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ONTARIO AGRICULTURAL COLLEGE

PRELIMINARY SOIL SURVEY OF SOUTHWESTERN ONTARIO

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INTRODUCTION.

Few people realize that the study of soils is a very complex subject. This is abundantly evidenced by the questions that are asked about the hundreds of samples of soils that are sent to us each year, and by the answers we are expected to give without seeing a sample or knowing anything of the previous manuring or cropping, the nature of the subsoil, or even the crops that are to be grown. Our inability to deal with these questions in a satisfactory manner led us to undertake a survey of the soils of the Province in order that we might get a proper perspective of the whole subject.

It is known that the soils are formed from the weathering of rock, and that different kinds of rock of widely different composition have been the source of our soils. Glaciers have shoved and carried these materials in certain directions; and later, water has further sorted the finer and coarser parts, giving us clays, loams and sands, some of which have been derived from one class of material and some from others. This difference in origin becomes a factor in classification. Because of these widely varying conditions the clay may be deep in some places, or it may be overlaid with sand or gravel in others, or the reverse condition may obtain, where we have sand overlaid by clay. On the other hand, we may have all the materials left unsorted, as in the morainal soils. These varying conditions not only affect the composition of the resulting soil, but, what is of equal importance, the aeration and drainage.

A study of these and other factors forms the first steps in a soil survey. Naturally a detailed study of the geology of the Province must be associated with the examination of the soils in their position. This necessitates going over the whole area and making frequent borings to locate the margins of the various series and types of soils and then charting these findings on a map of the Province.

VALUE OF A SURVEY.

The soil survey provides a complete inventory of our soils, and should bear the same relation to our soil resources that a geological survey bears to our mineral resources. Both are fundamental to the future development of the country.

In the past much of the value of fertilizer experiments has been lost, or at least misleading, because the results obtained on one kind of soil were not applicable to another. This is only to be expected considering the wide differences in composition and texture. Particularly is this true in Ontario with reference to the application of lime. In fact, in all fertility and crop production investigational work, we at the College would find the soil maps of inestimable value because, knowing the soils of each county, as shown on the maps, we could be of more service to the farmer.

The survey is also of value to farmers looking for a new location, and for city folks who want to buy land for specialized crops. It will have especial value to immigrants. Copies could be available at our Immigration Offices. Land appraisers and bankers making farm loans can use the soil surveys in determining land values.

High Schools and Colleges giving instruction in agriculture can use the soils surveys in dealing with soil and crop problems. Agricultural Representatives, the Underdrainage Department, and Farm Economics Department, and Extension Specialists will find constant use for the information in the Soil Survey maps and reports.

In the United States, where much soil survey work has been done, road engineers use the soil maps in locating roads and in finding suitable road material. Various manufacturing industries, such as canners, makers of clay products and cement, find the surveys useful in selecting locations for factories. The soil maps indicate deposits of materials of industrial importance, such as gravel, sand, shale, tile, brick and potting clays, limestone and marl.

Another use that is being made of the soil surveys in the United States is in connection with the large life insurance companies. They make use of these maps in making public health and sanitary surveys. They find there is a direct correlation between the health and wellbeing of the people of particular communities and the character of the soil. Often they are able to say, "On such a soil you will find such a degree of comfort and progress." This is of great value to them.

HOW THE SURVEY IS MADE.

This work may be done in two ways. By a preliminary or reconnaissance survey, or by a detail survey.

In the Preliminary Survey the soil men go up and down about every other concession road or side line, to get a broad general idea of the larger and more important soil areas. It is a preliminary investigation to find out what series of soils exist and to roughly chart out their areas. No attempt is made to show minor variations. The travelling is done by motor car with frequent stops to make borings where change of soil is indicated.

The Detail Survey is made by the soil men walking over every part of the land in order that they may detect all minor changes in the soil. Naturally this method is much more thorough, and, of necessity, much slower; but where the soil types are mixed and the farming consequently diversified, it is the more valuable. Yet some preliminary survey must precede the detail survey in order that it may be known what soil series and types there are in the Province.

In the Detail Survey two men work together. With a soil auger they examine the surface and subsoil to a depth of 40 inches. In some cases deeper borings are made. Observations of road and railway cuttings or other means

available are made use of in gaining a knowledge of the subsoil. Representative samples of each type are collected and sent to the laboratory for analysis.

A full report of a Detail Survey thus gives, in addition to the soil map, a description of the properties and chemical composition of the soil and subsoil, topography, water supply and drainage conditions, crop adaptation, general fertility, systems of farming and methods of soil management. There is also included in the report a description of farm improvements, important products, markets, transportation facilities and the general condition of the community.

It is granted that a report of a Preliminary Survey cannot be of much practical use to the average farmer. Its great value lies in the fact that it forms the basis for a practical systematic study of soil problems.

Plot experimental work on cultural methods and with fertilizers can then be established on the larger types of soil. Following up our Preliminary Survey we have established three experimental or demonstration plots on three widely different types of soil. Considerable other experimental work with fertilizers has been carried on where the type of soil under investigation has been kept in mind. This follow-up work will be of immediate practical interest to every farmer.

This report deals only with the Preliminary Survey, and the accompanying map shows only the great soil series. Some detail work has been done and many samples of soil from different Series and Types have been analyzed, but the discussion of the results will be reserved for another publication.

COMMENCEMENT OF THE WORK.

A start was made on our preliminary survey in 1914 by the late A. J. Galbraith. He continued the work in 1915 but made slow progress as the work was new to him. During the summers of 1916 and 1917 Mr. Woodward carried on the survey and considerable progress was made. But in 1918 another change had to be made, and the late W. L. Iveson, who had been more or less in touch with the work throughout the previous three years, took charge. He reviewed much of the earlier work and completed the mapping of the area east as far as Kingston. East of this point the soils are so diversified that little headway can be made on a reconnaissance survey. Nearly all of one season was spent in a somewhat semi-detail study of the soils of Dundas County and part of Russell and Carleton Counties, which will be discussed in a separate publication. Unfortunately, Mr. Iveson died suddenly early in the winter of 1920 before his field work was fully recorded.

