township 33, range 8. The topography is strongly undulating and exposures of bed rock are not apparent. Stones are fairly numerous on the surface and some are found well down in the profile. This suggests that part of the glacial till covering remains and on this sorted till the soil profile has developed. The A horizon is quite shallow, 4 to 8 inches deep, and contains considerable grit in its composition. A fairly high percentage of the surface has been eroded off exposing the hard B_1. In these eroded pits is collected considerable gravel and small stones. About one-third is now cultivated and one-quarter more is abandoned cultivation. It is of marginal arable value. Isolated quarter sections, where in general the B_1 horizon is more than eight inches deep and the eroded spots less frequent, may be considered as being of fair arable value. The area in township 35, range 5, is in undulating to gently rolling topography and contains numerous sloughs. It is marginal arable land.

Series 1.5.6. There are about 4,800 acres of this soil type mapped. The soils of 1.5.6 series outlined in townships 33 and 34, range 11, are areas of strongly solonized soils containing much gravel. The combination of these two detrimental factors seriously affect its utilization, and in general the areas of medium loam are non-arable and only fair pasture. The 1.5.6 light loams of this area contain very little gravel and have a deep A horizon, from 12 to 18 inches deep. Although drifting must be considered in its utilization it should have a better arable possibility than the medium loams of this area. The light loam in township 33, range 10, is pasture land. The area in township 34, range 9, of light loam is a transition strip along the sandy area. Portions of it are drifting badly. It is marginal arable land. The area in township 35, range 8, is lower land than the surrounding area. It is fair arable land. The areas south of Monitor are badly eroded and are generally pasture lands.

Series 1.6.6. An area of 1.6.6 loam comprising about 2,000 acres is outlined in township 35, range 10. It is light textured loam and contains a little gravel. The land is level to undulating and is slightly higher than the lake level. It is fair arable land.

Silt Loam.

A very small percentage of the brown soils of the Sullivan Lake sheet are mapped as silt loam. There are no large settling basins in this area and the two largest silt loam areas, located in range 1, are possibly more eolian than lacustrine in origin.

Profile 2. There is one area of silt loam with normal profile development outlined.

Series 1.7.2. An area of 1.7.2 silt loam, comprising about 5,000 acres, is outlined in township 36, range 1. The area is on undulating to gently rolling topography, and lies in a semi-basin surrounded on three sides by higher land. The silt deposition, containing considerable fine sand, is possibly partly water and partly wind laid over glacial till. In the center of this area in section 15 is a large marsh that normally produces considerable meadow hay. The soil of this area is of a cloddy structure, very friable, and has a fairly high lime carbonate accumulation often within a foot of the surface. The area is practically all cultivated. During the dry year of 1937 soil drifting was quite severe on this area. In general, it is fairly good arable land.

Profile 3. The areas of this profile that have been outlined are all in relatively low positions, but are non-saline. They have originated chiefly as local settling basins.

Series 1.7.3. About 2,500 acres of this soil type (1.7.3 silt loam) have been mapped. The areas are located in township

34, range 1; township 33, range 2; township 34, range 3; and township 33, range 4. All of these areas have a deeper and generally darker profile than the surrounding soils due to the fact that they receive run-off waters. All are at present cultivated and are good arable land. Portions of these areas, particularly the area in township 33, range 4, have irrigation possibilities.

In township 33, range 1, an area, comprising 5,500 acres of 1.7.3/4 silt loam is mapped. This area lies in a basin at the south side of Neutral hills. The profile, practically stone free, has a fairly hard granular B_1 horizon in some places; however, no strong solonetz development was found. It is all cultivated and is fairly good arable land.

Profile 4. To this group belong soils with a weak solonetz profile.

Series 1.7.4. One area of this type, comprising between 200 to 300 acres is outlined in township 34, range 5. The area is a fairly wide valley cut by a narrow drain. The profile in general has a hard B_1 horizon. The area is not cultivated at present, but might have irrigation possibilities.

Profile 5. To this group belong the poorly drained saline soils.

Series 1.1.5. Two areas of this soil type (1.1.5 light silt loam), comprising nearly 2,000 acres, are outlined in township 36, range 9. These areas are low and meadow-like in appearance. The surface or A horizon averages about two inches in thickness and is underlain by a very heavy massive B_1 and C horizon. The area is not cultivated. It is fairly good to good pasture land.

Profile 6. The soils of this group have the typical solonetz morphology.

Series 1.1.6. An area of this type, comprising about 4,500 acres is outlined in township 35, range 8. There may be a thin silt deposition over the parent bed rock in this area, but it appears to belong to the adjoining resorted residual area. The soil has a strongly developed solonetz profile and practically 50 per cent. of the surface or A horizon is eroded off. Portions of the area are poorly drained and are quite similar to the 1.1.5 area described above. It is of fair to fairly good pasture value and non-arable.

Series 1.7.6. An area comprising about 1,000 acres of 1.7.6 silt loam is outlined in township 36, range 4. It is on gently rolling topography and lies on a bench between Sounding creek and the hills to the east. The B_1 horizon is quite waxy and is fairly hard. The area is practically all cultivated. The southern half is good arable land and the northern half marginal to fair arable land.

Clay Loam.

Clay loam soils being of a fairly heavy texture are generally good dry land soils; however, in the brown zone of the Sullivan Lake sheet most of the clay loam areas are low, poorly drained and of little arable value.

Profile 2. Only one area of clay loam with normal profile development is outlined.

Series 1.3.2. An area of 1.3.2 clay loam, comprising about 700 acres, is outlined in township 35, range 3. This is an area of undulating topography surrounded by hills. It is practically stone free and has in all probability received considerable wash from the surrounding hills. It is all cultivated and is good arable land.

Profile 3.—*Series* 1.7.3/6. In township 35, ranges 1 and 2, there is a small basin-like area, comprising about 1,200 acres, of this soil complex. The center of the basin contains most of the solonized soils. The area is cultivated. The western portion is good arable land, the rest is marginal to fair arable.

Profile 4.—*Series* 1.7.4. The area in section 15, township 35, range 2, comprising about 100 acres, is in a level basin. It is cultivated and is good arable land.

Profile 5. To this profile group belong most of the clay loams of this area. They are generally on level land, slightly saline and non-arable.

Series 1.5.5. There are over 9,000 acres of this soil type mapped. The principal area of 1.5.5 clay loam is found along Sounding creek between Monitor and Sounding lake. It is part of the river flood plain, and although generally heavy in texture contains many gravel bars and lenses. The soil is very light in color and the surface has a washed appearance. The soil supports only a sparse grass growth, the dominant variety being salt grass. What little of the area that has been cultivated is now mostly abandoned. Parts of the area that slope gently towards the creek are level enough to irrigate, but they should be carefully inspected before such development is considered.

The area in township 33, range 10, is quite stony and generally non-arable.

Series 1.7.5. About 11,000 acres of 1.7.5 clay loam are mapped. The area of this series of clay loam texture in townships 33 and 34, range 4, forms part of the large Monitor flat. The soil has a washed appearance and contains considerable very fine sand. The alkali salt content of these soils is high and includes a fairly high percentage of sodium salts. Generally they are non-arable and of varying pasture value.

The areas in township 33, range 8, and township 34, range 10, have a definite solonetz profile where some A horizon remains, but in general they are fairly alkaline and support little vegetation.

Clay.

Very little clay soil is mapped in this portion of the Sullivan Lake sheet.

Profile 3.—*Series* 1.7.3. An area of this type (1.7.3 clay), comprising about 1,000 acres, is outlined in township 35, range 1. It is a deep stone free lacustrine clay. A small lake still exists at the northern end of the area. It is all cultivated and is good arable land.

Profile 5. The clay soils of this profile type are all of lacustrine formation.

Series 1.7.5. The areas of 1.7.5 clay, found south of Monitor, near Grassy Island lake and north of Kirkpatrick lake and totalling about 5,000 acres, are all heavy lacustrine flats. They have very little horizon differentiation and they support only a meagre vegetative growth.

Mixed Types.

This group has a surface texture so mixed that separation was not deemed practicable. All the soils of this division belong to the deposition group, gravelly outwash (see page 23).

Profile 0. The light textured mixes, composed mostly of sandy loams, carry the profile designation 0.

Series 1.4.0. There are about 13,000 acres in five areas of the 1.4.0 mixed surface type; one large area centers in township 34, range 4, and two fairly large ones in township 36, range 4. All of these areas, excepting one, are along Sounding creek drainage course. The washing away of the finer materials by flood waters, as well as a coarse alluvial deposition, have possibly both been responsible for their formation. The areas are non-arable, and very few attempts at cultivation have been made on them. They are, however, fairly good pasture areas.

Profile 2. To this group belongs the heavier textured mixes averaging about the texture of fine sandy loam.

Series 1.4.2. There are about 8,000 acres of series 1.4.2 mixed surface type mapped. The two largest areas of this type are outlined in township 33, range 2, and township 33, range 7. They are on gently rolling to rolling topography and support some scrub tree growth. They are only of fair pasture value.

Along the west side of the Kirkpatrick lake sandy area are mapped about 18,000 acres of 1.4.2/6 mixed surface type. These areas differ from the areas described above principally due to the presence of patches of solonized soils in some of the lower portions of the area. These areas are at the head waters of Sounding creek. All of these soils are gravelly and bars of almost pure gravel run in a generally east and west direction over most of the area. They are non-arable, but fairly good to good pasture.

By way of summary it can be stated that not over 15 to 20 per cent. of the brown soils of the Sullivan Lake sheet, under dry land conditions, are of fair or better arable value. With the possible exception of a few small areas carrying the profile designation 3, the arable lands are principally wheat growing areas.

Dark Brown Soil Zone

The dark brown soil zone forms a transition soil belt between the brown zone to the south and the black zone to the north and west. It has, therefore, a plant food content, particularly nitrogen, between that of these two zones (see Composition of Soils, page 70). In general the lime carbonate horizon is found from 15 to 30 inches from the surface, and averages about 24 inches in the Sullivan Lake sheet. The average annual precipitation for this area is about 15 inches and, due to a slightly lower temperature, evaporation is not as great as on the bald prairie farther south. In this area the total annual precipitation rarely falls below 11 inches, so that on most of the soil types some measure of growth can be expected in most years. The arable areas of the dark brown soil zone are generally good wheat land soils.

Sand.

The sand areas of this zone are characterized by open shifting dunes. There is considerable scrub tree growth in the areas.

Profile 0. The sands of this area have a single grain profile structure. That is there is insufficient silt or clay to cause definite profile development.

Series 2.6.0. There are about 65,000 acres of this soil type (2.6.0 sand) mapped. All the sands of this series lie in a broad belt stretching from Czar in township 40, range 7, through Metiskow south to Sounding lake, and then ending in township 36, range 1. The southernmost portion of this area lies in the brown soil belt, that is in township 36, ranges 1, 2 and 3, but since these sands are in the same general area they will be described under this 2.6.0 heading. This area forms the southern extension of a large sand area that carries north into the Wainwright sheet as far as Wainwright and then east through Chauvin into the great sand hills of Saskatchewan. This area is underlain by Belly River Pale beds from whence they possibly have their origin. In some places a heavy hardpan subsoil can be found at from four to six feet; in other places the sand accumulation appears to be of great depth. Trees, principally stunted Aspen poplar, grow over much of the sand areas, and often between the dunes there are small meadow-like flats of one or two acres. Creeping Juniper grows on the sand throughout this area, and is a valuable aid in holding down otherwise shifting sand.

The largest continuous areas occur in township 40, ranges 4 and 5; in townships 37 and 38, range 4; and in township 35, ranges 1, 2 and 3. Small patches are found along the drainage way between Provost and Hayter. None of these areas should be cultivated, and they should be so pastured that the surface does not become broken, allowing fresh dunes to start. In other words, over-grazing might permanently ruin a sandy area. Great care must be exercised where these sand areas occur in close proximity to arable lands.

An area of 1.5.0 sand in this general area is outlined along the north side of township 36, range 3. It is dune free. This area is composed of a deep deposit of very coarse sand, non-arable, but supporting a slightly better grass growth than the dune areas around.

Sandy Loam.

The dark brown sandy loam soils are principally located adjacent to the sandy area outlined above under 2.6.0 sand. The areas in general are dune free.

Profile 0. Although the sandy loam soils contain on the average slightly more silt and clay than do the sands, the profiles in general are quite loose (see Profile Description, page 35).

Series 2.2.0. There are about 6,700 acres of this soil type (2.2.0 sandy loam) mapped. In township 36, range 7, there are two areas of glacial sandy loam. These soils contain many stones and are on rolling to hilly topography. The hill slopes have a poor grass cover, but the draws are quite heavily grassed. Wells in this area obtain water at very shallow depths, which adds greatly to its range utilization.

Series 2.5.0. There are about 2,500 acres of this soil type mapped in township 39, range 1. This area, formed along an old drainage course, contains considerable gravel and pockets of coarse sand and clay. Where cultivated it has drifted badly and in general is only fairly good pasture land.

Series 2.6.0. There are about 85,000 acres of 2.6.0 sandy loam mapped. Most of the large sandy belt between Czar and Bodo is graded a sandy loam. In general the soil is loose and has very little silt or clay in its mechanical composition, but the surface is unbroken and there are no dunes in the areas. The entire area is dotted with meadows and small lakes. Most of these lakes were dry alkali flats in the spring of 1937, and the dry powdered salt was drifting over the adjoining soil. However, there are many slight depressions having a tight subsoil, and these grow a fairly heavy growth of grass, and therefore materially increase the bulk of feed produced. Running springs were found feeding some of the small lakes.

Two other areas of sandy loam are outlined, one in township 34, range 13, and one in township 35, range 13. These sandy areas were possibly once part of Sullivan Lake bed and originated from the underlying Edmonton formation. They are underlain by a fairly heavy subsoil.

Although the grass, in general, is of a coarser variety than that found on the heavier textured soils of the sheet the 2.6.0 sandy loams of this series are fairly good pasture lands.

Fine Sandy Loam.

Most of the fine sandy loam areas of this zone also lie in the general sand area described above. Many of them form transition belts between the sandy loam areas and the adjoining loams. Most of them are mapped as 2.6.2, that is, they are of alluvial or eolian origin; in most cases possibly both wind and water have shared in their deposition and sorting.

Profile 2. It has been stated previously that in general there is enough silt and clay in the mechanical composition of the fine sandy loams to give some structure to the profile.

Series 2.1.2. The small area of 2.1.2 fine sandy loam, comprising about 700 acres, is outlined in township 33, ranges 13 and 14. Edmonton sandstone exposures occur in this area. It is of marginal arable value.

Series 2.2.2. About 8,500 acres of 2.2.2 fine sandy loam are mapped. In township 37, range 1, there is a large area of 2.2.2 fine sandy loam on rolling to gently rolling topography that contains many glacial stones. Two small areas, one in township 39, range 7, and one in township 40, range 3, on rolling topography also appear to be of glacial deposition. These areas have a mixed surface texture, and are fairly light in color. In general they are pasture lands only, although small patches in the lower positions may be fair arable land.

Series 2.5.2. There are about 12,000 acres of 2.5.2 fine sandy loam. The area in township 36, range 7, is composed of a series of low gentle rolls dotted with alkali sloughs, and generally quite gravelly. The eastern half is fairly good pasture land, and a portion of the western half is marginal to fair arable land.

The area in township 37, range 6, lies at the base of the Neutral Hills backbone, and the mouth of the Little Gap drainage through the hills. The level portion on the south and west side has a profile development between 2 and 3. It is fairly good arable land. The higher and more rolling portion of the area is pasture land.

The area in township 38, range 12, contains some sandy loam and some light loam. Some of the lighter textured portions have drifted badly. The long arm that juts to the east is lower land and portions of it are fairly good arable land. The area in township 39, range 6, is on land that is undulating to the edge of the lake. It is fair arable land. Other small areas are outlined in township 38, range 12, township 39, range 13, and in township 33, range 14.

An area, comprising about 700 acres, of 2.5.2/6 fine sandy loam is outlined in township 37, range 14. This area is an old shore line of Lanes lake and is on level to undulating topography. Some of the lower portions of the area are solonized. It is fair arable land.

Series 2.6.2. There are about 50,000 acres of 2.6.2 fine sandy loam mapped. The areas in townships 37 and 38, range 3, and township 39, range 4, formed on gently rolling topography, have a deep stone free sand deposition over a heavier substrata. In general there is a fairly heavy lime carbonate horizon at from 24 to 36 inches. This also describes the fine sandy loam area between Provost and Hayter. Most of these areas are still cultivated but some are drifting badly. The eastern portion of the area in township 37, range 3, and the area in township 39, range 4, are fair arable land; the remainder of these areas is pasture to marginally arable. The area in township 39, range 4, and the eastern portion of the area in township 37, range 3, are fair arable land.

The areas centering in township 40, range 5, are generally on level to undulating topography. They have a fairly deep sand deposition, possibly of alluvial-lacustrine origin. There are many small slough-like depressions in the area, some of which have a fair growth of meadow hay. The area is of marginal to fair arable value.