During the summers of 1920 and 1921 no attempt was made to carry on survey work, as we could not procure a suitably trained man, and our energies were devoted to establishing the demonstration plots and conducting special fertilizer tests on the mapped areas. In the meantime we selected one of our own men and had him trained for the work.

In the latter part of the summer of 1922 a start was made on a Detail Survey of the soils of Kent County, and about 100 square miles were mapped.

THE AREA SURVEYED

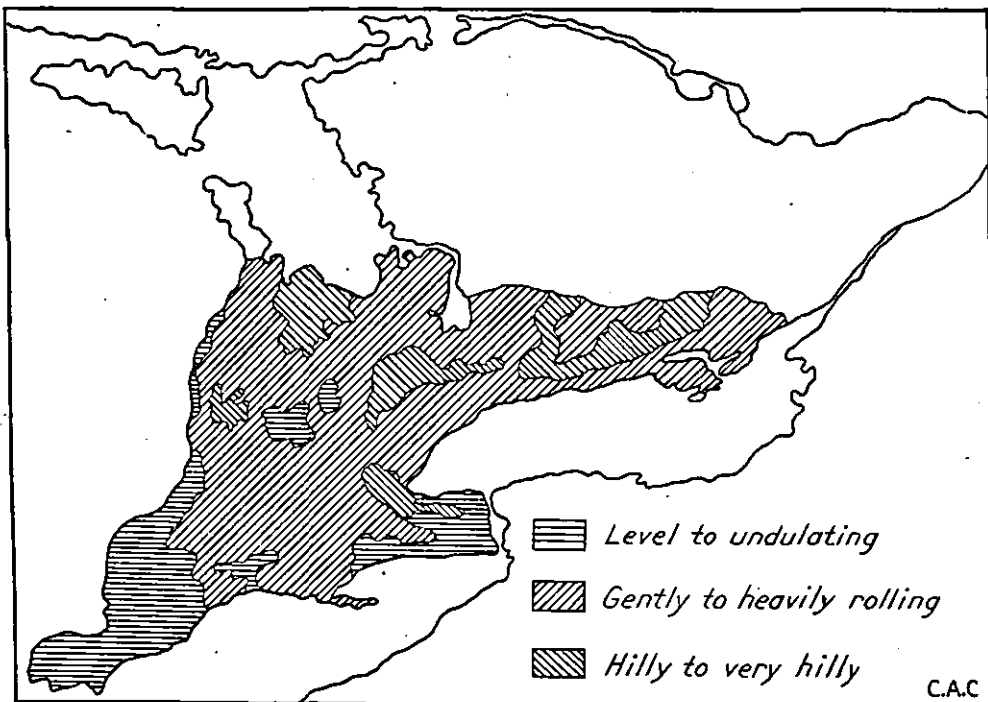
LOCATION AND EXTENT.—The area surveyed which is to be discussed in this publication includes that part of Ontario lying west of Kingston on the Albemarle-Amabel town line, an irregular line extending southeast from Sturgeon

Bay to Kingston. The most northern part, Nottawasaga Bay and Sturgeon Bay, extends a little above $44^{\circ} 50'$ north latitude, while the southern extremity at Pelee Point is a little below 42° north latitude, making nearly three degrees of latitude between the northern and southern borders. The extreme distance from east to west is a little over six and one-half degrees of longitude, extending from a little less than $76^{\circ} 30'$ west longitude, at Kingston the eastern boundary, to a little over 83° at Detroit River, the western boundary.

PHYSICAL FEATURES

ALTITUDE.—The surface of southwestern and central Ontario varies in elevation from 245 feet above sea level along the shores of Lake Ontario, to 1,700 feet or a little higher in the neighbourhood of Dundalk. This makes an extreme range of about 1,450 feet. Only a small area, which extends along

TOPOGRAPHICAL MAP OF SOUTH WESTERN ONTARIO



both shores of Lake Ontario, is below 400 feet; east of Trenton this area is usually twelve to sixteen miles wide, but farther west it is narrower, ranging from one or two miles to six or eight miles wide. Another small area, which extends from Orangeville Junction northward past Shelburne and Dundalk and culminates in a high promontory, called "the mountain", just west of Collingwood, rises above 1,600 feet. Dundalk is 1,700 feet above sea level and several points on the mountain are nearly as high. Other points in that section may be a little higher. On the east and north of this high area there is an abrupt descent, but to the south and west the surface slopes gradually toward Lake Erie and Lake Huron.

TOPOGRAPHY.—The topography of this area has been influenced to a large extent by the glaciers which covered all of southwestern and central Ontario

and by the waters of the glacial lakes which covered a large part of this area during the recession of the ice. Some pre-glacial and inter-glacial valleys, among which may be mentioned those occupied by the Bighead, Beaver and Pine Rivers, may have been deepened and widened to some extent by ice erosion, but most of them have been partially or entirely filled by glacial drift. In general the ice plowed down ridges and made the surface less rugged, but it also left large deposits in the form of terminal moraines, some of which are quite steep and hilly. Material, deposited in the beds of streams flowing through crevices in the ice, remained after the ice melted, as long, narrow ridges. Past glacial erosion has been active where there has been considerable fall. This is especially noticeable along the Bayfield, Maitland and Saugeen Rivers. In these sections, however, erosion has only extended a short distance back from the streams. Wind action has also been active in some sections, causing the formation of sand dunes, as seen in Norfolk, Simcoe and Prince Edward counties.

Between the steep eroded hillside and the poorly-drained level areas, there is a great variation in topography. As the lay of the land is of considerable importance in deciding what type of farming is most profitable, it seemed desirable to show the more important differences in topography, as well as the different soil types, on the map. This has been done by means of cross-lining. The topography has been divided into four classes and indicated on the map by parallel lines running in different directions. (See map of Topography.)