In township 39, range 6, a large area of fine sandy loam on rolling topography is outlined. The sand in this area is medium to coarse in texture and it is loose in structure. The sand here is quite deep. What land has been cultivated has drifted badly and is now abandoned. The area is fair to fairly good pasture. The sloughs are quite alkaline and do not support any quantity of palatable grass. A running spring was found in this area.

In township 38, range 5, there is a low, level to undulating area of fine sandy loam running through the center of the township. In the main this area is non-arable; however, patches of meadow land have grown good crops of hay and fodder grains. The area contains many hay marshes and in section 13 there is a large heavily wooded swamp. This was very wet during the dry summer of 1937, and it is thought that the water table must be quite close to the surface throughout this area. This would account for the good hay growth, as well as suggest fodder crop possibilities. The light loam areas adjoining have a similar utilization.

In township 40, range 7, and adjacent to it are many small fine sandy loam areas. Most of these contain gravel as well as some glacial stones. The area in township 35, range 12, has similar characteristics. In general they are from marginal to fair arable land. The area in the frog of Sounding lake is level and slightly higher than lake level. It is marginal to fair arable land.

The large area outlined in township 35, range 12, is mapped partly as medium and partly as heavy fine sandy loam. The area in general lies in a slight basin on undulating topography and contains varying amounts of stones. Cultivated areas have drifted badly. In general the area is only marginal arable land.

About 14,000 acres of 2.6.2/6 fine sandy loam are mapped. A large area lying to the northeast of Sullivan lake is on level to undulating topography and is possibly part of the old lake bed. The solonized areas are quite patchy and the B_1 is of varying depths. Some portions of this area should have arable possibilities.

The area in township 39, range 12, forms a band along Battle river, and slopes to the river. It has a heavy phase surface texture and a light subsoil. It is marginal arable land.

Centering in township 39, range 7, is a relatively low area of fine sandy loam. It is dotted with alkali sloughs and patches of solonized soils. It could not be considered better than marginal arable land.

Profile 6. Most of the fine sandy loam soils in the western half of the sheet have solonized profiles. Below is given the description of a profile taken in section 14, township 35, range 13:

A_1—0″-12″. Reddish dark brown color. This horizon is of a loose cloddy structure that crumbles easily.

A_2—12″-15″. Light buff colored horizon that is very loose and structureless.

B_1—15″-18″. A hard almost black horizon composed of 1 to 2 inch columns that are capped by the characteristic white cauliflower top. These columns break into small cubes.

B_2—18″-24″. The columns of B_1 carry down into this horizon, but gradually become more cloddy in appearance. This horizon is lighter in color than B_1 and not quite as hard. The lime carbonate concentration is quite high. Pockets of red sand were found throughout this horizon.

C —24″-30″. A hard gray sandstone that contains some salt pockets and has some red colored streaks running through it.

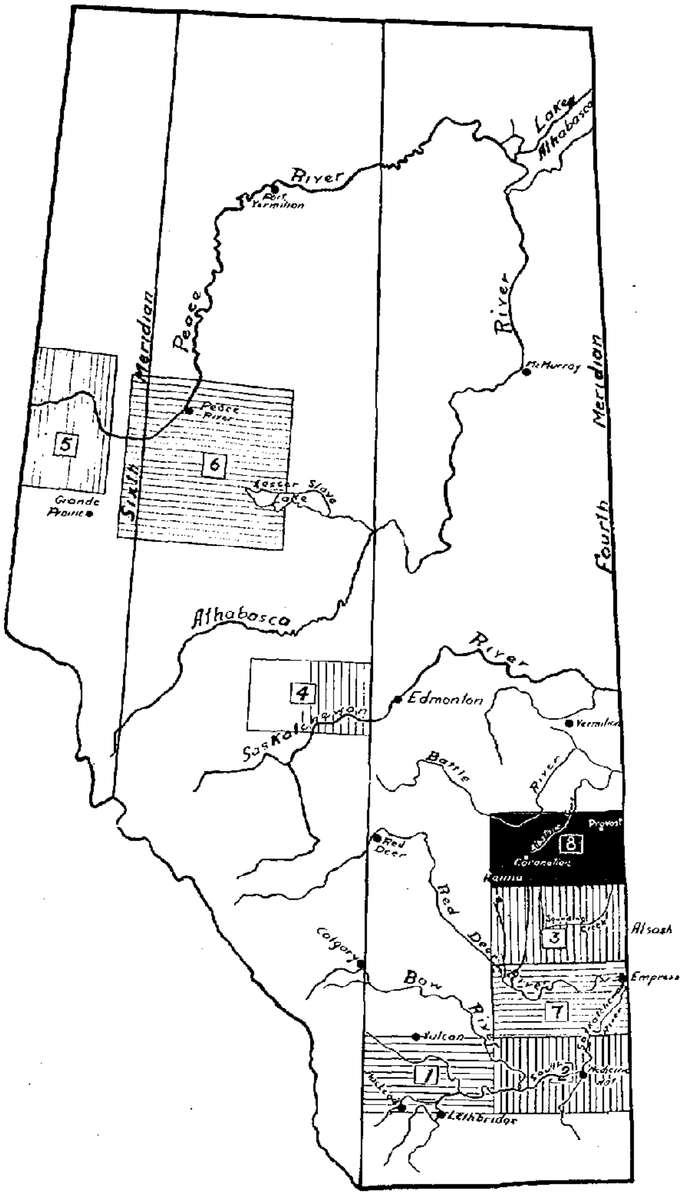
Series 2.1.6. There are about 5,000 acres of this soil type (2.1.6 fine sandy loam) mapped. In township 34, ranges 12 and 13, there is an area of 2.1.6 fine sandy loam with heavy phase surface. The B_1 horizon is relatively close to the surface and eroded pits are common. There are many stones throughout the area. It is fairly good pasture and generally non-arable.

Series 2.6.6. About 15,000 acres of 2.6.6 fine sandy loam type are mapped. The large area that lies along the east side of Sullivan lake was possibly at one time part of the lake. It is level to undulating topography and only slightly higher than the lake level. A portion of this area centering in section 23, township 34, range 14, is however a high ridge and here the sandy deposition is possibly more eolian in deposition. The average profile of the area follows the description given above. This indicates that there is a fair depth of A above the tight B_1 horizon. The area has drifted rather severely in places. Portions of this area should have arable possibilties for certain crops.

The area in township 35, range 12, has similar characteristics.

By way of summary it may be said that the level fine sandy loam soils having heavy substrata have arable possibilities.

PLATE 1



Sketch map of Alberta showing locations of surveyed areas for which reports have been published. (1) Macleod sheet; (2) Medicine Hat sheet; (3) Sounding Creek sheet; (4) St. Ann sheet; (5) Dunvegan area; (6) Peace River-High Prairie-Sturgeon Lake area; (7) Rainy Hills sheet; (8) Sullivan Lake sheet.

Fig. 1—Battle river valley showing grass and tree covered slopes. Such areas as these are mapped as eroded, but are good grazing lands.

Fig. 2—Erosion near Battle River. This shows parent rock exposures and the accumulated erratics from the glacial till.

Fig. 3—Ribstone creek flood plain. It contains many hay meadows.

PLATE 3

Fig. 1—A portion of Neutral Hills area. Note the level arable land in the valley.

Fig. 2—A typical undulating area of dark brown sorted glacial soil, one of the better soil areas.

Fig. 3—This undulating plain is typical of the blow-out area in the south-west quarter of the sheet. Note the narrow draws that afford the possibility for the construction of water reservoirs.

Fig. 1—There is a large level to undulating silt loam area in the northeast portion of the sheet. It is one of the better soil areas.

Fig. 2—Paintearth creek flat. Some of these creek beds have irrigation possibilities.

Fig. 3—Typical blow-out surface topography in southwest part of Sullivan Lake sheet. Note A horizon still in situ in right foreground with B horizon exposed nearby.

PRESENT CULTIVATED, ABAN
SULLIVAN

SOIL SU

I

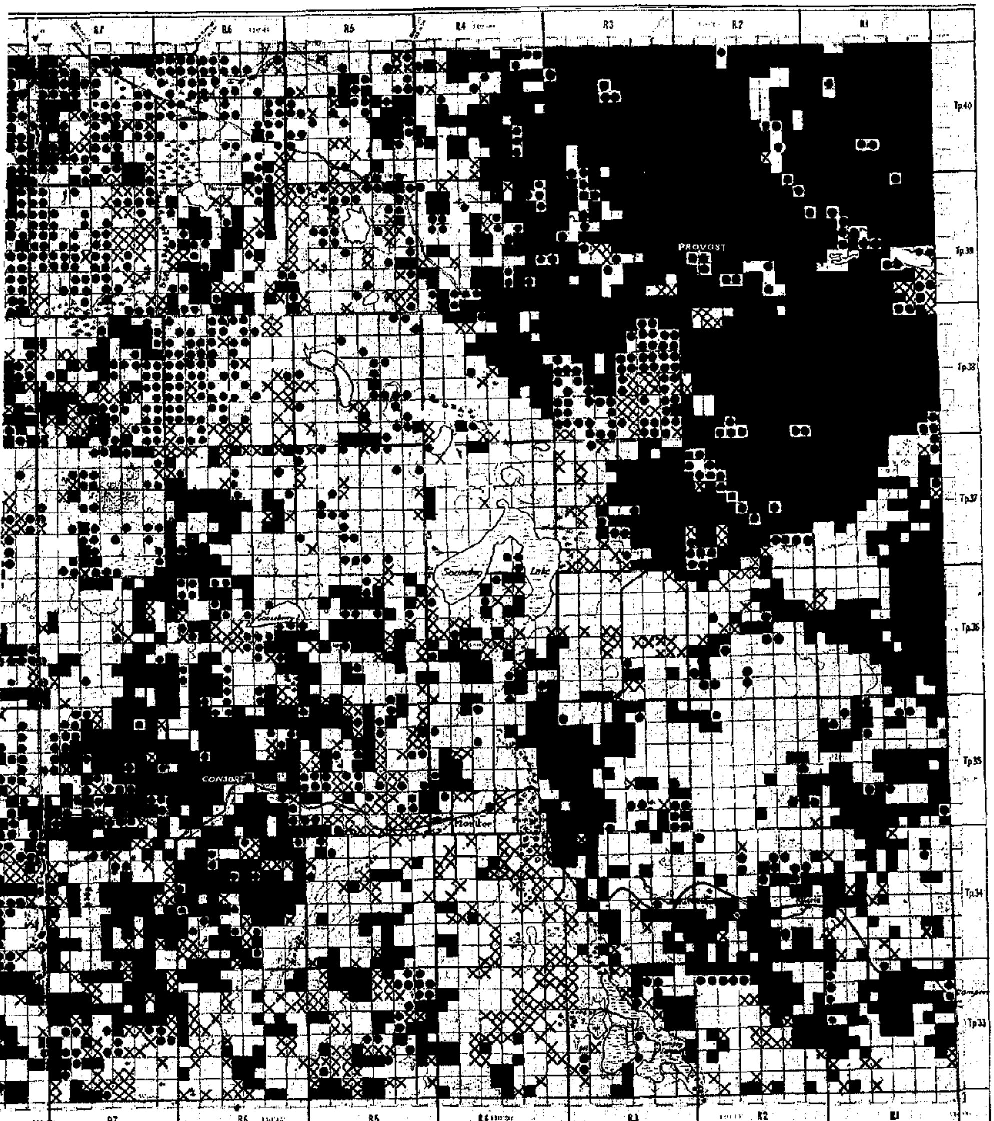
Completely Cultivated (140-160 acres) ....

Partially Cultivated (10-140 acres) ....

ATE 5

DONED and VIRGIN LANDS OF
AKE SHEET

RVEY 1937



EGEND

Abandoned Cultivation (10-160 acres)........................ ☒

Virgin Lands (Idle and Pasture).. ☐

Fig. 1—There are approximately 80,000 acres of sand on this sheet. Fairly good grass grows between the dunes.

Fig. 2—Deserted farmstead on sandy soil. Poplar and Caragana trees still alive. Note collapsed barn.

Fig. 3—Recent wind erosion on sandy land. This field was once cultivated.

PLATE 7

Fig. 1—Gully erosion by spring waters. Artificial reservoirs would retain much of that run-off.

Fig. 2—2.3.2 heavy loam. This profile is typical of the area pictured in Fig. 2, Plate 3. There are very few surface stones.

PLATE 8

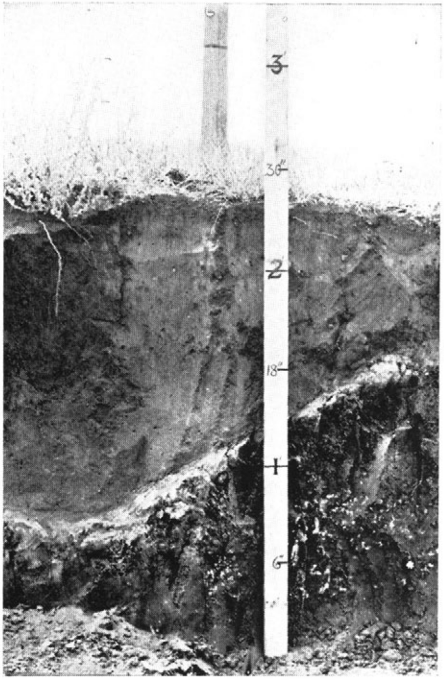


Fig. 1.—2.6.6 sandy loam. The surface horizon is much shallower in the heavier soil classes.

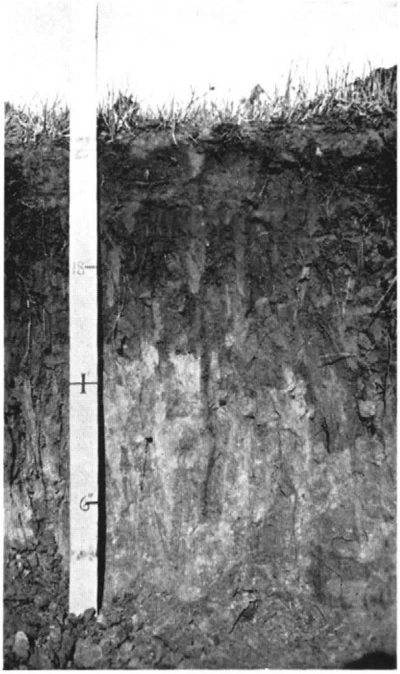
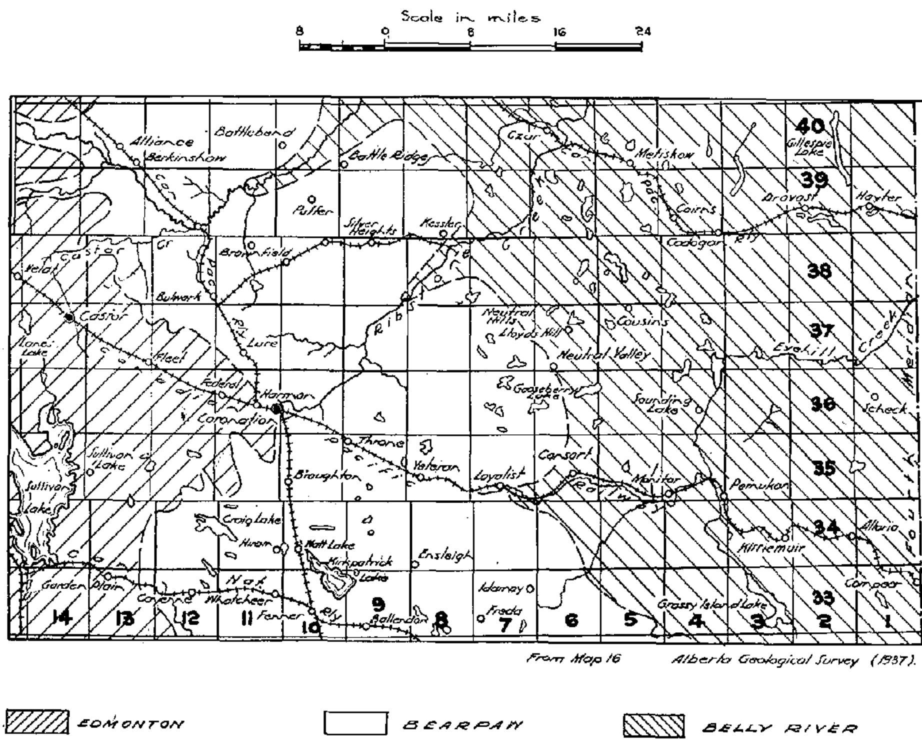


Fig. 2. — 2.7.2 loam. A dark brown stone free soil. Note the high lime concentration.

PLATE 9

GEOLOGY OF SULLIVAN LAKE SHEET



Particularly is this so if they are in relatively low positions. It should be emphasized, however, that they present a serious drifting problem, and their utilization possibly lies in the direction of rotations rather than straight grain fallow.

Loam.

As in the case of the brown soil zone a large percentage of the soils of the dark brown soil zone are of intermediate texture and are graded as loam. This zone coincides with a more humid climate than that of the brown zone and therefore the loam soils of this area that have normal profiles and are on farmable topography are, in general, fairly good arable soils.

Profile 1. In this group is classed the hilly areas that have a predominance of steep slopes and are locally more arid than the more level land.

Series 2.2.1. There are about 45,000 acres of this soil type (2.2.1 loam) mapped. There are two fairly large areas of hilly loam soils in the dark brown zone, one in township 37, ranges 5, 6 and 7, and the Nose hill area in township 37, range 9, as well as smaller areas in adjoining townships. There are also two small areas outlined in township 40, range 9. The description that applied to the 1.2.1 series (page 38) applies here with one possible exception; there is some tree growth in these areas. Small patches of poplar are found in valleys of the 1.2.1 series, but in the 2.2.1 series the down north slopes particularly are fairly heavily wooded. Because of a slightly higher rainfall the grass growth on these areas is slightly more luxuriant than in the brown soil zone.

Profile 2. In general the loams of this area with normal profile development are cloddy to clumnar in structure. The surface soil is quite friable and the subsoil generally much heavier than the surface soil.

Series 2.1.2. Two areas, comprising about 1,600 acres, of 2.1.2 loam are outlined. The area in the southwest corner of township 35, range 12, has some surface stones but bed rock is relatively close. It is only marginal arable land. The area in township 39, range 7, has a hilly topography. High residual knobs characterize the area, although glacial stones are scattered over the surface on most of the slopes. It is pasture land.

About 7,500 acres of 2.1.2/6 loam are mapped. The area in the southeast corner of township 35, range 13, is light textured loam. Parent sandstone is general throughout the area at two to four feet, but surface stone and gravel lenses indicate that subsequent sorting has taken place. It is marginal arable land.

The area centering at Castor is on level topography and generally slightly lower than the surrounding area. Castor creek cuts through the area. The profile is deep and in places from strongly columnar to solonized. Stones are rare and the area is fairly good arable land.

Series 2.2.2. *Rolling phase.* There are about 75,000 acres of this soil type (2.2.2 loam) mapped. A large portion of the area from Gooseberry lake to township 40, range 10, and east and west from Talbot in township 38, range 9, to Horseshoe lake in township 39, range 6, belongs to this soil type. The Neutral Hills moraine is less pronounced here than farther south and east, and the rolls are of a much lower order. Two small areas are also outlined in township 33, range 14.

The soils of the rolling phase, particularly in the dark brown soil zone, may be considered as being marginal to fair arable land. The amount of arable land per quarter section will naturally be limited and the distribution of these arable portions in relation to one another is of considerable importance. The area on the west side of township 35, range 7, is very stony but is still practically all cultivated. The soil is good and has produced good crops. However, erosion will be more pronounced on such areas as these, and the crops grown will vary greatly in yield and date of maturity between valley and hilltop.

Series 2.2.2. *Level to Gently Rolling Phase.* There are about 200,000 acres of this soil type (2.2.2 loam) outlined. The soils of this phase are somewhat similar to the corresponding soils of the brown zone. However, many of the areas of this phase instead of being in basins are areas of higher land surrounded by soils of heavier than medium loam texture. They all contain stones that are frequent enough to hinder cultivation. All are of a fairly gritty texture. Undoubtedly some of the more level portions of this soil phase have had some post glacial surface sorting, but, in general, the profile is more glacial than resorted glacial.

The areas near Provost, centering in township 38, range 1; township 37, range 2; and townships 39 and 40, range 2, border on silt loam soils. They are generally of a silty texture but are on higher land and are stonier than the adjoining silt loams. Lime is found in these soils at from 16 to 24 inches. Some of the higher knolls in these areas have drifted. Most of these areas are still being cultivated and they are fairly good arable land.

The areas in township 38, ranges 6, 7, 8 and 9, are at the bases of hills and have had a little water sorting; gravelly patches are found in all the areas. In general, however, the mixed surface texture and the presence of glacial stones throughout the profile gives a dominantly glacial character to the areas. Most of the soil in these areas is still being cultivated and is fair to fairly good arable land. The area centering in township 39, range 10, is on slightly rougher topography than the areas just described. The rolls are low but generally fairly steep.

The area centering in section 34, township 40, range 6, has partly rolling topography, but is fairly good arable land. The area southwest of Ribstone creek in the same township is high land and slopes to the drainage way. It is marginal to fair arable land.

The area in township 40, range 8, has a darker and a deeper profile than any of the above 2.2.2 areas. In this soil the lime is found at 24 to 30 inches underlying a reddish brown B_1 horizon. Stones are numerous enough to be a factor in cultivation. This area was fairly well covered with tree growth in its native state and many clumps still remain, particularly in the lower spots. The soil is fairly good to good arable land, and each quarter section should have at least 100 to 125 acres of land possible of cultivation.

The area of gently rolling loam in township 35, range 7, is fairly stony. It is still practically all cultivated and is fair to fairly good arable land.

There are about 8,000 acres of 2.2.2/4 loam outlined. An area of this complex with gently rolling topography is outlined in township 40, range 2. It is somewhat like the other loam areas of that township, excepting that some patches, particularly on the hill slopes, have a hard granular B_1 horizon. The area on the south side of township 36, range 11, is higher than the surrounding areas and is fair arable soil.

There are about 12,000 acres of 2.2.2/6 loam outlined. In township 34, range 12, there are numerous small loam areas of this complex. These areas are actually the crowns of a series of ridges that run in a southeasterly direction across the township. Since deep draws parallel these relatively narrow ridges the soil on the crown may be locally more arid than surrounding soils on more uniform topography. The ridges are fairly stony, particularly towards the north side of the township. Portions of the area are cultivated. They are marginal arable lands.

The areas in township 37, range 10, and on the east side of township 38, range 12, are generally higher land than the surrounding areas and strong solonization is found principally in the lower spots. Most of this land is cultivated, and is of fair to fairly good arable value.

Series 2.3.2. There are about 85,000 acres of this soil type (2.3.2 loam) outlined. Most of the loams of the 2.3.2. series are good arable land and are located in the northwest corner of the sheet. In this area they are principally on undulating to gently rolling topography, and as the second digit indicates they are formed on glacial till that has undergone some post glacial surface sorting. The following profile taken in section 10, township 40, range 12, is fairly typical of the soils of this series:

A_1—0″-12″. Dark brown in color; the surface two or three inches are generally black. The columnar structure breaks along horizontal cleavage lines and gives, when broken up, the appearance of clods.

A_2—12″-18″. A reddish brown friable horizon having a slightly platy structure. There is a fairly distinct break between this horizon and the A_1, but a gradual change between this horizon and the one below.

B_1—18″-26″. A reddish light brown horizon of a fairly hard cloddy structure.

B_2—at 30″. A yellow brown loose horizon with a heavy lime carbonate accumulation.

The area of 2.3.2 from Silver Heights, west of Brownfield and north to township 40, range 12, has the above profile characteristics. There are stones throughout the area, but they are not a serious handicap to cultivation. The area has, at one time, supported considerable tree growth, principally aspen poplar. The presence of many draws and low marshy spots lined with willow growth, although having many desirable characteristics, makes for a patchy cultivation. Practically the entire area is farmed; there being about two-thirds of each quarter actually tilled. It is good arable land.

The area in township 40, range 1, is classed as a heavy loam because of considerable silt in its mechanical composition. There are a few poplar and willow clumps in the area. It is practically all cultivated and is good arable land.

The area of heavy loam outlined in township 39, range 11, also contains considerable silt. There are a few large stones and in places many gravel stones. The soil is good arable land, but the area is badly cut by deep draws. The soil of the area in township 40, range 14, is similar to the one described above. It is good arable land.

A small level area at Eastervale in townships 39 and 40, range 8, is on undulating topography and is practically stone free. The profile is quite deep and of a dark color. It is all cultivated and is good arable land.

The areas in township 40, range 3, and in township 38, range 2, are higher than the adjoining areas. They are of a gritty texture and contain considerable stones. The area in township 37, range 7, is also of a gritty texture and has a shallow profile. The two areas in township 37, range 8, are on gently rolling topography and fairly stony. All these areas are cultivated and are fairly good arable land. The area of light loam in township 39, range 9, contains considerable waste land, but the arable land is of fair value. There is one area, comprising about 2,400 acres, of 2.3.2/4 heavy loam outlined in township 36, range 8. The profile in this area is of a normal to strongly columnar structure. It is fair to fairly good arable land.

There are about 75,000 acres of the loam complex 2.3.2/6 mapped. As the fraction indicates, the bulk of the soils in these areas have normal profile development. However, within their boundaries are some soils with profile 4 and some with profile 6. A large strip of this loam complex with undulating topography stretches from near Talbot in township 37, range 9, to Brownfield in township 38, range 11. It marks the transition between profile 6 to the south and profile 2 to the north. There is some tree growth on the area and the soil is a medium dark brown. The lime carbonate horizon occurs at from 20 to 30 inches. The area is about one-half cultivated and its utilization value is between that of the two bounding areas, generally fairly good.

The gently rolling areas in township 36, range 8, and township 36, range 12, are both fairly stony and both contain considerable gravel. They are practically all cultivated, and are fair to fairly good arable land.

The area in township 37, range 14, contains a series of very low and somewhat stony ridges. Between the ridges are many marshy spots that are grown over with scrub willow. Although bed rock exposures are fairly frequent in the area it seems evident that some glacial till remains. Much of the area has a weak solonetz development, grading on the higher land, however, into normal soils, and in the low spots into round top development. In general, the B_1 horizon is not very hard or impervious. Practically the entire area is cultivated. It is fairly good arable land.

The areas in township 40, range 13; township 38, range 12; and township 39, range 11, are all fairly good arable land. The area centering in section 5, township 39, range 9, is good arable land.

Series 2.5.2. There are about 36,000 acres of this soil type (2.5.2 loam) mapped. In general, the loams of this series are river deposited and consequently are variable in deposition and contain gravel often in the form of lenses. Most of them are quite sandy and are classed as light loam.

The areas in township 40, range 10, and township 39, range 7, are small and are relatively low areas around water basins. They are marginal to fair arable lands. The area in township 35, range 12, is a stony gently rolling area and contains sand streaks. Most of this area has been cultivated, but some of it is now abandoned. It is marginal arable land.

There are three areas in township 40, range 4; two of light loam and one of heavy loam. The light loam areas contain considerable fine sand which gives the profile a massive structure. Some of the fields in these areas have drifted. The area of heavy loam is on slightly higher land and does not contain the percentage of sand found in the other two areas. They are fairly good arable soils.

The area in township 40, range 8, is quite variable: parts of the area are very gravelly and marshy; other spots are fairly uniform and arable. The area is in the river bed of Shorncliffe creek.

The area in township 38, range 6, is quite gravelly towards the northern end, but the southern end, in a partial basin, is relatively stone free and is fair to fairly good arable land.

The small area just west of Sounding lake in section 27, township 36, range 5, is at the base of the hills and at a drainage mouth. It is fairly good arable land.

The area in township 37, range 5, contains considerable gravel and is cut by a drainage way. Only portions of this area are arable.

There are about 45,000 acres of the complex 2.5.2/6 mapped. The loam area with undulating topography in township 38, range 7, lies at the base of Neutral hills and has been sorted by the flood waters from these hills. Portions in the northern end of this area have a profile 3 development, that is, they are locally more humid. The profile is deep and contains some gravel and sand. The area is all cultivated. It is fairly good to good arable land.

The area in township 38, range 8, is similar to the one described above. The southern portion of this area, which extends down into township 37, is of level to undulating topography and is fairly good arable land. It is very little higher than the creek flat. The northern portion of the area has a gently rolling topography and contains more stones.

The area in township 39, range 13, has a level to undulating topography, but is badly cut up by deep draws. There are gravel and sand lenses through the profile and the solonized patches are quite numerous. The southern portion of the area is mapped as a light loam. The land near the river is still uncultivated; the rest of the area is fair arable land. The areas in townships 38 and 39, range 12, contain less gravel than the area described above. They are fair to fairly good arable land. The area of light loam in the top of township 36, range 2, and in township 37, range 3, is partly in the creek flat. Portions of it have drifted, but excepting the stony portion at the eastern end it is fair arable land.

Series 2.5/0.2. An area, comprising about 1,000 acres of this soil type, is outlined in township 39, range 12. The area lies in a semi-basin. A good depth of soil, alluvial in nature, overlies parent shale. This shale is found from 12 inches to six feet from the surface. It is fairly good arable land.

Series 2.6.2. There are about 39,000 acres of this soil type (2.6.2 loam) mapped. The loam soils of this series differ from the 2.5.2 loams in having a more uniform deposition, that is, there are few sand and gravel streaks through the profile.

The area centering in township 38, ranges 2 and 3, is practically all cultivated although some of the fields are rather patchy. The surface, a light loam, contains considerable very fine sand and has, in places, drifted. It would appear that there is a combination of wind and water deposition of considerable depth over ground moraine. In general, this area might be considered fair arable soil under rotations that will control soil drifting.

The area in townships 38 and 39, range 4, forms a transition zone between the sandy loams in the west and the heavier soils to the east. Most of the area has a gently rolling to rolling topography, and the heavy subsoil is fairly close to the surface. The broken topography and the light texture are both detrimental factors affecting its utilization.

A small area in township 35, range 14, has a level topography near lake level and is stone free. It is practically all cultivated at present and is marginal to fair arable land.

An area, comprising about 1,500 acres, of 2.6.2/6 light loam is outlined in township 40, range 5. It is an area of slightly higher land in the general sand area. It is cultivated and is fair arable land.

Series 2.7.2. There are about 25,000 acres of this 2.7.2 loam mapped. The area around Cadogan is the only loam of this series outlined. It is a large stone free basin practically all cultivated. The dark colored surface soil contains much very fine sand and the subsoil is a silty clay loam. There is a very heavy lime carbonate horizon in this soil at 20 to 24 inches. The profile has a cloddy structure that is quite friable. Besides having desirable profile characteristics, the basin-like position of the area should make for a good utilization of the available precipitation.

Profile 3. Although very few loam areas of profile 3 were outlined on the map there are numerous small patches of this profile type in this zone, particularly in the hilly sections. There are also some larger areas that are midway between profile 2 and profile 3, depending on surface and subsurface drainage.

Series 2.3.3. One area of the complex 2.3.3/6, comprising about 3,000 acres, is outlined in township 38, range 9. This is a low basin-like area dotted with numerous sloughs and meadows. Some of the slopes have fairly strongly solonized soils, although there are patches of good soil in the area. In general, it is only marginal to fair arable land.

Series 2.5.3. The area of 2.5.3 loam, comprising about 1,800 acres, at the base of township 37, range 6, is a low basin on the south side of Neutral hills. It has a deep profile of a dark color. It is practically all cultivated and is good arable land.

Series 2.7.3. There are about 600 acres of this soil type mapped. A small area of heavy loam texture is outlined in the bed of Shorncliffe creek in township 40, range 8. It has a deep stone-free profile containing much silt and very fine sand. It has possibly been deposited in a protected bay of the creek bed. The area is all cultivated and is good arable land. A small area between township 37, range 6, and township 37, range 7, follows a drainage course. It is good arable land.

Profile 4. To this profile group belong the soils that have a weakly solonized profile.

Series 2.1.4. There are about 5,300 acres of the complex type 2.1.4/6 loam mapped. The area outlined in township 33, range 13, is somewhat higher land than the surrounding 2.1.6. These higher areas contain weakly solonized soils, that is, the B_1 has a columnar structure but is not as hard as in profile 6 and the characteristic rounded B_1 tops are absent. Because of this the soil is much more pervious than the surrounding profile 6 soils. Most of the area is cultivated and is fair arable land.

Series 2.3.4. There are about 25,000 acres of the complex 2.3.4/6 loam mapped. There is a fairly large area of this type centering at Alliance, in township 40, ranges 13 and 14, on level to undulating topography. In general, the profile shows a strong columnar development with fully developed solonetz profiles principally in the lower areas. The soil is quite dark and has had a fairly heavy tree growth. It is practically all cultivated and is fairly good arable land.

Profile 5.—*Series* 2.5.5. One area, comprising about 2,000 acres, of this 2.5.5 loam is outlined in township 37, range 14. It forms a rim around Lanes lake and in general is land that is likely to flood during periods of high water. During the dry years most of it was cultivated, but during wet years most of the area would not permit spring cultivation. It does not appear to be very saline.

Profile 6. A large percentage of the loams of this zone, particularly those on the west half of the sheet, have solonized profiles; that is, the profile is characterized by a hard subsoil exhibiting when fully developed a cauliflower-like top. Eroded patches, shown on the map by dots, are generally not quite as numerous as in the brown zone. In the dark brown zone many of the eroded spots support a little vegetation due possibly to the slightly more humid conditions. In general, these soils are found on level to undulating topography and on soil that may have been subjected to the sorting action of post glacial waters. Below is the description of a typical solonized loam profile taken in section 16, township 37, range 13. It is in the dark brown zone and has more A or surface soil than some areas farther east in the brown zone.

A_1—0″-6″. A dark brown loose friable horizon containing considerable grit. There is a slight tendency to a cloddy structure.