Class I includes poorly-drained, flat to gently undulating areas. On a large part of these areas, artificial drainage is necessary before they can be successfully cultivated. These areas are shown by horizontal rulings.

Class II includes areas that are gently rolling to hilly. Practically all of this class has good surface drainage and with a few exceptions the surface is not steep enough to interfere with cultivation. This class is shown by north-east-southwest rulings.

Class III includes areas that are hilly to very steep and broken. In practically all of this class the slopes are steep enough to interfere with cultivation. A large part should not be cultivated at all but, instead, should be used for pasture or forestry. This class is shown by northwest-southeast rulings.

There is very little of Class IV either in southwestern or in central Ontario, and some of the areas that were found are so narrow that they could not be shown on the map. This class is very steep and broken. It is found mainly along escarpments where the descent is very abrupt.

All classes necessarily include small areas of others. In some sections there are areas of two or more classes that are too small to indicate separately. These are grouped together and shown as the class that has the greatest area. In other areas the surface was near the dividing line between two classes and it was difficult to determine what class to place them in. In spite of these difficulties, however, the cross-lining indicates fairly well the character of the land surface.

MORAINES.—A study of the map will show a large body of the rough hilly land (Classes III and IV) in the northern and central parts of Grey County. This section is near Georgian Bay, and on account of the high elevation above that body of water, was badly eroded before the advent of the glacier. As the glacial stream had a tendency to follow the depressions, it did not cover this high land so soon or remain so long as on the lower country to the east, west and south. Consequently the preglacial features were modified to a less extent, and, in addition, some of the preglacial valleys were eroded still further by the ice and many rough morainal ridges were formed. These moraines

are only a part of the terminal moraines of southwestern Ontario. (See map of Moraines.) From this section strong moraines, known as the Goderich, Wyoming and Seaforth moraines, stretch away to the southwest through the southeast corner of Bruce and on into Huron County, continuing as far as Wyoming and the St. Clair River. Below Clinton, however, the relief is not great. Between Hanover and Teeswater, the moraine is strong, but most of the slopes are long and not steep enough to interfere with cultivation, so this section is included in Class II. There are, however, some steep slopes along some of the streams which flow in preglacial valleys. These valleys are deep canyons, but they are so narrow that they could not be shown on the map, so they are included in Class II. From Teeswater to Clinton there is a considerable area of rough steep land which is shown as Class III. Just north of Wingham the country is so rough and hilly that it is known as the "Alps."

Beginning in eastern Grey County, two strong moraines known as the Paris and Galt moraines, extend southward across eastern Dufferin County, the northwest corners of Peel and Halton Counties, eastern Wellington County, and Southern Waterloo County, continuing as far south as Galt and Paris. A small area of rough hilly land is found along the Waterloo moraine, which extends from a point west of Waterloo to a point south of Galt.

The Oak Ridges moraine, which extends from southeast Dufferin County across York, Durham and Northumberland County, is one of the strongest moraines in southeast and central Ontario. The greater part of this moraine is very rough and hilly. In York and Ontario Counties the rough hilly land occupies a rather narrow strip, but in Durham County it is much wider, and in Northumberland County it occupies almost the whole of the southeast part.

North of Barrie, in Simcoe County, there is another region of strong ice action. This area, which is small but very rough, is partly kame formation. In Bruce County between Southampton and Shallow Lake, the Port Elgin moraine is steep and rugged, forming a small area of rough land.

Along the north side of Niagara Peninsula there is a narrower steep bluff. This bluff, which marks the boundary between the hard resistant Niagara limestone and the softer shales of the Medina and Cataract formations, is known as the Niagara Escarpment. It follows the south shore of Lake Ontario to Hamilton, then turns northward to Inglewood, where it is buried by morainal deposits. It appears again a few miles west of Alliston and continues in a general northwesterly direction to "the mountain" near Collingwood.

There are a few places along the lake shores, particularly along Lake Huron, where the sand deposited by the waves has been blown into dunes. These dune areas are rough and hilly, but they are less extensive than the dune areas found along the Oak Ridges moraine.

South of the rough, hilly area in Grey County, and between the Paris and Galt moraines on the east and the Seaforth and Wyoming moraines in the west, there is an undulating to gently rolling plain. The northeastern part of this plain has an elevation of 1,600 to 1,700 feet above sea level, but there is a gradual slope towards Lake Erie on the south and Lake Huron and Lake St. Clair on the west. A large part of this plain was covered by the waters of the glacial lakes. (See map of Ontario Island.) In most places there is no marked change in topography at the line of division between the "Lake Plain" and the "Upland Plain." The former, however, has a larger area of flat land than the latter. The upland has some flat areas, particularly on the divide in southeastern Grey, northeastern Wellington, and western Dufferin Counties. A large number of these lime areas are swampy, and form the headwaters of many of

the streams flowing south and west. A number of long narrow ridges are found in this section. The material in these ridges or eskers was deposited in the beds of streams flowing through crevasses in the ice. Some areas of rolling country are found in the "Lake Bed," particularly where the elevation above the present lakes has favoured erosion.

FACTORS INFLUENCING DEPOSITION OF SOILS

Glacial lake waters covered a large part of Simcoe County and a small area south and east of Lake Simcoe in York and Ontario Counties. The greater part of these areas are level to gently rolling but there is a large area just south of Sturgeon Bay that is very rough and hilly. In this area the material seems to have been deposited, for the most part, in cavities within the ice and then covered with water from the retreat of the ice. Stratified material is frequently encountered in cuts along the roads but this material is often covered by bouldery material. Lake action modified the surface by removing material from hills and depositing it in the valleys.

There is a narrow strip of lake plain along the north shore of Lake Ontario. West of Scarborough there is a gradual rise from the "Lake Plain" to the Upland, but farther east there is an abrupt rise.