A_2—6″-9″. A loose gray brown very gritty horizon. There is a marked flaky structure particularly at the bottom of this horizon and the color becomes lighter towards the bottom.

B_1—9″-15″. A hard columnar horizon almost black in color. The rounded tops of the columns are quite sandy and light in color. When dry the columns break into numerous small cubes.

Upper B_2—15″-20″. This horizon has a hard columnar structure of B_1, but is lighter in color and contains some lime.

Lower B_2—20″-25″. A dark yellow brown cloddy columnar horizon containing much more grit than the B horizons above. The lime concentration is heavier than in the upper B_2.

Upper C—25″-36″. A yellow brown structureless to slightly cloddy horizon containing a heavy concentration of lime and salts.

C—at 42″. This horizon is shale-like in character, but contains some sand streaks. Rosettes of salt crystals, principally selenite, and red colored flakes are found in this horizon.

This profile is a good example of what is considered to be a sorted residual deposition. The C horizon appears to have characters closely associated with the parent bed rock; the upper horizons by the presence of gritty streaks and some gravel indicate water sorting; and the occurrence of scattered glacial erratics on the surface would indicate a till covering at one time.

Series 2.1.6. There are between 110,000 and 120,000 acres of this soil type (2.1.6 loam) mapped. The main area of this series continues west from the 1.1.6 at Coronation to township 38, range 14. The profile description given above is typical of this area. The eroded spots in this area carry more vegetation than they do farther east in the 1.1.6, and in general there is a fairly good grass growth in the native state, particularly in the slightly lower areas. Towards the western side the area is badly cut with deep drains. Cultivation is patchy and there has been some abandonment towards the eastern side. The eastern portion of the area might have some arable possibilities, particularly if the hard subsurface could be broken up. The western half is generally fair arable land. The area in township 35, range 13, is similar to the general area described above.

An area of 2.1.6 loam is outlined in townships 33 and 34, range 13. Here the Edmonton sandstone is fairly close to the surface and the very hard B_1 horizon has considerable sand in its composition. This area forms a height of land, draining to the east into Sounding creek and west into Sullivan lake. This fact plus the hard nature of the B_1 horizon may limit water storage in the soil. It is only marginal arable land. Adjacent to this area to the north and west is a large area of 2.1.6 light loam. The area is similar to the one just described. Due partly to the more sandy texture the A horizon is fairly deep and eroded slick spots are not very numerous. The parent sandstone is quite close to the surface in this area. There is considerable abandoned land in the area. It is no better than marginal arable land.

Series 2.2.6. There are about 15,000 acres of 2.2.6 loam mapped located principally in township 35, range 11; township 36, range 11; and township 37, range 11. These areas are higher than the surrounding lands and are more stony; the stones being distributed throughout the profile. The eroded spots are few in number on these areas and the A horizon is generally 6 to 12 inches deep. They are nearly all cultivated and are fair arable land. The area in township 39, range 1, is lower land and is quite stony. It is good pasture land.

There are about 7,000 acres of the complex 2.2.6/2 mapped in township 33, range 12, to township 34, range 13. The light loam at the north end of the area is very stony and is pasture land. The rest of the area is a high ridge, quite stony, flanked by drains on either side. It is generally marginal arable land.

Series 2.3.6. There are about 85,000 acres of 2.3.6 loams in this sheet and most of them lie on the outer rim to the north and south of the 2.1.6 series. In these areas the higher spots have a much weaker solonetz development than the lower areas, and if outlined would have a 4 rather than 6 profile development. The A horizon varies from about 8 to 12 inches in depth and slick spots are relatively few in number. There are gravelly stones and some glacial boulders present, although rarely are they numerous enough to materially hinder cultivation.

In the area from township 37, range 10, to township 38, range 11, there is considerable cultivation and little abandonment. In general, its utilization differs little from the area of 2.1.6 to the south; that is, it is fair arable land.

The area in townships 36 and 37, range 13, has a fairly deep A horizon and is well into the dark brown zone. It supports a good growth of native grass. Most of the area is cultivated and it is fair to fairly good arable land.

The area in township 40, range 13, is dark in color, but has a shallower A horizon than the soil areas surrounding it; about one-half of the quarter sections in the area are partially cultivated. It is fair to fairly good arable land. The area in township 37, range 1, is a fairly low area partly in the creek bed. It is fair arable land.

Series 2.5.6. There are about 12,000 acres of this 2.5.6 loam mapped, composed generally of small areas along drainage ways. The area of light loam in township 37, range 2, is part of the river flood plain. It is fair pasture and no better than marginal arable land. The area in township 36, range 5, is in a deep draw. It is all cultivated and is fairly good arable land; portions of the area might be irrigable. The area in township 35, range 12, contains considerable stones and gravel. These detrimental factors plus the presence of a solonetz profile makes it generally only of pasture value, although there may be some patches of marginal arable land within the areas.

Series 2.6.6. There are about 7,000 acres of 2.6.6 loam mapped. The area of 2.6.6 light loam in township 36, range 13, forms a transition area between the alluvial fine sandy loam of Sullivan lake and the 2.3.6 loam to the north. The B_1 horizon is quite hard and of a sandy nature. The area is only partially cultivated. It is marginal arable land.

The above descriptions of the dark brown loam soils of the Sullivan Lake sheet do not specifically mention each individual soil area. The general characteristics of all the series have been given and the principal areas of each series have been described. The descriptions of these areas should adequately fit the smaller areas of the same series in the locality.

Silt Loam.

Most of the silt loam soils of this zone, that is, soils with a predominance of silt particles in their mechanical composition, are located in the northeast corner of the sheet. Both wind and water have been responsible for their deposition.

Profile 2. The silt loams with normal profile development are all located in the Provost district. The profile has a cloddy prismatic structure B horizon underlain by a C horizon generally quite high in clay.

Series 2.3.2. There are about 30,000 acres of 2.3.2 silt loam mapped. The silt loam soils in township 40, range 1, are very dark brown in color and generally of a friable cloddy structure. The area is uniformly undulating and contains many small hay meadows. The western portion of the area, which extends down into township 39, range 1, is a light textured silt loam; the small area along the east side is a heavy silt loam due partly to the closeness to the surface of the B_1 horizon. The area in township 39, range 3, is similar to the ones described. All these areas contain some stones, mostly in the lower horizons. They are all cultivated and are good arable land.

There are about 31,000 acres of 2.3.2/6 silt loam mapped. A small area of this type is outlined in township 40, range 14. It is light textured with a fairly deep A horizon containing a few scattered stones. The many low marshy spots in the area have made for a patchy cultivation. The fairly large area on the east side of township 40, range 4, is on undulating topography and contains a few stones. The soil is of a light texture and the profile is fairly deep. The area is all cultivated. A large area of light textured silt loam on gently rolling topography is outlined in townships 37 and 38, range 1. The profile, containing some stones, is cloddy to strongly columnar in structure. The soil is quite dark in color and is all cultivated. All these areas are good arable land.

Series 2.7.2. About 20,000 acres of 2.7.2/4 heavy silt loam are mapped in township 39, range 2. The soil has a very dark brown surface color that gradually changes with depth to a yellow brown. The B_1 horizon, quite granular in places, is usually found at about 10 to 16 inches underlain by a fairly heavy lime carbonate horizon. There are a few scattered glacial stones. The area is all cultivated, and appears to be good to very good arable land.

About 21,000 acres of the complex 2.7.2/6 are mapped. A large area of this type forms the western half of the large silt loam area south of Provost. The area has an undulating topography, contains very few stones, and the soil is generally of uniform texture throughout. Over most of the area the profile has a cloddy structure with a heavy lime carbonate concentration at 18 to 24 inches. In some places a fairly hard columnar B_1 horizon comes quite close to the surface, but these spots carry a normal grass growth. In general, it is good arable land and is all cultivated at present.

Profile 3.—*Series* 2.7.3. One area of about 400 acres of this soil type (2.7.3 silt loam) is located in township 37, range 6. It is stone free and the profile is deep. It is good arable land. An area of about 400 acres in township 37, range 8, is a level flood plain. Patches of this are arable. Both of these areas might be irrigated.

Profile 5.—*Series* 2.1.5. Two areas, comprising about 3,500 acres, of 2.1.5 silt loam are outlined in township 37, range 12. They are low areas that are poorly drained. They are good pasture lands and might be arable for certain crops.

Profile 6. A profile description of solonized silt loam is somewhat like the one given on page 61 for dark brown loam. Most of the solonized silt loams of this sheet do not have as distinct a color break between the A and B horizons as was found in the loams, but the B horizon is just as hard, just as waxy, and often deeper than in the loams. Most of the soils of this group are in the northwest corner of the sheet where moisture conditions are more favorable.

Series 2.1.6. An area of 2.1.6 silt loam, comprising about 1,200 acres, is outlined in township 38, range 12, in a slightly basin-like position. The A horizon is generally deeper in this area than in the surrounding loams and there are less eroded slick spots. Most of the area is cultivated. It is fair arable land.

Series 2.3.6. The fairly large area of this type (2.3.6 silt loam), comprising about 25,000 acres, in townships 38 and 39, range 14, has an undulating to gently rolling topography and is cut by many deep eroded draws. The profile contains glacial stones and in many places gravel bars and lenses. The solonized B_1 horizon, varying from 6 to over 12 inches in depth, underlies a surface horizon containing a high percentage of silt and sand. There are numerous low marshy spots in the area that are flanked by tree growth and that produce a good stand of grass. There are more eroded spots in the southern portion of the area. Most of the upland portion of the area is cultivated. It is from fair to fairly good arable land.

Series 2.5/0.6. A level to undulating area, comprising about 6,000 acres, of alluvial deposition of varying depths over Edmonton sandstone is outlined in township 36, range 14. There are gravel lenses through this profile and unweathered shale is found in some places within the profile depth. The A horizon varies from 6 to 18 inches in depth and the underlying hard B_1 is practically continuous. The area is nearly all cultivated. It is fairly good arable land.

Series 2.7.6. About 15,000 acres of 2.7.6 silt loam are outlined. The area in townships 33 and 34, range 14, is on level to undulating topography and much of it is approximately at lake level. The very hard B_1 horizon is quite close to the surface, and in general appearance the profile suggests a slightly saline condition. The area contains some cultivated and some abandoned land. It is, in general, marginal arable land.

At the base of Nose Hill, centering in township 36, range 8, is a level stone free area of solonized silt loam. This area receives some run-off water from the hills. It is fairly good arable land. The small patches of silt loam in township 40, ranges 12 and 13, are generally areas slightly lower than the surrounding soils, and contain marshy land. They may be of value to grow fodder crops.

Two areas of this series are outlined in township 40, range 14. The area centering in section 35 is level, stone free, and a few feet lower than the surrounding soils. The entire area is strongly solonized and the B_1 horizon is, in general, found at 4 to 8 inches. The entire area is cultivated. It should be fairly good arable land excepting during very dry years. The area in this township south of Battle river is very similar to the one above, excepting that the A horizon is generally deeper, and contains more sand in its composition. It is fairly good arable land. The small area in section 33, township 33, range 13, is level and has a deep profile. It is fairly good arable land.

In general, the silt loams of this zone are good arable soils; this is particularly true of those in the northeast corner of the sheet. They are heavy enough to retain precipitation water and still not too difficult to cultivate.

Clay Loam.

A very small percentage of the soils of the dark brown zone are mapped as clap loam; they are all low areas and generally saline.

Profile 3.—*Complex* 2.7.3/6. One area of about 400 acres of 2.7.3/6 loam is outlined in township 40, range 10. This is in a level basin surrounded by hills. The hard B_1 horizon, where found, is generally fairly deep. It is cultivated, and is fairly good arable land.

Profile 5. Most of the clay loams fall into this group. They have poor to fair drainage and often show a distinctly washed appearance.

Series 2.4.5. In township 34, range 12, there are about 3,200 acres of this type (2.4.5 clay loam) outlined. The areas, mostly in draws, are very stony and badly washed. They are of little value even as pasture.

Series 2.5.5. About 1,500 acres of 2.5.5 clay loam are outlined. The areas along Ribstone creek in township 40, range 6, contain some gravel and sand. The profile is a mixture of 4, 5 and 6. It is fairly good pasture. A portion of the area on the east of section 26 is arable.

Series 2.7.5. There are about 36,000 acres of 2.7.5 clay loam mapped. Although most of these areas are along drainage ways and therefore partly alluvial in origin, the profile is heavy textured and practically stone free. They are possibly more of a flood plain origin. Ribstone creek flat from township 37, range 9, to township 39, range 7, contains solonized patches although in general the soils have a washed saline appearance. It supports only fair grass growth.

In township 33, range 12, there are two large draw-like flats that are midway between 5 and 6 in profile development. Portions of these areas are cultivated, and where not too alkaline may produce fair crops.

The area in township 36, range 14, is level and slightly lower than the surrounding land. There are numerous slick spots that have little vegetative growth, but where some of the surface or A horizon remains grass growth is fair. The area in township 35, range 11, is similar to this one.

The area in township 37, range 11, is along a stream course. It is quite heavy textured and supports a good growth of grass. There are few slick spots, and there is a lack of the washed and eroded appearance common to the areas of this type.

Clay.

The only clay areas mapped are marsh-like flats. Many of these would be under water during wet years.

Profile 5.—*Series* 2.7.5. There are about 3,400 acres of this soil type (2.7.5. clay) outlined. The area in township 38, range 11, is a heavy lacustrine flat. Wild barley is the principal growth at present. Numerous small areas are outlined in the northeast corner of the sheet; most of these support some grass growth, although some are practically bare. In general, the areas are non-arable.

Mixed Textures.

As was stated in the corresponding section in the brown zone, all of the soils of this texture are of outwash origin and are very gravelly.

Profile 0. The light textured mixed soils composed principally of sandy loams are given the profile 0 designation.

Series 2.4.0. There are about 5,000 acres of this type outlined on the map. The areas in township 37, range 1, and township 36, range 5, are low areas along drainage ways. They are fair pasture lands. The areas in townships 38 and 39, range 6, are on rolling to hilly topography, and are possibly partly glacial in origin. They are quite gravelly, and the main soil constituent is coarse sand. Both are fairly good pasture.

Profile 2. To this group belong the mixed areas that average a fine sandy loam to light loam in texture.

Series 2.4.2. There are about 11,000 acres of this soil type mapped. The areas in township 40, range 1; township 40, range 7; and township 36, range 11, are relatively low areas and are principally of alluvial outwash formation. They are fair pasture lands. The small area south of Fleet is at a stream headwater. There is a deep gravel deposition here that has been used commercially. The areas in township 40, range 14, are gravelly and sandy knolls, some of them being cultivated along with the better soil around. A part of the area in section 12 of this township has a deep gravel deposition that has been used commercially.

In township 35, range 11, there are about 6,000 acres of 2.4.2/6 mixed type mapped. The soil is quite gravelly, mostly in the form of a series of a gravel bars, interspersed with lower spots that contain soils with solonized profiles. The area is fairly good pasture land.

By way of summary, about 50 per cent. of the soils of the dark brown zone are arable. Wheat will form the principal crop, but due to a slightly higher rainfall than on the brown soil zone some diversification of crops should be possible.

Marshes, Alkali, and Lakes

The separation of marshes, alkali flats and lakes in this sheet was a very difficult task during the summer of 1937. Whether a "lake" contains water or is a dry alkali flat depends, in many cases, on the season. Following two or three wet years a great number of these dry lake beds would fill with water and their alkali appearance would be much less apparent. An attempt has been made to separate the marshy areas into alkali flats, which are definitely alkaline and support little or no vegetation, and true marshes, which grow some native hay.

The number of hay meadows in the sheet is rather limited. The flood plains of Ribstone creek south of Czar, the marsh at Pemukan, Hamilton lake bed, and the marsh in township 38, range 11, are sizable areas that produce meadow hay. Small flats occur throughout the sheet, but a surprisingly large percentage of them are alkaline wastes. Only a very limited number of the flats in the Neutral Hills area and in the large sandy areas produce meadow hay. About 150,000 acres of marshes, alkali flats and lakes are found on the Sullivan Lake sheet.

Eroded Lands and River Bottom Soils

Approximately 110,000 acres on the Sullivan Lake sheet are classed as eroded lands. In most cases these areas constitute the steep coulee and creek banks. In a few places, principally near Sullivan lake and along the upper reaches of Ribstone creek near Coronation, the erosion is mainly denuded banks of parent rock exposures. The eroded areas along Monitor and Loyalist creeks are the steep banks of the river and their tributary draws. They are all grass covered and, excepting for the very steep portions where there is some hillside slip, they are of good pasture value. The greatest amount of erosion is outlined along Battle river and its tributaries. Battle river, in general, has a moderately wide valley quite densely covered with tree growth. Because of this tree growth the area has a rather low pasture carrying capacity. The removal of the trees might, however, lead to accelerated erosion. Most of the creek beds north of Castor have steep denuded sides of bed rock, but the creek beds are fairly level and support a good grass growth (see Plate 3, Fig. 2). In general, these eroded areas are non-arable; however, in the creek and river beds and at the mouths of tributary coulees are small level patches of good soil. Where a fairly large level area is found it is outlined on the map as river bottom soil and carries the symbol R.B. These soils are of alluvial origin and generally have a mixed surface texture. River bottom soils are often more humid than the upland soils, and during wet years produce a fairly rank growth that is late in maturing. Early fall frosts are often a hazard in these low areas. However, most of them are good arable soil and some have irrigation possibilities. Their utilization might be in directions other than wheat growing.