That part of the old lake bed which has been influenced most by the lake water includes all of Niagara peninsula south of the escarpment and extends along Lake Erie to the Detroit River, Lake St. Clair and the St. Clair River. This was the first part of Ontario covered by lake waters, and this is where most of the large glacial streams deposited their sediments and accounts for their high fertility. A number of water laid moraines give some relief and there has been a limited amount of stream erosion. The greater part of the area, however, is level to undulating. Practically all of Essex, the greater part of Kent and Lambton and a considerable area in Welland and Haldimand Counties is flat and poorly drained. Quite a large area in northern Essex County is only a little higher than Lake St. Clair. The only way that a large part of this area can be drained is by pumping the water from the drainage canals into the lake.

Although there are a few flat areas in that part of the old lake bed bordering on Lake Huron, the greater part of the surface is rolling. In this section the ice remained for a longer period than further south and fewer large streams deposited sediments in this area. Consequently the topography has been only slightly influenced by the lake waters. There is also considerable fall and erosion is more active than along Lake Erie. Small areas of badly eroded land are found along the Bayfield, Maitland and Saugeen Rivers.

REGIONAL DRAINAGE.—The greater part of Ontario drains westward and southward into Lake Huron, Lake St. Clair, and Lake Erie. This is due to the height of land which extends from "the mountain" southward, passing east of Dundalk, west of Shelburne and Orangeville and east of Guelph and Galt. As already mentioned, a large part of the country to the west of this divide is undulating to rolling, with a gradual descent to the west and south. Nearly all the large streams in southwestern Ontario have their origin in this section. The direction in which they flow is determined by slight irregularities of the surface.

Another sharp divide is found extending east from southwestern Dufferin County across north Peel and central York, central Ontario, central Durham and central Northumberland Counties. Streams rising to the north of this

divide flow into Georgian Bay and Lake Simcoe, Lake Scugog and the lakes of the Trent Valley system, while those rising to the south flow into Lake Ontario.

CLIMATE.

TEMPERATURE.—Plant growth is influenced by climate as well as soil, but, while the farmer can modify the soil to a certain extent, he cannot change the climate. However, some knowledge of the climate is necessary in order to determine what crops are best adapted to a particular section. In Ontario, corn is a good illustration of this fact. In the southwestern counties of Essex, Kent and Lambton, seed corn is grown successfully. In nearly all other sections, the season is not long enough for this crop to mature, so it is grown only for silage. The chief factors which influence the distribution of crops are temperature, precipitation and sunshine.

The mean annual temperature in southwestern and Central Ontario varied from 41° F. at Coldwater in Simcoe County to 46° F. at Cottam in Essex County. The average mean annual temperature for the entire section is 44° F. In some periods of years January is the coldest month; in others February. In a few places, March is nearly as cold as December, while in most places it is considerably warmer. July is the hottest month, but there are a few places where the mean monthly temperature of August closely approaches that of July. Very high summer temperatures and very low winter temperatures have occurred. Temperatures of 100° F. or over and also of —30° F. or lower have been reported.

From an Agricultural standpoint, the mean monthly and annual temperatures and the maximum and minimum temperatures are of less importance than the length of the growing season or the number of days between the last killing frost in the Spring, and the first killing frost in the Fall. In southwestern and central Ontario the average date of the last killing frost in the Spring falls on May 14th. The earliest is May 3rd at Kingston and the latest May 29th at Alton. The average date of the first killing frost in the Fall varies from September 16th at Alton to October 18th at Hamilton and Windsor. The length of the growing season varies from 110 days at Alton to 169 days at Hamilton and Windsor.

The data in the following table has been summarized from the records of the Ontario Meteorological Bureau; years 1893–1913.

LENGTH OF GROWING SEASON.

District.	Late Frost.	Early Frost.	Growing Season.
Agincourt, Port Hope, Uxbridge.....	May 18th.	Sept. 29th.	134 days
Hamilton, Toronto, Stony Creek, Welland....	May 5th.	Oct. 11th.	159 "
Port Dover, Port Stanley, Chatham, Windsor.	May 9th.	Oct. 9th.	153 "
Paris, Guelph, London, Brantford, Woodstock	May 17th.	Sept. 26th.	132 "
Stratford, Clinton, Listowel, Lucknow, Lindsay, Orillia.....	May 20th.	Sept. 24th.	127 "
Goderich, Kincardine, Southampton.,.....	May 14th.	Oct. 10th.	149 "
Collingwood, Meaford, Owen Sound.....	May 13th.	Oct. 6th.	146 "

The chief factors which influence the length of the growing season are nearness to large bodies of water, latitude, and elevation. The influence of large bodies of water is shown by a comparison of the data from inland points such as Stratford, Clinton, etc., and Kincardine and Goderich. At the former points the growing season is less than 130 days while it is over 145 days at the latter points. Inland points have frosts later in the Spring and earlier in the Fall. At Port Hope, however, the average date for early Fall frosts is September 27th, which is only three days later than at Durham, an inland point.

Altitude has some influence, as shown by a comparison of Alton, with an altitude of 1,250 feet and a growing period of 110 days, and Agincourt, with an altitude of 590 feet and a growing period of 142 days. This difference is only partly due to difference in elevation as Agincourt is near Lake Ontario and has undoubtedly been influenced to some extent by that body of water.

PRECIPITATION.—The average annual precipitation in southwestern and central Ontario, based on twenty years' records (1893-1913), varies from 24.21 inches at Bloomfield in Prince Edward County to 41.27 inches at Woodstock in Oxford County. The average for 32 stations is 31.84 inches. There is no region that is unusually wet or dry. Marked variations are found at points only a few miles apart. Woodstock and Brantford are a few miles apart, yet, Brantford has 11.21 inches less rainfall than Woodstock. The same is true regarding the monthly precipitation. One place may have a high precipitation during a certain month and another place only a few miles away will have a low precipitation during the same month. As a general rule the precipitation is quite evenly distributed over the twelve months, yet, at certain places, the precipitation is unusually low or high during certain months.