COMPOSITION OF SOILS OF SULLIVAN LAKE SHEET

The nitrogen, phosphorus, calcium, and magnesium content were determined on the soil samples taken in the Sullivan Lake area. In Table VII are reported only a few representative profiles. The profiles were selected to give a fairly complete coverage of the main soil areas of the sheet, as well as coverage for the two soil zones. The boundary between the brown and dark brown soil zones passes through the Sullivan Lake sheet and here, in general, there is very little difference due to zones. This is to be expected since the change from one zone to the next is naturally gradual. The average nitrogen content (calculated in the surface foot) of eighteen dark brown soils was .18 per cent. and for nine brown soils was .16 per cent. The average nitrogen content of the soils of the Rainy Hills sheet, which is well within the brown zone, was about .14 per cent.

For the entire Sullivan Lake sheet seven silt loams averaged .19 per cent. nitrogen in the first foot; sixteen loams averaged .16 per cent., and three fine sandy loams averaged .16 per cent. The one sand sample that was analyzed contained .08 per cent. nitrogen in the surface foot. A silt loam near Provost, not reported in Table VII, which had over .4 per cent. nitrogen in the A_1 horizon was highest in nitrogen.

For the samples reported in Table VII it will be seen that the range in nitrogen content for the surface foot varied from .088 to .248 per cent. with the three samples from the brown soil zone averaging .14 per cent. and the seven samples from the dark brown zone averaging .17 per cent. The eleven typical samples (all from the brown zone) reported in the Rainy Hills sheet averaged only .12 per cent. for the surface foot.

In some of the solonized profiles analyzed the B_1 was higher in nitrogen than the leached A_2 horizon. This condition has not been found in the soils of normal profile.

The phosphorus analyses given in Table VII are reported on a horizon basis and also on a surface foot basis. The differences between horizons are not great. There is usually an accumulation in the A_1 horizon which corresponds to the organic matter accumulation. For the medium textured soils the phosphorus content averaged about .06 per cent. in the surface foot. A similar average for the soils of the Rainy Hills sheet is slightly less than .05 per cent.

TABLE VII.—Chemical composition of representative soil profiles.

			Per Cent.						
Sample No.	Depth in inches	Horizon	N	N first 12″	P	P first 12″	Ca	Mg	pH
		1.6.0—Sandy loam in level areas—27-33-10-4							
671	0″-12″	......	.147	.147	.036	.036	.37	.13	7.6
672	12″-24″	......	.061	......	.035	......	.42	.13	7.6
673	24″-36″	......	.042	......	.033	......	.40	.14	7.9
674	at 40″	......	.049	......	.036	......	.83	.21	8.0
		2.1.6—Solonized fine sandy loam—14-35-13-4							
650	0″-12″	A1	.105	.105	.041	.041	.68	.15	7.2
651	12″-15″	A2	.063	......	.043	......	.47	.15	7.8
652	15″-18″	B1	.087	......	.053	......	.74	.50	8.1
653	18″-24″	B2	.095	......	.072	......	5.73	.81	8.6
654	24″-30″	......	.037	......	.041	......	1.51	.55	8.1
		1.2.1—Brown loam in rolling area—14-34-1-4							
565	0″- 2″	A1	.157	.088	.065	.050	.44	.31	....
566	2″- 6″	A2	.110	......	.047	......	.44	.41	....
567	7″-11″	B1	.058	......	.056	......	.57	.53	....
568	11″-15″	B2	.051	......	.059	......	5.41	1.08	....
569	20″-	B2	......	......	.051	......	3.83	1.26	....
		2.2.1—Dark brown loam in rolling area—29-39-9							
714	0″- 4″	A1	.167	.131	.042	.040	.75	.58	7.3
715	4″-10″	B1	.123	......	.039	......	.92	.60	8.2
716	12″-14″	B2	.069	......	.044	......	3.65	1.22	8.3
717	24″-28″	C	.069	......	.050	......	3.90	1.31	8.4
		1.5.3—Loam in undulating area—27-35-6-4							
624	0″- 5″	A1	.254	.183	.064	.055	.65	.36	6.1
625	5″-10″	A2	.137	......	.050	......	.64	.44	6.6
626	10″-18″	B1	.125	......	.050	......	.67	.61	7.1
627	18″-24″	B2	.084	......	.052	......	1.97	.68	7.6
		2.3.4—Weakly solonized loam—19-38-10-4							
724	0″- 4″	A1	.378	.202	.074	.054	.51	.36	6.4
725	4″-10″	A2	.115	......	.045	......	.45	.36	5.9
726	10″-16″	B1	.113	......	.041	......	.53	.57	6.5
727	17″-20″	B1	.088	......	.036	......	.45	.46	7.3
728	20″-30″	B2	.058	......	.045	......	1.71	.60	8.1
729	at 36″	C	.046	......	.045	......	1.76	.72	8.2
		2.1.6—Solonized loam on Edmonton formation—16-37-13-4							
635	0″- 6″	A1	.382	.248	.071	.061	.45	.23	5.4
636	6″- 9″	A2	.121	......	.059	......	.38	.23	6.7
637	8″- 9″	A2	.113	......	.055	......	.25	.21	5.9
638	9″-10″	B1	.098	......	.039	......	.29	.31	7.2
639	9″-15″	B1	.106	......	.043	......	.48	.56	7.6
640	15″-20″	B2	.063	......	.039	......	.57	.31	7.6
641	20″-25″	B2	.050	......	.055	......	1.16	.54	8.3
642-3	25″-42″	C	.047	......	.050	......	2.52	.65	8.2
		2.3.2—Undulating heavy loam—10-40-12-4							
705	0″-12″	A1	.197	.197	.069	.069	.56	.31	6.8
706	12″-18″	A2	.101	......	.047	......	.49	.47	6.7
707	18″-26″	B1	.098	......	.053	......	.56	.53	6.6
707	at 30″	B2	.055	......	.055	......	3.31	.84	8.3
		2.3.6—Solonized light silt loam—33-38-14-4							
690	0″- 4″	A1	.366	.192	.112	.069	.34	.29	5.2
691	4″- 6″	A2	.119	......	.055	......	.33	.28	6.3
692	6″- 9″	B1	.127	......	.046	......	.28	.55	7.1
693	at 16″	B2	.075	......	.045	......	1.10	.68	7.4
694	at 30″	C	.026	......	.053	......	.44	.70	7.8
		2.7.2—Light silt loam in gently rolling area—9-38-2-4							
555	0″- 6″	A	.216	.134	.063	.054	.65	.39	....
556	6″-12″	B1	.053	......	.045	......	.60	.52	....
557	12″-	B2	.007	......	.055	......	8.80	1.10	....

Available phosphorus (at pH 3) was determined on some of the samples. The results are very variable, and there were too few determinations to draw any definite comparisons. In general, the total available phosphorus is low in the surface horizon; ranging from a trace to about 30 parts per million.

The calcium and magnesium, as a rule, are lowest in the surface horizon and highest in the subsoil. This is accounted for by the fact that being slightly soluble they are carried downwards by the penetrating rain water. Many of the surface soils contain twice as much calcium as magnesium, and many of the subsurface and subsoil samples contain three times as much calcium as magnesium. The magnesium of the soil is less soluble than the calcium, and the plants demand less magnesium than calcium; thus the ratio is narrower in the surface than in the subsoil. In all cases there is a big increase in calcium in the B_2 horizon. This concentration generally carries down into the upper portion of what was sampled as C horizon. Since many of the samples of B_2 and C contain upwards of 5 per cent. calcium and upwards of 1 per cent. of magnesium and rarely do the amounts fall below 1 per cent. and ½ of one per cent. respectively, it should be noted that none of the soils of this sheet are deficient in either calcium or magnesium. There were no marl deposits found on this sheet during the course of the survey.

There were no potassium determinations made, but analyses of other brown soil samples from southeastern Alberta indicate that they range from 1 to 1.75 per cent.

Iron was not determined, but in many of the soils, particularly those mapped as resorted residual, red flecks were quite pronounced in the lower horizons.

The figures of Table VII might appear more significant and the comparisons stand out in better relief if we were to show the relation between the supply of essential elements present in the soils and the quantity required by crops. From the per cent. of any essential element found in the soil and in a crop it is possible to calculate how many crops such a soil could theoretically produce. For example, a 20-bushel crop of wheat, including straw, would require 38 pounds of nitrogen, 6 pounds of phosphorus, 4.2 pounds of calcium, 3.2 pounds of magnesium, and 24 pounds of potassium. The average soil to a depth of 12 inches would weigh approximately 4 million pounds to the acre. Thus it may be calculated that the theoretical number of 20 bushel crops of wheat that the total nitrogen and phosphorus in the surface foot of some of the profiles would produce range in the case of nitrogen from approximately 100 to 200 crops, whereas in the case of phosphorus the range would be from less than 300 to more than 400 crops.

The other essential elements for plant growth, which include calcium, magnesium, iron, potassium, and sulphur, are generally present in large quantities as compared with the amounts required by crops.

From these figures and statements it might seem as though the supply of essential elements, other than nitrogen and phosphorus, is practically inexhaustible. However, the fact of the matter is that crop growth may be retarded by the lack of a certain element, even though there is enough of that element present to produce hundreds of crops. The explanation for this is that the essential element dissolves slowly or becomes available slowly, and only in its available form can it be used by the plant. The rate of solution can often be hastened by better methods of tillage and soil management and by rotation of crops. The decomposition of organic matter is more intense in fallow soil than in cropped soil. However, the percentage of organic matter in these soils is relatively low and therefore the amount of essential elements coming into solution by such a process would be limited.

Although the importance of soil moisture as a limiting factor in crop production in southeastern Alberta should be epmhasized, the importance of soil fertility should not be disregarded. Among other things the efficiency of a unit of soil moisture will vary directly with the concentration of the soil solution. This, in turn, depends on the amount of readily available essential elements. So that, although there is an abundance of total plant food in the soil, the plant may be starved because there is not enough food readily available for its use. Much of the available food is in the surface soil and the removal of this surface through soil erosion seriously reduces the productive capacity of the soil.

The reactions of the profiles are given in the last column in Table VII. From these figures it is seen that none of the soils is acid enough to be considered sour nor are the surface horizons in any measure alkaline. The B_2 and C horizons are quite alkaline, but this is principally due to the presence of lime.

FARM PRACTICE

The purpose of the soil survey is principally to locate and map areas of soil according to their agricultural desirability. Each area on the soil map carries a three digit number as well as the soil texture designation (see page 21). Each of these numbers indicates a specific characteristic of the soil profile, and each of these affects the soil's adaptability or possible utilization. Included in this report is a possible land utilization map of the Sullivan Lake sheet. There are five grades of land mapped in this sheet, grading from poor pasture, non-arable to good arable land. These grades are calculated from the physical data obtained in the field on the scale used in this survey, namely a mile basis; a fuller description of this map is given on page 79 under the heading of Land Class Map. Lands vary in their productive capacity and adaptability, and it is generally recognized that many of the failures on Alberta farms are attributable to an incorrect utilization of those land areas. After a soil survey has been made and its data evaluated one of the great problems of crop production in southeastern Alberta is to find how to best utilize the available soil moisture. Although part of this sheet is in the dark brown soil zone, that portion may also be reckoned as being within the area where moisture conservation is of vital importance. For the thirty-one year period, 1906 to 1936, the average annual rainfall for this sheet was 12 to 15 inches, with an extreme variation from 9 to 26 inches. Since, up to a certain limit, increased available moisture means a greater rainfall efficiency in the crop produced, every effort should be made to efficiently utilize as much of that moisture as possible. This means conservation of moisture by fallow, prevention of run-off as much as possible, and the prevention of loss of moisture by transpiration through weeds.

By carefully controlled experiments it has been found that growing plants utilize a surprisingly large amount of water. The amount utilized varies with the kind of crop and the growing conditions. The average of many determinations and many crops is over 400 pounds of water for each pound of dry matter. The water must pass from the soil into the plant roots and out through the leaves. This quantity of water thus transpired for each pound of dry matter produced is known as the transpiration ratio. Using this figure and a given weight for a given crop, we can calculate roughly how much water would be transpired by that crop. Thus, for example, a thirty-bushel crop of wheat, including grain and straw, would contain at least 5,000 pounds of dry matter, and require 1,000 tons, or about 9 acre-inches of water. The loss of water by evaporation and run-off would bring the above figures somewhat higher.

Under actual farming conditions in south and eastern Alberta during the last ten years the wheat crop has required not 400 pounds of water, but 1,000 to 1,500 pounds of water to produce one pound of dry matter. This means that between two and three thousand pounds of water were required to produce one pound of grain and one pound of straw. The farmers of the Sullivan Lake sheet have received about 1 bushel of wheat for each inch of rainfall.

The difficulty of keeping weeds under control and the necessity of getting the greatest efficiency from the rainfall has resulted in a two-year wheat-fallow rotation practice for the semi-arid section of the province. Figures from the Swift Current Experimental station show that wheat on fallow required only about two-thirds as much water to produce a bushel of grain as did a crop of wheat following wheat. There are no two-year rotation results available for the brown soil portion of the Sullivan Lake sheet. However, the average wheat yield on fallow at three stations on the Rainy Hills sheet, which represents a slightly dryer condition than the brown soil of the Sullivan Lake, was 14 bushels per acre for the period, 1925 to 1935. The illustration station at Consort, which is on a good soil type located between the brown and dark brown soil zone, has six years results on a three-year rotation. On this rotation the wheat following fallow averaged 11 bushels per acre and second crop wheat averaged 8.7 bushels per acre. These results are for the last six years, which have been very dry. It may be interesting to note here that Mr. Fawcett, who operates the illustration station at Consort, has wheat yields dating back to 1910. He has used principally the three-year rotation and for the period 1910 to 1936 has averaged 20.7 bushels of wheat per seeded acre. Still farther north in the darker soil zone it seems reasonable to suggest that a three-year rotation that provides adequate means to conserve moisture would give a higher gross yield than the two-year rotation.

However, the one-crop farming system tends to reduce the soil's supply of organic matter, and of nitrogen also, since the soil nitrogen is very largely held in the form of organic matter. Organic matter is constantly decomposing in the soil. The stubble and roots of grain, together with any residue from weeds that may have grown on the land are sources of organic matter. When the land is fallowed the increased air and moisture favor a more rapid decomposition of the organic matter, and at the same time no new organic matter is added to replace that which is decomposed. Experiments conducted at the University of Alberta show that the accumulation of available plant foods, particularly nitrate nitrogen, is much greater at the end of the season on land under fallow than on land that has been cropped. It is, therefore, not difficult to understand why this system of farming tends to exhaust the soil's supply of readily decomposable organic matter.

Dr. Shutt showed that soil from Portage la Prairie lost 22 per cent. of its nitrogen in the twenty-five years it had been cropped and fallowed; or the nitrogen content fell from .651 to .506 per cent. This is equal to about 2,900 pounds per acre for the surface soil.

Normally a rotation that would maintain the percentage of organic matter in the soil and therefore its nitrogen content is to be recommended over the one crop grain rotation. Organic matter also increases a soil's water-holding capacity. The average soils may hold from 15 to 40 per cent. of water when saturated, whereas organic matter may hold from 50 to 200 per cent. at saturation. These rotations include grass and clover crops. At the Consort illustration station the hay on the plots in the six-year rotation yielded an average of one-third of a ton per acre during the last six years. However, just as the wheat yields were very much higher during the more favorable years than during the last six years, so it may be assumed that the hay yields would also be considerably higher. Although there are no sweet clover yield averages from this station it is believed that this crop has a place at least on some of the soil types. Strong growth of sweet clover was seen along the roadsides during the dry summer of 1937. Information regarding crops for this area can be obtained from the experimental stations at Lethbridge, Alberta, or Scott, Saskatchewan, or from the local district agriculturist.

The wheat-fallow rotation, if properly conducted, will give a relatively high rainfall utilization factor. The fallow cannot be expected to conserve much moisture, however, unless weed growth is controlled throughout the entire season.

The one crop rotation, however, has another objection and that is, it aggravates the problem of soil drifting. Practically all Alberta soils will drift after ten or fifteen years of the one crop grain farming system which destroys the soil fibre unless adequate provision is made for its replacement. This is particularly true in years of low rainfall and high winds. In general, the light sandy soils and the heavy clays are most subject to drifting. Many of the sandy soils of this area should never have been cultivated, and others untouched by cultivation at present should remain so. These have been discussed under the soil types. The sandy areas that are drifting badly at the present time should be covered to prevent them from encroaching on to better types of soil nearby. It should be noted here that level areas of light textured soils that have an underlying water table relatively close to the surface, may have arable possibilities. If these soils were cultivated every year they would certainly drift. Their utilization, therefore, lies in the direction of seeded pasture lots or hay fields. The soils of intermediate texture, such as loams and silt loams, are least likely to move with the winds.

Soil drifting not only damages the growing crop, but it reduces materially the soil's plant food resources. One inch of top soil removed by the wind would mean a loss in this area of about 170 pounds of phosphorus and 450 pounds of nitrogen per acre. This amount is equal to the phosphorus removed by thirty twenty bushel crops of wheat, and the nitrogen removed by fourteen twenty bushel crops of wheat.

The longer soils are cultivated the greater will become the tendency for them to drift, due to the loss of fibrous organic matter. This will be particularly true if it is not practical to include a green manure crop in the rotation. However, any permanent system of agriculture that is developed for this area should consider the possibility of periodically seeding portions of the farm to grass to restore the organic matter content, as well as of including a legume in the rotation. Under existing climatic conditions grass and legumes might have to be seeded at opportune times when the soil moisture conditions were adequate. Past records indicate that the good series of years come frequently enough to allow for the inclusion of such crops in the rotation as often as required. These crops not only keep the soil supplied with organic matter, but also supply winter feed for the farmer's stock.

A discussion of the methods of controlling soil drifting has occurred elsewhere in printed form, but it is not out of place to mention a few methods that are particularly applicable to this area. Control weeds on summerfallow by using such implements as the rod weeder and the duckfoot cultivator, which do not pulverize the surface soil and which leave the trash on top. The cultivator is used for the first operation and the rod weeder for subsequent cultivations. If the stubble is particularly heavy a one-way disc may be used instead of the duckfoot cultivator. The trash covering, as well as aiding in drift control, helps to hold the spring run-off water. Experiments at Lethbridge Experimental Station from 1929 to 1934 with the plowless fallow give the following results: The average wheat yield on plowed fallow was 17.4 bushels per acre, while the average yield on the plowless fallow was 19.4 bushels per acre. This would indicate that fallowing so as to keep the trash on the top does not reduce yield. Alternate strips of crop and fallow at right angles to the prevailing winds might be advantageous in the areas most liable to drift. When the strip method of farming is used proper cognizance must be given to insect control. Soil drifting is accumulative. Often litter spread over a few of the more vulnerable spots may prevent the field from starting to drift. Spring drifting before the crop adequately covers the ground surface is most damaging. It is therefore advantageous to get the surface covered as quickly as possible. This is at least partly aided by having sufficient soil moisture to start the crop growing and to carry it along until the June rains (records show that the average June rain at Alix is almost three inches, or one-fifth of the annual fall). Conservation of spring run-off should substantially add to the soil moisture reserve. When it is considered that May is a vital period in crop establishment, and since the soil moisture during this period normally hovers very close to the marginal line, the conservation of run-off water is very important. The development of daming listers may offer some solution to this problem. This implement used along the contour would in some years conserve considerable water. In any discussion on soil drifting the value of wind breaks must not be underestimated. It is calculated that one foot of tree growth has a protective action for about fifty feet on the leeward side.

About 20 per cent. of the soils of the Sullivan Lake sheet have a strongly solonized profile. These soils are characterized by a very hard impervious subsoil and in the loam textured soils, particularly, a patchy surface topography or microrelief due to the removal of the surface horizon. A limited amount of experimental work has been done on these soils to determine the best means for their utilization. Due to their impervious nature, water and root penetration is limited so that during dry periods these solonized spots quickly dry out and the crops as a result are very patchy. Certain general suggestions might be made regarding the management of these soils. Observations made to date indicate that in the brown soil zone where the hard pan subsoil is close to the surface these soils are only marginal arable soils. However, if the better phases of these solonized soils are cultivated they should be broken when moist. This is the only condition under which it is possible to get the plow into this tight layer of soil. If this hard layer is broken up, mixed with the surface soil and, if possible, with some organic substances, water and root penetration should be facilitated and the normal feeding range of the plant roots substantially increased.

This discussion under farming practice for the Sullivan Lake area has, up to the present, been confined principally to the growing of crops. What is the place of live stock in the general scheme?

In the descriptions of the various soil types, and in the utilization map, certain areas are designated as useful only as grazing lands. Some of the larger areas would provide leases for the rancher farmer. However, such areas are limited in number. Some of these pasture areas are overgrazed at present, but with a planned grazing program the carrying capacity of these areas could be materially raised. Increased grass covering helps to check run-off and weed growth and to lessen evaporation from the soil, both of which would increase the amount of grass produced per unit of rainfall. The smaller areas of grazing lands should prove valuable pasturage for the farmer rancher's stock. It would provide him with a supplementary revenue from lands otherwise non-productive. The keeping of some cattle or sheep necessitates providing for winter feed, and the value of holding a reserve of feed from year to year cannot be over-emphasized. There is no profit to be made by building up a herd during the good years and then having to sacrifice that herd because of the lack of feed and water during the dry years. It seems reasonable to assume that the size of the herd or flock should never exceed the long term carrying capacity of the area. This may mean the storage of feed during a good series of years as well as a built up range pasture and stock water dams. Such a policy should lead to a stability of agriculture and settlement that is highly desirable. Viewed on a long term basis, it is much more profitable to hold the surplus of the good years than it is to buy extra feed during the lean years.

The value of small irrigation schemes in this area should also be emphasized. Three small pumping projects on this sheet were seen in operation. There are many small level areas of good soil that have irrigation possibilities. These could be irrigated from dams across the drainage ways and coulees. The larger of these projects would be of great value in supplying feed for stock; the smaller ones would irrigate a garden patch. A few square rods of irrigated land planted to vegetables and small fruits would not only have a monetary value, but would provide a feeling of security in the dryer years.

The size of the farm unit that would provide adequate returns under a system of agriculture as outlined above would vary with the soil type and with the zone, but would be larger than in the more humid sections of the province.

LAND CLASS MAP

Accompanying this report is a suggested land class map of the Sullivan Lake sheet on the scale of six miles to the inch. This map divides the area into five land classes: two pasture, two arable, and a marginal class between the pasture and arable classes. No attempt has been made to state the type of crop that should be produced on the arable land. The map is applicable only under dry land conditions.

The data on this map is based entirely on the physical characteristics of the area; that is, the economic and human factors were given no consideration. In making the map such physical data as soil texture, soil color, mode of deposition, the type of soil profile, degree of stoniness, topography, relief, alkali, and rainfall and rainfall variability were all taken into consideration. Each of these factors was given a number value for each soil area, and the multiplying together of these values gave the final index rating of the soil area. With the aid of pasture carrying capacity data and with wheat yield data obtained from government statistics and the Alberta Economic Survey, P.F.R.A., a suggested productivity grouping of these rated areas was obtained. These groups each carry a number and a legend on the map: Group 1 is poor to fair pasture, group 2 is fair to good pasture, group 3 is pasture or marginal arable land, group 4 is fair to fairly good arable land, and group 5 is fairly good to good arable land. It is realized that this grouping is based on past performance under existing farm practices.

The introduction of more drought resistant varieties of farm crops, the introduction of improved farming methods as well as a change in economic requirements, might, for example, make some of the areas now designated as marginal land definitely arable land. It must also be noted that the number of quarter sections of land necessary to constitute a self-sustaining unit varies from class to class.

It is practically impossible to set any definite productivity limits for these groups. The following tentative limits, however, are suggested to give an approximate idea of the productive capacity of the various groups. Group 1 areas would take over 40 acres to pasture one head of cattle and group 2 areas would take less than 40 acres per head. Group 4 soils over a long term of years have produced from 10 to 15 bushels of wheat per seeded acre, and group 5 soils have produced from 15 to 20 bushels of wheat per seeded acre. Group 3 soils, marginal land, in general have produced less than 10 bushels. Some farmers in the Sullivan Lake sheet have exceeded these limits.

ALKALI

Soils are formed by the weathering of rock materials and alkali salts come originally from this decomposed rock. Since some of the parent material, particularly shales, were formed in salt water they contain various salts, and these salts when set free by the decomposition of the rocks tend to accumulate wherever the rainfall is not sufficient to dissolve and carry them off in the drainage water.

Alkali lands usually occur in areas where the annual rainfall is less than twenty inches. Alkali generally appears in the valleys and depressions that receive the drainage from the surrounding soils and from which there is no drainage outlet. However, alkali may occur in level land that is not too well drained even though the land is slightly elevated.

The alkali salts are commonly classed as brown, black or white. Brown alkali consists chiefly of the nitrates. Black alkali consists chiefly of the carbonate and bi-carbonate of sodium, and owes its name mainly to the fact that when this alkali salt is present it dissolves organic matter and produces a dark brown to black color. White alkali consists chiefly of the neutral salts, such as sodium sulphate, sodium chloride, magnesium sulphate, magnesium chloride, and the similar salts of calcium, and even at times potassium. The main salts of both the brown and white alkali are neutral in reaction and not alkaline, as is the case with black alkali.

Black alkali is the most toxic, and when present in quantities exceeding .1 of one per cent. is usually detrimental to plant growth. The white alkali is least toxic, and seldom causes injury unless present in quantities exceeding .5 of one per cent. Black alkali deflocculates fine textured soil, and causes them to become tough and impervious. White alkali has a less injurious effect upon the physical condition of soils, and sometimes tends rather to produce a granular character which accompanies good tilth. The injurious effect of black alkali is largely caused by its corroding effect upon the plant roots; however, in the case of white alkali it is believed that the high concentration of salt outside the plant roots prevents water absorption. If the concentration of the salt outside the plant roots is sufficiently great the osmotic pressure would cause the water to be drawn from the plant roots into the soil, thus causing the death of the plant.

Many samples of soil, as well as some alkali incrustations, representative of various soil types on the Sullivan Lake sheet were analyzed; only representative profiles, however, are reported in Table VIII. The normal soils of this area are, in general, relatively free of alkali salts. The first four profiles reported in Table VIII, one sandy loam, two loams, and one silt loam, all show negligible quantities of water soluble alkali salts. In none of these cases do the total non-volatile solids go over .05 per cent.

Most productive arid or semi-arid soils contain from .25 to .50 of one per cent. of water soluble salts. Soils containing more than .50 of one per cent. of total water soluble salts exclusive of calcium sulphate are justly viewed with suspicion, but soils containing large quantities of gypsum (calcium sulphate) as do many of the soils of southern Alberta will produce crops when they contain quantities of soluble salts which would be decidedly injurious were there no calcium sulphate present since this salt, partly by its flocculating action, ameliorates the toxic effect of the other alkali salts. As stated previously, however, black alkali may be toxic in concentrations greater than .1 per cent. The sodium reported in this table was obtained by difference. That is, the sodium is calculated to make up the difference in positive ions necessary to link with all the anions determined. The sum of the ions, then, approximates the determined figure of total non-volatile solids.

There are four profiles of solonized soils reported in Table VIII. In all of these the A (surface) horizon is relatively alkali free, but in the B and C horizons there is a definite alkali concentration. The concentration is principally of sulphate salts with a little bicarbonate. The positive ions are principally sodium and calcium with sodium often the predominant cation. Profile 682 to 689 is formed on Edmonton sandstone and the consolidated rock is within the profile in this particular sample. The salts present in this profile are principally sodium sulphate and calcium sulphate (gypsum). Profile 585 to 588 is from the washed flat of Monitor creek bed, and represents an area of approximately 12,000 acres. There is over 2 per cent. of water soluble salts in this profile and they are principally sodium salts. This soil can be considered definitely alkaline. Most of this area is in the level river flat and from a topography standpoint might be considered irrigable. It is felt, however, that if irrigated it would soon become an alkaline waste unless satisfactory provision could be made for its drainage. The badly solonized areas as represented by the profiles of 116 loam and 216 loam contain considerable alkali salt. However, since they contain a considerable amount of calcium sulphate, under dry land farming they may be considered as being below the toxic limit of alkali.

The profile 680 to 681 is taken near the edge of the dry flat of Hamilton lake. This flat grows considerable native vegetation. Determinations gave only .13 per cent. water soluble salt in the surface 16 inches. The last five samples reported in Table VIII represent dry slough and lake crusts and surfaces. Sample 676 is a slough crust in a gently rolling loam area. This is in the low moraine south of Sullivan lake, but Edmonton sandstone is exposed throughout the area. This sample showed a very high concentration of sodium carbonates, black alkali. The slough surface was practically devoid of vegetation. Sample 718 is a slough crust from the west side of the Neutral

Hills moraine. This moraine is underlain by Belly River sandstone, but the till is quite deep and there were no exposures seen in the vicinity. The principal salt in this sample is sodium sulphate. Sullivan Lake bed is composed of a loose granular very heavy clay. Sample 661 contains sodium carbonates in toxic quantities. It should be noted here that only the collection basins in the vicinity of Sullivan lake showed a toxic concentration of black alkali.

In general, under dry land farming, the bad alkali problems in the Sullivan Lake sheet are confined to local areas. However, since there is a concentration of alkali salts in the lower horizons, particularly of the more level solonized areas, and since sodium salts form a big percentage of this alkali, any suggested irrigation project for this area should consider the alkali problem. The tendency of irrigation frequently is to produce a concentration near the surface. The water dissolves the salts, and when evaporation begins, the water moves upward carrying the salts and leaving them at the surface. This may ruin the land for ordinary crops. Seepage waters from canals and ditches sometimes pass through porous soil formations, which permit of large losses of water, and may cause a great amount of alkali trouble. The water may come to the surface at some spot or field below the ditch and bring up alkali gathered while passing through the soil, resulting in the spoiling of valuable land.

There is a considerable number of soil areas on this map that carry the unit digit 5. These are generally in low areas which are poorly drained and consequently have developed a saline profile. Because of the more humid soil conditions in these areas their utilization warrants careful study. With this in mind the following tentative suggestions are made. The draining away of surplus spring water from these areas should carry with it a considerable load of soluble salts. Deep plowing prior to seeding, which turns down the alkali which has accumulated near the surface will enable the seeds to germinate and the young plants to become established, and by proper tillage a mulch may be provided which will check evaporation and the rise of alkali until the crop is high enough to shade the ground. The choice of alkali resistant plants, e.g., sweet clover, is desirable.

VEGETATION

The Sullivan Lake sheet lies within two color zones and within its boundaries the park lands of central Alberta give place to the bald prairie characteristic of the southeastern por-

TABLE VIII.—Water soluble or alkali salts of Sullivan Lake sheet

Sample No.	Location	Horizon	Depth	Remarks	Non-volatile solids	HCO3 and CO3	Cl	SO4	Ca	Mg	Na	T.S.
671-3	27-33-10	A	0″-36″	1.6.0. S.L. Level area near lake level	.02							.15
674	"	B	30″-		.05							.09
624-5	27-35-6	A	0″-10″	1.5.3 L. Undulating area of good soil	.025							.15
626-7	"	B	10″-24″		.02							.16
628	"	C	24″-32″		....							.14
705-6	10-40-12	A	0″-18″	2.3.2 H.L. Good soil area, some tree growth	....							.15
707	"	B	18″-30″		.04							.10
555	9-38-2	A	0″- 6″	2.7.2 S.L. Undulating area of good soil	....							.06
556	"	B	6″-		....							.04
682	13-36-11	A1	0″- 7″	1.1.6 L. Strongly solonized area, consoli-	.05							.07
683	"	A2	7″- 9″	dated parent rock close to the surface	.15							.20
684	"	B1	9″-12″		.15							.26
685	"	B2	12″-16″		1.72	.03	trace	1.19	.21	.04	.26	1.96
686	"	B3	at 17″		1.72	trace	trace	1.16	.22	.04	.22	1.81
687	"	C	18″-20″		1.19	trace	trace	.78	.13	.03	.17	1.21
689	"	C	30″		1.67	trace	trace	1.14	.21	.04	.23	1.70
635	16-37-13	A1	0″- 6″	2.1.6 L. Solonized area. Deep layer of un-	.03							.08
636	"	A2	6″- 9″	consolidated material	.05							.03
638	"	B1	9″-10″		.03							.14
639	"	B1	10″15″		.01							.12
640	"	B2	15″-20″		.36	.02	....	.29	.07	.02	.03	.51
641	"	B2	20″-25″		.11							.16
642	"	C	28″-36″		.25	.03	trace	.13	.01	. .	.07	.39
643	"	C	42″		1.35	.02	....	.94	.23	.05	.10	1.53
668	4-34-12	A 1 & 2	0″- 2″	2.7.5 C.L. Completely solonized in low area	.07							.22
669	"	B1	2″- 12″		.15							.30
670	"	B2	18″-24″		1.13	trace	trace	.80	.21	.05	.05	1.34
585	33-33-4	A1	0″- 2″	1.7.5 C.L. Completely solonized in washed	.10							.13
586	"	B1	2″- 5″	river flat	.47	.05	.01	.30	.01	trace	.16	.50
587	"	B2	6″-10″		2.24	.02	.01	1.56	.06	.05	.60	2.39
588	"	C	14″		2.88	.01	.01	2.04	.17	.07	.66	3.10
680	6-35-9		0″-11″	1.7.5 C.L. Hamilton lake bed	.13							.27
681	"		11″-16″		.13							.24
675	34-33-10		0″-10″	Kirkpatrick lake bed	.27	trace	trace	.16	.01	trace	.06	1.22
676	33-33-10		surface	Slough crust in Sullivan lake area	20.00	12.75	0.20	6.13	trace	trace	7.79	25.26
661	29-34-13		1″-12″	Sullivan lake bed	1.48	.15	.04	.70	.01	trace	.40	1.64
662	1-33-14		surface	Slough crust	.44	.24	.04	.15	.01	....	.18	.68
718	25-39-10		surface	Slough crust from hilly area	61.31	.16	.34	42.35	.03	1.66	17.39	73.00

tion of the province. In general, the zone line on the map marks the southern limit of tree growth on the uplands. There are occasional patches of poplar and willow growth in the low spots and along the stream courses in the brown soil zone. Battle river in the northwest portion of the sheet has fairly heavily wooded slopes composed mainly of black and aspen poplar and willow. The undergrowth is composed principally of wild cherry, saskatoon, raspberry and hazel. There are scattered patches of white birch and the occasional white spruce. North of Battle river and in the Brownfield district the tree growth is quite heavy where it has not been cleared for cultivation and has a decided economic value in reducing soil drifting, as well as a source of wood materials. On the slopes of the drainage ways tree growth prevents erosion, but also cuts down the pasture capacity of this particular area. Patches of silver willow and buck brush are found throughout the entire sheet, particularly in the lighter textured soils.