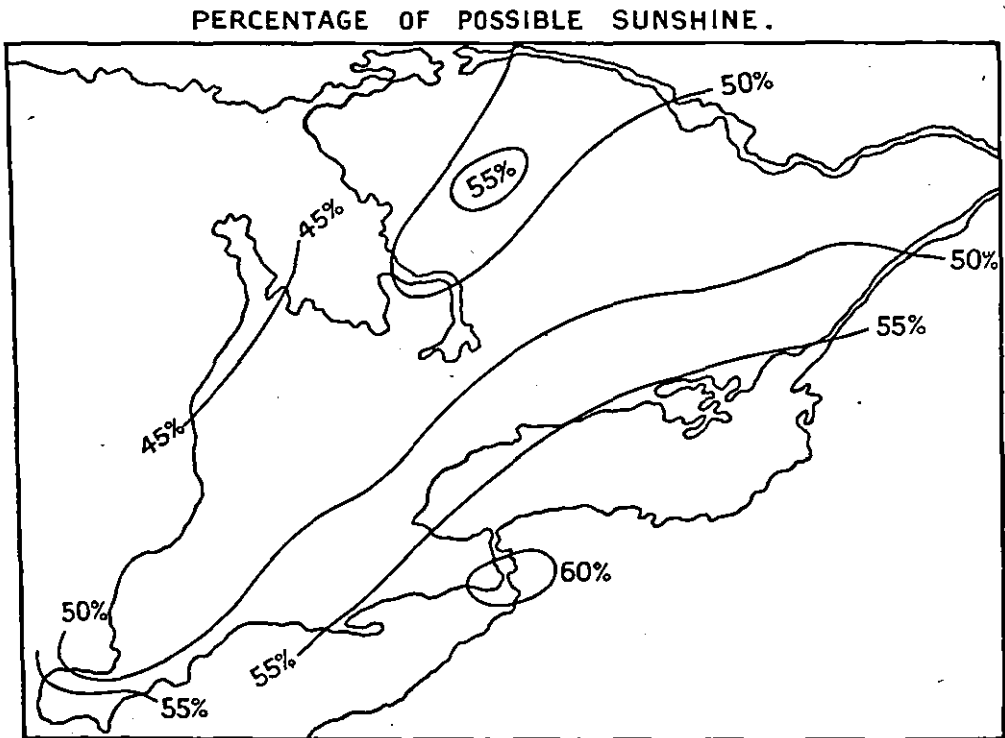
SUNSHINE.—The annual total possible hours of sunshine for southwestern Ontario is 4,452 hours. The actual hours of sunshine in a certain district is expressed as a percentage of this total. This percentage varies for the different districts. While the possible sunshine is the same for all during a definite period, the sky is overcast by clouds more in some than in others. The lower the percentage the more hours of cloudy weather. In Ontario there is a gradation from 60 per cent., or 2,671 hours, at Windsor in the south to 38 per cent., or 1,815 hours, at Barrie in the north. Well marked belts receiving the same percentage of sunshine extend across the Province in the southwesterly direction. For instance, if a line be drawn through Kingston, Belleville, Cobourg, Stony Creek and Port Rowan, the records of the area south of this line show us that it receives 55 per cent. or more of the possible hours of sunshine during the period May to October. The Niagara Falls-Port Colborne District receives 60 per cent. or more, so also does the district west of the line Rondeau to Sandwich. Proceeding north from the lakes the percentage of sunshine decreases approximately five per cent. for every fifty miles to a certain point, then it increases. (See map.) Note the high percentage of sunshine in a portion of the Muskoka District, one of the recreation spots of Ontario. This doubtless helps to account for its popularity.

FORMATION OF SOILS.

Almost the entire land surface of the earth is covered by a layer of unconsolidated material which is known as "mantle rock" or "the regolith." This "mantle rock" has been formed by the disintegration and decomposition of the solid rock by atmospheric agencies, chiefly changes of temperature, and solution.

This action, which is known as weathering, removes a large amount of material, but, in most places, there is an accumulation of rock debris which is mixed with a varying amount of plant and animal remains. The surface layer of this material, where the decomposition of the organic matter and the weathering of the rock debris has produced conditions favourable for the growth of plants, is known as the soil. The term soil is applied to the surface layer, and subsoil to the material directly underneath. In humid regions there is usually a rather distinct line between the soil and subsoil, the former being darker in colour.

In southwestern and central Ontario, part of the soil material is granite fragments brought down from the Laurentian plateau by the glaciers. The greater part, however, came from the underlying rocks. These rocks are limestones, sandstones and shales. Marked differences are seen between soils



SUMMER HALF YEAR — MAY TO OCT.

*Courtesy of Ontario Meteorological
Bureau. Records 1893-1913.*

derived from limestone material and those derived from sandstone and shale material. The greater part of this area is underlain by limestone and that rock forms the chief constituent in a correspondingly large proportion of the soils.

Marked differences are seen in soils formed under different conditions of moisture. Some were formed where there was thorough underdrainage as well as surface drainage; others where there was good surface drainage but poor underdrainage, and still others where surface and underdrainage were so poor that water stands on the surface most of the time. Soils showing all gradations from those formed under good drainage conditions to those formed under swamp conditions are found in southwestern and central Ontario.

Variations in texture are found ranging from dune sand to heavy clay. The greater part of the area has a medium texture, loams and clay loams predom-

inating. The clays are found where the surface was covered by glacial lakes. They represent sediments deposited in quiet water. Large areas of this type are found on Niagara peninsula and between the west end of Lake Erie and the southern end of Lake Huron. Some of the sand areas are morainal deposits reworked by the winds; others, delta deposits, and still others, shore-line deposits. Both the delta and shore-line deposits have been modified to some extent by the wind.

UNDERLYING GEOLOGICAL FORMATIONS OF OUR PRESENT SOILS.

The Niagara escarpment extends along the north side of the Niagara peninsula from Niagara River to Hamilton; then north and northwest to "the mountain" just west of Collingwood; then west to the city of Owen Sound; then north along the west side of Owen Sound; and then west along the south side of Colpoy's Bay. This escarpment was formed by the differential erosion of the hard resistant Niagara limestone and the softer Medina and Cataract shales and sandstones underlying it. This difference in erosion has left the Niagara formation standing in a steep bluff or cliff where it is not covered by glacial deposits. Along Georgian Bay there are two bluffs. The first, which borders the bay and has an elevation of 400 feet in some places, is formed from shales of the Cataract formation. Several miles farther back the Niagara limestone forms a second but lower cliff.