The more level area in the western half of the sheet, which is composed principally of medium textured solonized soils, supports a fair growth of short grass. June grass (Koeleria cristata), a fine leafed grass of medium height having a spike like head; blue joint (Agropyron Smithii), a medium to tall grass having a spike head; rough hair grass (Agrostis hiemalis), a fine leafed grass of medium to tall height having a spreading panicled small flowered head; and Kentucky blue grass (Poa pratensis), a medium to tall grass, having a spreading panicled small flowered head, are the common grasses in this area, and all of them are good to excellent forage plants. Over this entire area is found an abundant growth of pasture sage (Artemesia frigida), a bushy medium to tall plant of gray green color. It has practically no pasture value and consequently reduces the carrying capacity of the range. A low growing salt sage (Atriplex nuttallii) grows in the strongly solonized flats of this area. If differs from the pasture sage in having fewer and broader leaves, but also is of questionable forage value.

In the Neutral Hills area the four grasses described above, as well as the pasture sage, are found. Also found in this area is Canby blue grass (Poa Canbyi), a grass of medium height with a fairly compressed panicled head of good forage value; blue grama grass (Bouteloua gracilis), a low growing fine leafed grass having a curved spike like head of very good pasture value; spear grass (Stipa comata), a grass of medium height, characterized by the spear like seeds of very good forage value until the seeds begin to ripen; and Mat Muhly (Muhlenbergia squarosa), a grass of medium height well supplied with fine leaves and having fairly compressed panicled head of a bluish color. This last grass is very common in this area, but is not relished by the stock and is only eaten when the other more favored grasses are picked off.

In both these general areas described above, particularly in the more southerly portions, there is considerable club moss (Selaginella densa). This is a very low growing moss that spreads over the ground surface to the exclusion of the forage grasses. It is found particularly in areas where the pasture is depleted.

In the more level areas in the northern portion of the area, blue joint and Kentucky blue grass are the common grasses. Found here also, particularly near the edge of the poplar groves, is timber oatgrass (Danthonia intermedia). This is a medium to tall grass with a spike like head. The seeds are enclosed in oat-like glumes. It has fair forage value.

Rose bush, silver willow and pasture sage are very common on the sandy areas of the sheet. The sand areas in the dark brown zone, however, have an extensive growth of juniper, a creeping woody plant with cedar like leaves. This plant, found in the dune areas, aids in tying down the loose sand. Sand grass (Calamovilfa longifolia), a tall fairly coarse grass with an open panicled head, is the principal grass in most of the sandy areas. It is only of fair forage value, and although appearing quite green and succulent is not relished by stock. On the sandy areas south of Hamilton lake inland blue grass (Poa interior) is a very common plant and is of fair to good pasture value. It looks somewhat like Canby blue grass, but has less leaf growth. Horse tail (Equisetium affine) and Indian pink (Perilome serrulatum) were both found in this sandy area.

Wild barley (Hordeum jubatum) is the principal grass found in dry slough and lake beds, particularly of the more southern areas. Mixed with this is some alkali grass (Paccinella nuttalliana), a tall growing fairly coarse grass with an open panicled head. Both of these grasses are of fair forage value. In the sloughs and flats in the more northern portion of the sheet there is much slough grass (Beckmannia erucaeformis). This gives a rank growth and is used for winter feed. The Ribstone flat has some large hay meadows composed principally of this grass.

The control of weeds is a major problem in the dry belt of Alberta. Weeds take the moisture that should go to the growing crop, and are generally of no fodder value. Russian thistle is possibly the most common weed, particularly in the dryer southern section. It has been used for fodder when better foods were not available. Farther north lambs quarter and

Russian pigweed are the common weeds. These have become particularly troublesome during the last few dry years, in some cases entirely choking out the grain crop. Buckwheat is quite bad in some places. Patches of tumbling mustard and of pepper grass were seen, particularly on the level solonized soils. Poverty weed was found to be quite prevalent on the gravelly soils. The fields of abandoned cultivation are soon covered with weed growth, Russian thistle and mustard being among the first to appear. If left alone they will eventually go back to sod and native grasses will take the place of the present weed growth. However, experiments are at present being conducted to determine possible means to hasten the regrassing of the deserted areas that are now of questionable arable value.

SOIL SURVEY METHODS

The soil survey was generally carried out by driving along the roads and stopping frequently to take notes regarding class of soil and subsoil, topography, stones, suitability of soil for cultivation, etc. The roads running north and south are one mile apart, and the roads running east and west are two miles apart. In most cases the land was traversed at intervals of one mile. In some cases roads had not been opened up, and it was then necessary to drive across the prairie. The location was usually obtained from corner posts and speedometer readings. In some cases one soil class changes abruptly to another, and in these cases there is no doubt regarding the point at which the boundary line should be placed, but more often one soil class merges gradually into another, and in these cases the point at which the boundary line is placed must be chosen arbitrarily. Then, of course, it is necessary to draw in the boundaries arbitrarily between roads, or between points of observation. After the boundaries had been established in this way the areas were sampled systematically and the samples were sent into the laboratory for analysis.

Most of the field notes were recorded on township maps obtained from the Topographical Surveys Branch of the Dominion Department of the Interior. The township map is made with a scale of two inches to the mile. Further notes were recorded in convenient field note books.

In a survey carried out in this manner, and recorded finally on a map with a scale of three miles to the inch, minor areas cannot be outlined, and boundaries cannot always be very accurately established. It should also be noted that in a survey such as this one, small areas could not be outlined. Hence, although the extensive soil types are outlined fairly accurately, the map should not be depended upon without further inspection for the soil type of individual quarter sections.

APPENDIX

THE RELATION OF THE GEOLOGY TO THE SOILS IN THE SULLIVAN LAKE SHEET

By John A. Allan*

INTRODUCTION

From the geological point of view soils may be regarded as young deposits of Recent or Pleistocene age and are unconsolidated rock. The inorganic part of soil consists of mineral and rock particles which vary in size and shape, but these particles have been derived at some time and in some way from solid rock formations. This unconsolidated mantle of weathered rock material when acted upon by organic agencies and mixed with organic matter may contain the required conditions to support vegetable growth. When rocks are exposed at the surface, various chemical and mechanical agents of erosion act upon the rock surfaces and slowly transform the solid rock into soil. The more soluble constituents in the rock are first affected and the structure of the rock is weakened. The less soluble portions of the rock remain to form the regolith or unconsolidated mantle which may be further broken up by mechanical agents of erosion to produce gravel, sand, clay or silt. If the rock debris produced by weathering is not removed by other agents then the product is residual soil; that is, soil which has been formed *in situ* from the underlying rock. Soils formed in this way will have some of the physical and mineral characteristics of the underlying rock.

All soils are formed from the decomposition and disintegration of rocks, but all soils are not formed from the rock immediately underlying the soil. There are four major processes in the development of soil; namely, decomposition, disintegration, transportation and deposition.

Most soils have been transported from their original source and become mixed during the process of transportation. The three principal transporting agents are wind, running water and ice in the form of glaciers. However, transported material must eventually come to rest and here the fourth process in the development of soil, namely, deposition, results. The material transported by wind or by glaciers may be deposited on a land surface. Such deposits transported by wind are known as

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dune, eolian, or some loess deposits. Moraines are deposits left from the melting of glaciers. Water transported material is usually deposited in bodies of water, such as lakes, giving rise to lacustrine deposits, swamps as palustrine deposits, and along the margin of river courses as alluvial soils. In water transported deposits there is greater sorting action and the finer particles will be carried farther than the coarser particles. Such deposits might vary from the finest clays and silts, and even colloidal particles, up to the coarsest of gravel. This fact often explains why the texture of a soil may change materially even within the same section of land. During the process of transportation many kinds of rocks become mixed and the soils produced from these transported deposits may be heterogeneous mixtures and of complex mineral composition as, for example, a soil produced from the weathering of an interbedded-sandstone-shale formation will be different from a soil derived from a shale formation, or from shale and granite rock debris, and so on.

There is still another kind of unconsolidated material influenced by water transportation. Rain falling upon any kind of surface deposit such as glacial moraines, residual soils or wind deposits may wash out the finer rock particles and deposit them further down the hillside or on the flats at the bottom of the slopes. These are known as alluvial fans or outwash plains. The character of the soil in these outwash areas might be quite different physically and even chemically from the soil in which the outwash has become deposited.

These introductory notes on the origin of soils are given to make it clear that there is frequently an obvious and close relationship between the kind of soil and even the depth of soil in an area and the geology of the district. There is obviously no sharp line of demarcation in surficial unconsolidated deposits between what may be called soil and what may be called gravel, sand, till, or boulder clay. In some parts of Alberta, particularly in the mountains, or in the Precambrian rock area in northeastern Alberta, certain types of vegetation grow on gravel deposits and even in fractures on rock surfaces void of soil. In the latter case the plants derive their food from the decomposed products of minerals in the solid rock. If the rock contains potash-bearing minerals, the rock decay will produce the potassium carbonate which is favorable to plant growth. Other rocks with a phosphate content will support a luxuriant plant growth even though the soil is scarce. However, these finer points in the origin of soil do not enter into a discussion of the geology of the Sullivan Lake sheet because rocks of this composition do not occur in this area and there are quite limited areas of solid rock exposed in this map-area. On the other hand the conditions of soil origin as suggested above, occur throughout much of the Sullivan Lake sheet.

The entire area of the Sullivan Lake sheet has been traversed to obtain geological data but only a short time has been spent in the field examining the unconsolidated superficial deposits in this map-area. On this account the following notes must not be regarded as a complete geological report on the surficial deposits in Sullivan Lake sheet. Some of the more prominent geological features responsible for the distribution of several of the soil types shown on the accompanying map will be recorded. More detailed observation would have to be carried out in the field before all soil types in every part of the area mapped could be interpreted correctly. A correct interpretation of the soil occurrences requires, not only a knowledge of the subsurface geology and structure of the rocks underlying any area, but also the source of the transported soil and the sorting and mixing processes which have occurred since the transported material has been deposited by these agents. This detailed information is not yet available in some parts of the Sullivan Lake sheet. The rock exposures in this area are confined largely to the valley slopes along Battle river, Sounding creek, and a number of the smaller tributaries and more particularly in the "eroded" areas shown on the accompanying map.

PHYSICAL FEATURES

The major physical features and the character of the surface of Sullivan Lake sheet have been adequately described in the earlier part of this report under the heading "Description of Area," and will not be repeated, but a few additional observations are suggested.

The surface topography of this sheet is shown by means of contour lines drawn at fifty foot contour intervals. The elevation of stations along the railways, and the elevation of a number of the lakes are shown on the map. Bench marks have been established by the Topographical Survey of Canada, and altitudes determined every 3 to 4 miles along the base lines, the 4th meridian and the east outline of Range 12.

The area of the Sullivan Lake sheet is in the eastern part of the central plains of Alberta. The relief of the surface ranges from a minimum of 2,000 feet on Battle river at the north edge of the map in range 9, to a maximum elevation of 2,955 feet above sea-level in Nose hill, 11 miles north of Veteran and to

2,900 feet in the southwest corner of the sheet on the south boundary of township 33, range 14, west of the fourth meridian. Over 90 per cent of this map-area lies between 2,200 feet and 2,700 feet above sea-level. Battle river in the northwest corner of the sheet has incised a post-Glacial valley less than 300 feet deep into the upland. Monitor creek in townships 33 and 34 and Sounding creek in townships 35 and 36, have cut valleys about 200 feet deep through the north end of Mud Buttes and Neutral Hills, respectively.

The two most prominent uplands in the Sullivan Lake sheet are the Neutral Hills and the Mud Buttes. The Neutral Hills form the most prominent physical relief in the map-area. The trend of these hills between the fourth meridian and Sounding Creek is N 80° W, and west of Sounding Creek the direction changes to N 65° W. The Neutral Hills terminate in the northwest corner of township 37, range 7, but Nose Hill, formerly part of Neutral Hills but disconnected by erosion, is offset about six miles to the southwest in township 37, between ranges 8 and 9, and east of Ribstone creek. There is a small highland in the southwest corner of Sullivan Lake sheet which is the extension of a ridge from the east side of Dowling lake in Sounding Creek sheet. The greater part of the map-area may be described as consisting of rolling topography with the exception of a lowland plain extending from Coronation in a southeasterly direction to Kirkpatrick lake and the south boundary of the sheet.

SUB-SURFACE GEOLOGY

The areal geology of Sullivan Lake sheet is known and this information is shown on the small scale map (Plate 9) with this report. This information is taken from the geological map of Alberta prepared by the writer and published in 1937.

The geological formations which occur at the surface or immediately below the unconsolidated deposits in the entire area of the Sullivan Lake sheet belong to the Upper Cretaceous, the older rocks occurring at the east side of the sheet and the younger ones at the west. There are three formations represented by the rocks under this map-area, which, in order of age from the youngest to the oldest, are as follows:

Edmonton—non-marine or continental soft sandstone and dark shale with some thin coal seams.

Bearpaw—mainly marine sandstone and shale.

Belly river series—Pale beds formation—non-marine sandstone and shale.

The Belly River series forms the surface rock in 50 out of 112 townships in the map-area, from the fourth meridian westward. The contact between the Belly River and the Bearpaw is represented by a line drawn from the centre of the south boundary of township 33, range 4, in a northwest direction to the centre of the north boundary of township 40, range 10, at the north margin of the map. The contact swings westward from six to twelve miles up the depressions formed along Monitor creek, Ribstone creek and Battle river due to the slight southwesterly dip in the strata.

The strata in this map-area belong to the *Pale beds* or uppermost formation of the *Belly River* series. This has been proven in the core samples in three wells drilled in a search for oil. One well was drilled to a depth of 3,490 feet by the Northwest Company, Limited, on the northwest of quarter section 17, township 39, range 7, west of the 4th meridian, in the vicinity of Tit Hills. In this well the drill passed through 760 feet of *Pale beds*. The same company drilled the Misty Hills well just south of this map-area on the northeast quarter of section 29, township 32, range 4. This well was drilled to 3,304 feet and passed through 890 feet of *Pale beds*. A third well was drilled by the West Regent Oil Company three miles south of Monitor on section 19, township 34, range 4, to a depth of 3,050 feet and passed through over 600 feet of *Pale beds* at the surface.

The *Belly River* strata are of fresh water deposition and consist chiefly of "pale" yellowish to grey sandstones, clayey sandstone, sandy shale, often lenticular in form, and several thin coal seams and coaly lenses. Crossbedding caused by deposition in shallow water is common in the sandstone. Nodules of hard sandstone and clay ironstone are also common in this formation. Frequently there is bentonite in the sandstones and sandy shales which when wet forms a very slippery surface. The sandy character of most of the beds in this formation prevents these strata from forming a heavy residual soil when weathered, but where the residual soils from the *Belly River* strata have been partially sorted by rain, as in the east and southeastern part of the map, large areas of silt loam and clay loam are formed. In small depressed areas where the drainage has been more severe, small patches of clay have been developed. The slightly stony character of the surface soil on the *Belly River* in the southeast corner of the sheet is due to the outwash from the glacial material in the higher land at eastern end of Neutral Hills. On account of the thick deposit of glacial debris over much of the area underlain by *Belly River* strata there is little, if any, residual soil from this formation. The best exposures of the *Belly River* rock occur in Mud Buttes south of Monitor, along Monitor and Loyalist creeks west and southwest from Monitor, along Ribstone creek and some of its tributaries, and especially along Battle river in townships 39 and 40. There are a few scattered small outcrops of these rocks in the vicinity of Neutral Hills. A small exposure of these soft clayey sandstones occurs about two miles east of Metiskow.

At the close of Belly River time the land surface was submerged and the sea covered this part of Alberta. In this sea were deposited marine muds which have been consolidated into shales. These shale strata form the *Bearpaw* formation which is of marine origin. The *Bearpaw* consists mainly of shales varying in color with grey, brown and green predominating. There are occasional beds of sandy shale and a few bands of ironstone nodules. There are several bentonitic beds in this formation. One of the chief characteristics of bentonite is that it absorbs water rapidly up to seven times its own volume and forms a very soapy-like clay. Small quantities of bentonite mixed with clay is commonly known as "gumbo." Where these bentonitic shales occur at the surface gumbo clays are produced which are very slippery when wet. This characteristic is readily recognized when driving along almost any of the secondary roads after a rain storm, particularly through the centre of the Sullivan Lake sheet in a north-south direction where the surface soil is influenced by the underlying *Bearpaw* shales. This gumbo content of the soils is especially noticeable between Coronation and Loyalist, south to include ranges 5 *to* 12 at the south boundary of the map-area, and north to the top of Nose Hill and northwest across Battle river to the vicinity of Alliance.

The Bearpaw shales are almost entirely free from lime so that any soils formed from these rocks will not contain any appreciable amount of lime unless it has been washed in from the glacial till. Calcium sulphate in the form of gypsum crystals occurs rather abundantly in this formation. Sodium and magnesium sulphates have been observed by the writer in areas where the Bearpaw is the surface formation. These sulphates from the Bearpaw shales are, at least in part, responsible for the alkali content of the surface soils in that area where these shales are near the surface. The alkali flats southeast from Coronation, Throne and Veteran and especially the small basins of Watts, Rushmere and Fitzgerald lakes have been developed in this way.

The Bearpaw shales form the surface member in 45 out of 112 townships in the Sullivan Lake sheet as shown in Plate 9.

This formation occurs beneath the soil between ranges 5 and 12 on the south boundary of the map, between Coronation and Loyalist in township 35, and between ranges 10 and 13 on the north boundary of the Sullivan Lake sheet. These shales occur quite close to the surface in the broad flats extending southeast from Coronation towards Fitzgerald lake in township 33 and in ranges 7, 8, 9, and 10. There has been some mixing with the fine material transported from the glacial deposits to the north by water and wind. Somewhat similar conditions exist in the lowlands north of Coronation, especially in the vicinity of Brownfield and on both sides of Battle river, where the underlying Bearpaw shales have had a marked influence on the composition of the soil.

The best exposures of the Bearpaw are along the valley of Battle river, and also in Nose Hill ten miles north of Veteran where the shales outcrop almost to the top at an elevation of approximately 2,900 feet above sea level. These shales also occur in the west slope of Neutral Hills in township 37, range 8, and in the hills on the north side of Ribstone creek in range 9. On account of the softness of these shales they are easily weathered and exposures are not frequent on the plain level, however there are exposures in fresh road cuts in the Bearpaw lowlands, which indicate the shallow occurrence of bedrock beneath the unconsolidated deposits.

There is a very close relationship between the occurrence of the *Bearpaw* formation close to the surface and the distribution of "blow-outs" in the loam and silt loam types of soil. This relationship can be seen most definitely by comparing the geological map (Plate 9) with the soil map accompanying this report.

Within the Bearpaw shale formation there is a thin sandstone member called the *Bulwark* sandstone. This sandstone member is water-bearing and is therefore important as a source of well water. As the strata dip to the west the depth to this water-bearing sandstone increases toward the west. The depth would depend on the location. The entire *Bearpaw* formation is about 400 feet thick in the Sullivan Lake sheet.

The *Edmonton* non-marine formation overlies the *Bearpaw* shales and represents the uppermost Cretaceous strata in Alberta. At the close of *Bearpaw* time the sea receded to the east and brackish and fresh-water sediments were deposited, which consolidated to form the *Edmonton* formation. The strata in this formation consist of rather soft, cross-bedded sandstones, light and dark colored sandy shales, bentonitic clays and sandstones and several thin coal beds. The most accurately measured section of the *Edmonton* formation, exposed on Red Deer river between Ardley and Willow Creek south of Drumheller, contains 1,224 feet of strata, but it is only the lower two or three hundred feet of beds that occur in the Sullivan Lake sheet. In a well drilled by the Hudson's Bay Oil and Gas Company, Limited, north of Castor, in the valley of Paintearth creek, on legal subdivision 5, section 27, township 39, range 14, west of the 4th meridian to a depth of 4,670 feet, about 160 to 180 feet of *Edmonton* strata were penetrated. The lower members in the *Edmonton* formation are shaly in character and in some places it is difficult to determine the contact with the underlying *Bearpaw*.

The *Edmonton* formation forms the surface rock in seventeen townships of the 112 townships in the Sullivan Lake sheet. On the geological map (Plate 9) this formation is shown to occur along the west side of the sheet, chiefly in ranges 13 and 14, with an eastward projection as far as Coronation in township 36.

Coal beds in the *Edmonton* formation have been exposed by mining in the Garden Plain district at the southeast end of Sullivan Lake in townships 33 and 34, ranges 13 and 14, and also in the vicinity of Castor in townships 37 and 38, ranges 13 and 14. It is from this formation that domestic coal is mined on a large scale at (1) Sheerness and in the Drumheller (2) district. In the Castor district the well water obtained from the vicinity of the coal beds is quite strongly colored by the organic material from the strata.

The lime content in these rocks is high and in some beds the cementing material holding the grains together is high in lime. Bentonite, known as *gumbo* in the impure form, is an important constituent of the sandstones. Very heavy clay and gumbo-high soils are formed from the residual weathering of the *Edmonton* strata, or from the transported fine material from these rocks. It is quite possible that the small patches of clay loam and mixed types of soil shown on the accompanying map along the west side have been formed largely from *Edmonton* strata. The prevalence of sandy shale and light shale in the lower part of the formation and near the *Bearpaw* content are in part responsible for the widespread distribution of "blow-out" loam in the western portion of the Sullivan Lake sheet.

(1) Allan, J. A.: Research Council of Alberta, Report 33, 1935, p. 27.

(2) Allan, J. A.: Geology of Drumheller Coal Basin, Res. Council of Alberta, No. 4, 1922.

ORIGIN OF SURFICIAL DEPOSITS IN SULLIVAN LAKE SHEET

It is not always possible to determine the origin of the surface deposits in certain areas, because frequently the unconsolidated material is of mixed origin. This is particularly true in the case of reworked deposits such as outwash plains, alluvial, and marginal deposits.

The soil differs from underlying deposits upon which it is developed in that weathering agents have changed its original texture, color and composition. In some soils the accumulation of organic material, both vegetable and animal, has caused the soils, particularly the surface soils, to assume a dark color. In most cases the surface leaching has deprived the soils of certain original minerals, and often the mineral content of the subsoils has been changed.

The surface unconsolidated deposits in the Sullivan Lake sheet are higher in calcium carbonate on the west side of the map-area than in the centre and eastern part of the sheet. This may be explained by the fact that the *Edmonton* formation, which occurs in the western part of the map-area is higher in lime, than the Bearpaw or Belly River strata which underlie the eastern three-quarters of the Sullivan Lake sheet. On the other hand, if the unconsolidated deposits contain certain soluble minerals these are brought to the surface in the ground waters, and in such cases the soils will be richer in those minerals than the subsoils. All these conditions have to be considered in explaining the origin of the soil types that occur in the map-area.

The unconsolidated deposits in the Sullivan Lake sheet can be classified under four major types:

(1) Residual.

(2) Glacial moraine, unsorted.

(3) Resorted glacial deposits.

(4) Transported deposits of alluvial, lacustrine and dune or eolian origin.

The first type includes the *residual soils* formed by erosion processes from the underlying rock formation. Soil formed in this way will have a composition somewhat similar to the composition of the underlying rock from which the soil has been formed. More frequently the residual soils have been resorted or affected in some way by various transporting agents of erosion and in such cases the composition of the soil is not similar to that of the underlying strata. There are very few areas on the Sullivan Lake sheet where residual soils occur which have not been partly sorted by later erosion. Between Castor and Sullivan lake are patches of residual soil, and also at points through the lowlands underlain by the Bearpaw shales and where there has been little if any ground moraine. It is, however, apparent that much of the soil in the "blow-out" areas in the western half of the sheet is in part of residual origin, in places mixed by the different transporting agents.

The second major type includes those deposits of glacial origin which occur in the form of terminal moraine, often quite thick, or as ground moraine, usually thin or represented by scattered glacial boulders and pebbles. It is a fact that the "stones" in the areas mapped as "stony" in the Sullivan Lake sheet, are of glacial origin, because the underlying rock formations, namely, *Belly River, Bearpaw* and *Edmonton* are too soft to form boulders with a wide distribution. The writer has not seen a single rock over a few inches in diameter which is not of glacial origin and has been transported a short or long distance.

The glacial deposits in this part of Alberta have been transported by Keewatin glacial ice during the Ice Age from the northeast. Some of the boulders and pebbles have been carried from the Precambrian areas in the vicinity of Hudson Bay. When the ice melted the gravel, sand and clay was left over the surface. If the ice front remained in one position for a longer time, a terminal moraine was formed consisting of an unsorted "dump" of till or boulder clay. If the ice front retreated steadily, a ground moraine was left over the surface. During the thousands of years that have elapsed since the glaciers melted in this part of Alberta, erosion agents in various forms, such as running water, or wind, have resorted or washed over the slopes on the moraines and removed the finer materials to lower levels. Glacial deposits which have not been affected by water or wind can be recognized by the presence of unstratified boulder clay or till without many pebbles and boulders. When stratification or evidence of sorting occurs in the surficial deposit the material would be classed in the third or fourth type.

The Sullivan Lake sheet contains a portion of one of the morainal belts in Alberta. It has been called the *Viking moraine* by Dr. P. S. Warren (1). This Viking Moraine marks the limit of advance of a great ice sheet from the northeast. The westerly side of this moraine extends from the west end of Cypress hills northwards to Medicine Hat, then continues in

(1) Warren, P. S.: The Significance of the Viking Moraine. Trans. Roy. Canadian Institute, Vol. 21, No. 46, 1937, p. 301.

a north northwesterly direction passing east of Steveville, Youngstown, Coronation, Viking, Vegreville and Athabaska Landing.

In the Sullivan Lake sheet this moraine forms the Neutral hills and the western edge may be indicated by a line drawn from township 33, range 5, on the south boundary of the sheet, through township 37, range 9, to the north boundary of the sheet about township 40, range 11. There is a wide distribution of unsorted morainal deposits from this position to the northeast corner of the map-area. The unsorted morainal deposits are thickest from the southeast corner of the map-area, northwest through Neutral hills and north to Cadogan and Czar. The numerous, irregular, small lakes and lake basin in this part of the map-area indicate the presence of the moraine. There are also innumerable kettle holes over this area. These are depressions formed in a thick moraine and represent irregularities on the surface of the moraine, formed after blocks of ice entrapped in the glacial debris had melted. Frequently a lake formed in these depressions. Many have become alluviated and no longer contain water. One of the largest of these glacial lakes is Gooseberry lake, which has not been reduced in size and which is still one of the largest lakes in the Sullivan Lake sheet. It is not known what the maximum thickness of the moraine is, but it might be several hundred feet in the Neutral hills. The moraine is quite thick from Compeer in township 33, north to township 36 and also south of Sounding lake.

It is not possible with the data available to differentiate the unsorted morainal deposits from the third type, which includes the resorted deposits chiefly of glacial origin. From the Viking Moraine surface waters have removed the finer material and washed gravel, sand, clay and silt down the slopes to the southwest and also to the northeast. Outwash plains have been developed marginal to the thick moraine, and the finer material has been carried further and deposited in numerous local basins. On the northeast side of the main moraine the numerous areas of sand, sandy loam and fine sandy loam, extending from the east side of the map-area, westward along Eyehill creek in the north part of township 36, to Sounding Lake, then broadening north westward and then northward through the west half of range 4, all of range 5, and the east half of range 6 to the north boundary of the map, have been formed by the outwash. The finer materials have been carried farther from the moraine and are represented by the large areas of silt loam shown on the map from Eyehill creek in township 37, ranges 1 and 2, to the north boundary of the map and west to the vicinity of

Provost, with irregular areas around Hansman lake and the east side of range 4. In some places pebbles and boulders are more numerous where the finer gravel, sand and clay have been removed. In other areas loose rocks are scarce or absent where the fine sediments are thicker.

On the southeast side of the moraine there is a wide distribution of outwashed material. In places the *Bearpaw* shales have been mixed with the outwash. The area of mixed soil types from Grassy lake northwest to Monitor has been formed chiefly from the material washed down from the higher land to the north and in part transported by wind. In a belt through the centre of the Sullivan Lake sheet, from township 33, ranges 5, 6 and 7, to the Battle river in township 39, ranges 11 and 12, the ground moraine was very thin or entirely missing. The few scattered rocks, or rocky patches, indicate that there was some ground moraine over these areas, but as stated above the Bearpaw shales are largely responsible for the soil types as mapped.

There is no evidence of thick morainal deposits along the west portion of the map area underlain chiefly by the *Edmonton* formation. The presence of some glacial pebbles and small boulders of Precambrian rock indicate that there was some ground moraine over those areas where the rocks occur, but there are other areas, particularly in ranges 13 and 14, where there are no rocks of glacial origin and there was no ground moraine.

The fourth type of surface material includes the *transported deposits.* The transporting agents are wind and running water, either along stream courses or as run-off. The former gives rise to dunes or eolian plains, the latter to alluvial, flood plain and lacustrine deposits. Transported soils are bedded in character due to the sorting action of the transporting agents. The sand and clay may occur in separate layers or lenses, forming a sandy soil or a clay soil. These deposits may be a mixture of sand and clay with varying proportions of each, giving rise to a sandy clay or a clay loam or a sandy loam soil.

It is not always possible to distinguish the fourth type, that is the transported deposits of recent origin, from the resorted or transported glacial deposits. The unconsolidated material around Kirkpatrick lake and also around Grassy lake have been formed by alluvial agents and to a lesser extent by the action of wind, but in the latter there is also considerable fine outwash from the higher land to the north.

Typical dune topography extends widely through the Viking moraine in the eastern end of Neutral hills and in the rolling country to the northeast. In some places the dunes have a mantle of vegetation. The dunes are most common in the sand and sandy loam areas such as those in the vicinity of Sounding lake and extending east, north and northwest from the lake. There is also evidence of considerable eolian action on the sand and sandy loam area in the vicinity of Kirkpatrick lake.

Alluvial deposits are distributed along the present drainage channels such as Sounding, Eyehill and Ribstone creeks, Battle river and some of its tributaries, and also along old drainage courses that were more active after the sheet had melted. One of these glacio-alluvial courses extends from Hansman lake, and Cairns, to the eastward to the north of Cadogan and on the south side of Provost, to Fleetinghorse lake, and St. Lawrence lake at the Fourth Meridian in township 39. There is considerable alluvial material in the southwest corner of the map-area associated with numerous small drainage courses extending southeastward from the Sullivan lake plain to the Kirkpatrick flats, particularly in townships 34 and 35, ranges 12 and 13.

The lacustrine deposits consist chiefly of clays and fine sand and silt deposited in lake basins sometimes large, as in the former extension of Sullivan lake, Grassy lake and Sounding lake, but usually small in extent. There may be a remnant still present of a much larger lake or there may not be any surface evidence of such a lake except a broad plain surface. In this type of deposit the character and composition of the soil are usually uniform. There was a narrow lake about twenty-five miles long in Ribstone valley extending from Czar south to township 37. There is a large lacustrine basin extending from Provost to the north boundary of the map-area. This same basin extends southwards from Fleetinghorse lake to Rosenheim in township 37. There is a small basin with glacio-lacustrine deposits around Coates lake about four miles west of Compeer. Other smaller lake basins occur throughout the map-area. In every case these old basins can be recognized by the flatness of the surface unless the fine soil has been piled up by wind action.

WATER SUPPLY

There is a lack of accurate information on the possible water supply or on possible water-bearing horizons in the Sullivan Lake sheet. The Geological Survey of Canada obtained considerable information on water wells throughout part of this map-area in 1936, but the results have not yet been published and are not available.

The domestic water supply problem is not considered acute except locally. There is usually water associated with the sand area and especially on and along the slopes of Neutral hills. Springs were observed in section 2, township 34, range 1, about 2 miles from Compeer, and in section 21, township 34, range 3, west of Kerrimuir. The water at Castor comes from beds close to the coal seams, and is distinctly colored by the organic matter, but the quality is reported satisfactory. There is a scarcity of good water reported from the lowlands underlain by the *Bearpaw* marine shales, due no doubt to the soluble salts associated with these shales.

The Bulwark sandstone which is a marine sandstone member in the *Bearpaw* shales, is regarded as a good water-bearing sandstone. Good supply of water has been obtained in several wells drilled into this horizon. There should be no great difficulty getting good water in sandstone beds in both the *Belly River* series and in the *Edmonton* formation. Fuller details on the water supply cannot be supplied at the present time.