Nearly all of the area west and south of the Niagara escarpment is underlain by limestone and this rock has furnished the greater part of the soil material. Even in the small section where the underlying rock is shale, the rock is covered by sedimentary deposits which contain a large part of limestone material. On the other hand, glacial action has deposited sandstone and shale material over a small area of the limestone north of Hamilton.

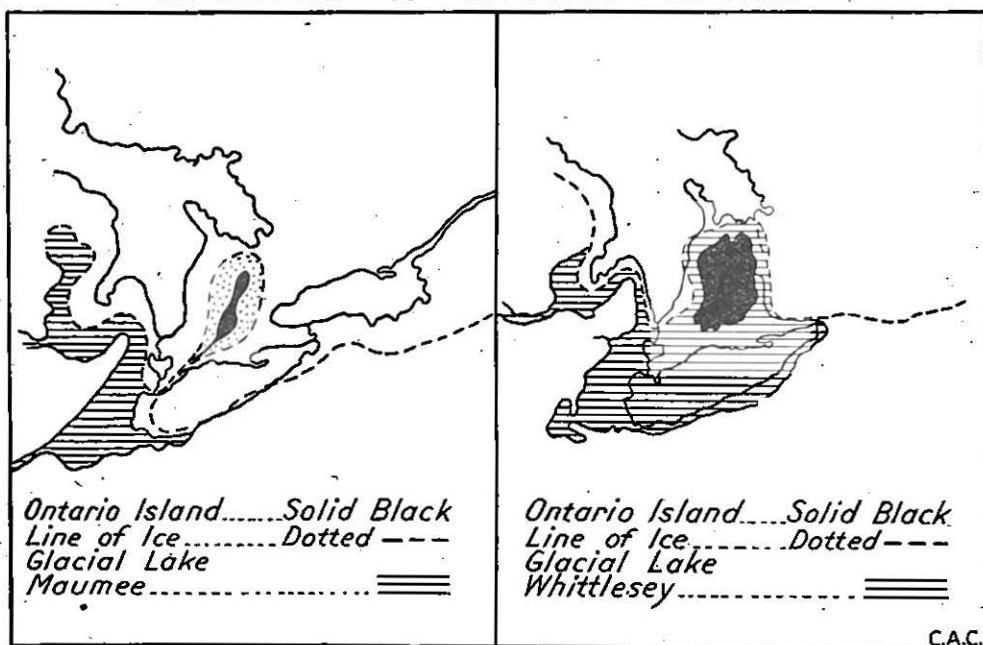
To the north and east of the Niagara escarpment and extending north to a line from Nottawasaga Bay to Lake Ontario near Oshawa, there are the Cataract, Hudson River, and Utica formations. Farther north and east, the Trenton limestone forms the country rock. In the southern part of this section, where the direction of the ice movement was from Lake Ontario inland, the soil material came from the underlying sandstones and shales. But farther north, where the direction of the ice movement was towards the south or southwest, a large part of the soil material is from the Trenton limestone lying to the north, making the soils similar to those in the areas which are underlain by limestone. A large part of the area of shale and sandstone rocks in Simcoe, Peel, York, and Ontario counties is covered by calcareous material and the soils derived from this material are typical limestone soils.

EMERGENCE OF THE HIGHLANDS.—Taylor in his book on "The Moraines of Southwestern Ontario" gives an account of the emergence of the Highlands, what afterwards became known as "Ontario Island," which was the first part of Ontario to appear above the ice sheets. Because of its interest in connection with the soils of Ontario we quote from Taylor's book an account of the probable geological origin of this section of Ontario. "When the advancing ice sheet reached the high promontory west of Collingwood, its advance was retarded at this point but continued to the east and west in two mighty lobes which are known as the Erie, Ontario and the Huron lobes. In time, however, these two lobes coalesced, covering all of southwestern Ontario and extending on into New York, Ohio and Michigan."

"The highlands between Dundalk and 'the mountain' were probably covered to a depth of two thousand or three thousand feet, but the ice remained for only a comparatively short time. The first area uncovered, however, was not at this point but farther south. Here as the melting ice became thinner, it finally ceased to move. Rivers were formed which cut deep canyons in the ice. These streams gathered up large quantities of material from the dirty ice. A large part of this material was deposited either in the stream beds or in large cavities into which the streams sometimes emptied. These deposits remain, the former as long, narrow ridges known as eskers, and the latter as hills known as kames. In time the ice disappeared from a small area of land northeast of London. Although this area increased in size as more land was uncovered to the north, it was surrounded on all sides by ice for a long time and is known as 'Ontario Island.'

"During the warm season each year the ice sheet was affected by melting, not alone along its edge, but over a marginal belt several hundreds of miles wide.

EMERGENCE OF ONTARIO ISLAND



Adapted from Smithsonian Report 1912

It is to be remembered also that great ice streams like those which flowed past this island were hundreds of feet higher along the line of their central axes than at their sides. On this account, an extensive high obstruction in the path of the ice sheet, but over which the ice moved, always caused a depression in the surface of the ice sheet, and where the obstruction was so great as the highlands between Lake Ontario and Lake Huron, it formed a correspondingly large depression. The surface of the ice sheet for fifty to a hundred miles all around sloped toward this depression, and all the water from the melting on these slopes flowed into it. It is manifest that there was no chance for an outlet for this water anywhere north of London. But along a line running southwest from London, the ice of the Huron and Erie lobes met head on. This produced a deadline in the ice and a trough or crease in its surface. This crease led southwest from London to the edge of the ice sheet and was the only possible way of escape for the water

that flowed into the depression of 'Ontario Island.' Judged by its hydrographic basin, that river, which we may call the 'Crease River,' should have been a river of large size. It was the glacial precursor of the modern Thames river."

As the ice retreat was really a series of retreats and advances, each advance being less than the preceding retreat, the size of "Ontario Island" fluctuated from time to time. There were periods when the ice front remained in one place for a long time. The ice sheet was still advancing, but it was melting just as rapidly as it advanced, and so the edge of the glacier remained at the same place. As the ice melted it deposited its load of rock debris. Where the ice front remained in one place for some time, these deposits form terminal moraines which vary from low ridges to rough, steep hills. Terminal moraines were formed during periods of retreat as well as during periods of advances, but the former were obliterated when the ice advanced again. Material deposited between the terminal moraines is known as the ground moraine. In general, a ground moraine is less hilly and contains more fine particles than a terminal moraine. The morainal soils are characterized by the presence of unsorted materials varying in size from fine clay particles to large stones, e.g., Guelph stony loam. Occasionally, ground moraines include small areas of water-laid or sedimentary soils, such as Puslinch plains near Guelph. Terminal moraines were formed on both sides of "Ontario Island." These mark different stages in the retreat of the glacier. During the retreat of the glacier a strip of land appeared between the basins of Lake Simcoe and Lake Ontario. Several moraines were formed in this region. The most important of these is the Oak Ridges moraine, which extends from the Niagara escarpment as far east as Trenton. This is one of the strongest moraines in Ontario. (See map of Moraines.) This accounts for the hilly land a short distance north of Lake Ontario.

WATER-LAID OR SEDIMENTARY SOILS.

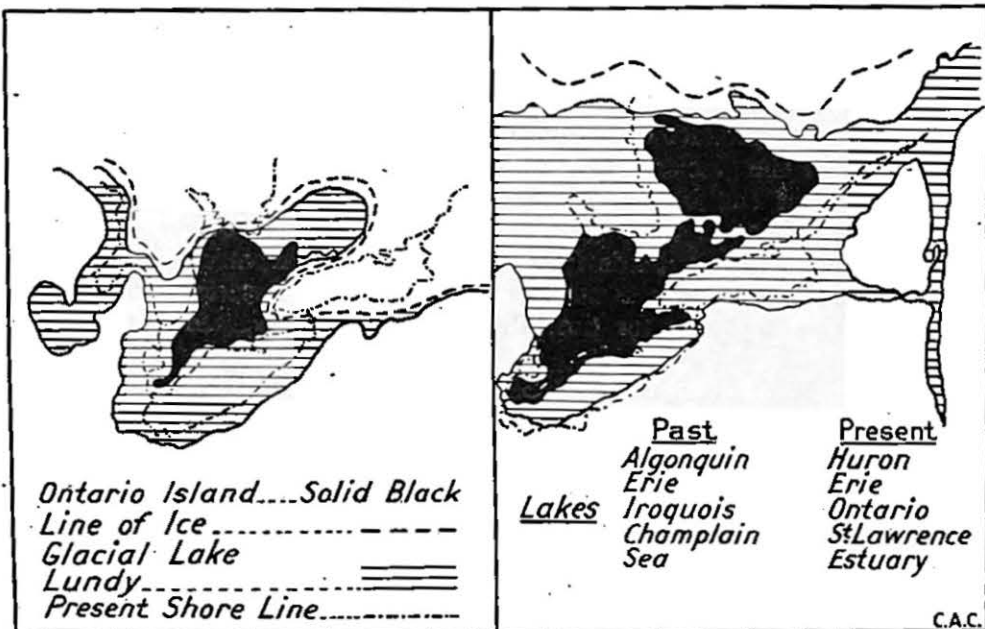
The water from the melting ice formed large lakes which changed their level as the retreat of the ice opened up new outlets. These lakes covered a large part of southwestern Ontario, including all the country from the Detroit River almost up to London; all of Niagara peninsula; a wide strip along the north shore of Lake Erie, and narrow strips along the east shore of Lake Huron and the north shore of Lake Ontario. Another area that was covered with lake waters lies between Georgian Bay and Lake Simcoe. These lakes received the waters from many large streams which were formed during the ice retreat. These streams carried vast quantities of material into the glacial lakes. The coarser particles settled near the mouths of the streams in the form of deltas, while the finer particles were carried farther away and settled in quiet water. These lacustrine or lake deposits give rise to soils having different characteristics from those derived from the glacial till of the uplands which were not laid down in water. As the former have been subjected to the sorting action of water, they have a wider variation in texture, all grades being found, from light sands to heavy clays. On the other hand, the glacial till soils are of medium texture, varying from sandy loam to clay loam. The lacustrine soils have been influenced less by the underlying rock. These two great divisions of soils form our two Soil Provinces. The areas are shown on the accompanying map.

In some sections the glacial till as well as the lacustrine deposits have been modified by wind action. Post-glacial streams are so young that their valleys are quite narrow. In some the stream occupies the full width of the valley. Others have small areas of bottom land but they are too small to indicate on the map so were not considered on the preliminary survey.

CLASSIFICATION.

Soil differences are due to two sets of factors, the character of the material out of which the soils were formed and the agencies which have changed that material from rock debris and inert plant and animal remains into a medium favourable for the growth of plants. The origin of the soil material, whether derived from crystalline rock limestone, or sandstone and shale, or a mixture of these, has an important influence on the character of the soil. The weathering of rock in place produced soils different from those formed by the weathering of glacial drift or sediments deposited in lakes or along streams. Glacial drift soils differ from lacustrine and river terrace soils. Soils formed under marsh conditions are markedly different from those formed under good drainage conditions. All of these factors must be considered in a soil survey as well as the variation in texture or difference in the size of particles.

GROWTH OF ONTARIO ISLAND



Adapted from Smithsonian Report 1912

Following the classification of the Bureau of Soils, United States Department of Agriculture, the soils of southwestern Ontario have been separated into provinces, groups, series and types.

A *Soil Province* is an area where there are similarities in the main agencies of accumulation. As previously shown, there are only two soil provinces found in southwestern Ontario, the Glacial and Loessal Province, and the Glacial Lake and River-Terrace Province. The former province is divided into two groups, the one including soils derived from limestone material, and the other, soils derived from sandstone and shale material.

A *Soil Series* is a group of soils differing in texture but having all other characteristics similar. All soils within a series are similar in colour of surface and subsoil, origin of material from which they are derived, agencies by which this material was accumulated, and differences due to variations in the process of weathering since the material was deposited. Each series is given a name, which is usually that of a town or city, township, or county, e.g., Guelph, London

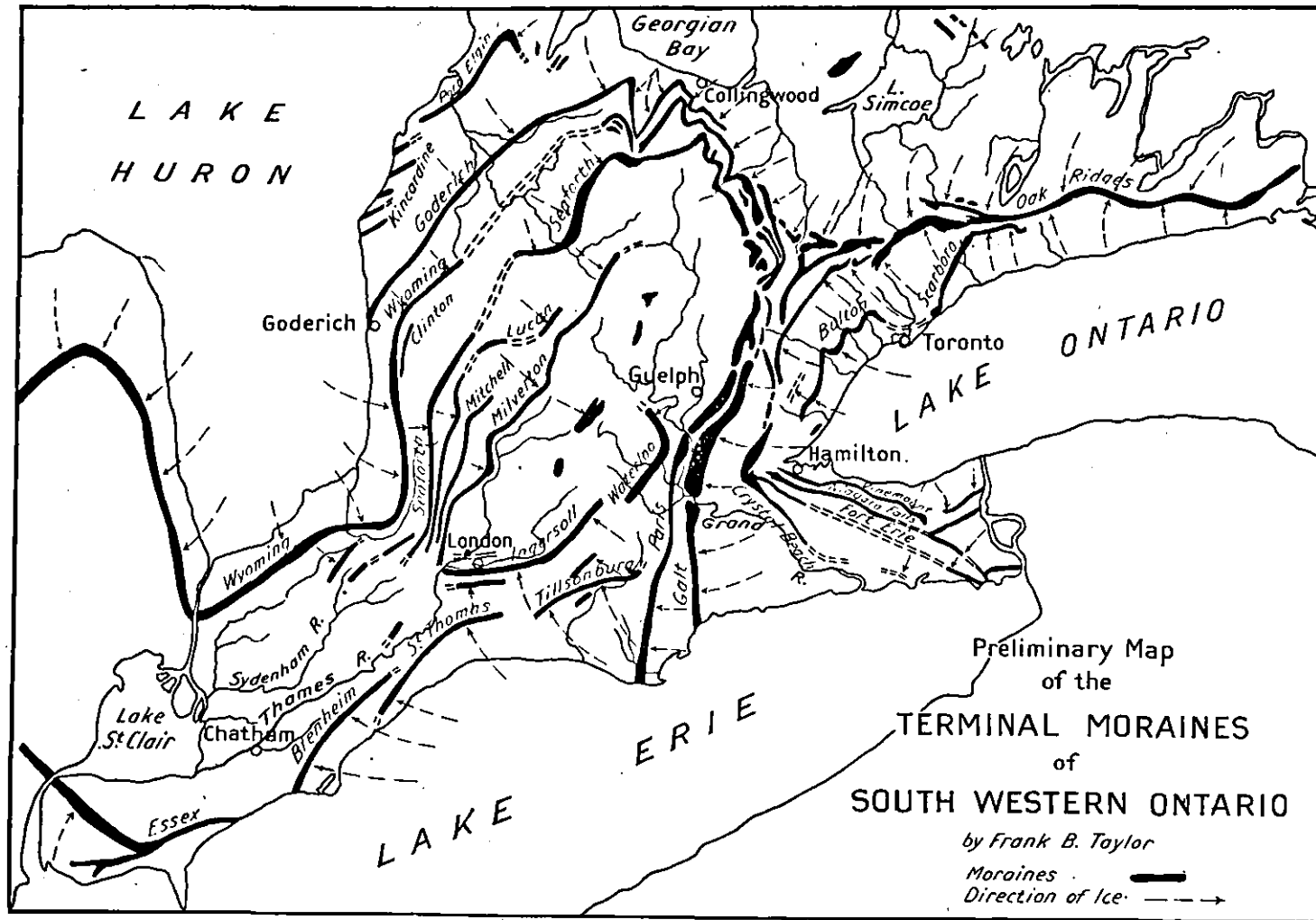
and Milton series, where one of the types within the series was first discovered. It is not a difficult matter to master this classification and be able to recognize the various series of soils.

A *Soil Type*, which is the soil unit, is a textural division within the series. All areas of soils uniform in all their characteristics are placed within the same type. According to texture, soils are divided into sands, fine sands, sandy loams, fine sandy loams, loams, silt loam, clay loam, silty clay loams and clays. The name of the soil type is the name of the textural division preceded by the name of the soil series in which it is found, e.g., Guelph sandy loam, Guelph loam, London clay loam, Clyde clay.

In the following table, the soils of southwestern and central Ontario, as found in the preliminary survey, are arranged according to province, group, series and type:—

CLASSIFICATION OF THE SOILS OF SOUTHWESTERN AND CENTRAL ONTARIO.

Province.	Group.	Series.	Type.
Glacial and Loessal Province	Glacial Limestone Group	Guelph Series	Guelph stony loam Guelph sandy loam Guelph loam
		London Series	London loam London silt loam London clay loam London silty clay loam
	Glacial Sand and Shale Group	Milton Series	Milton loam Milton clay loam Milton clay
		Lockport Series	Lockport clay
Glacial Lake and River Terrace Province	Glacial	Dunkirk Series	Dunkirk sand Dunkirk sandy loam Dunkirk loam
		Haldimand Series	Haldimand clay loam Haldimand clay
	Lake	Clyde Series	Clyde sandy loam Clyde loam Clyde clay loam Clyde clay
	Group	Warners Series Hastings Series	Warners loam Hastings stony clay loam
Organic Soils			Muck and peat.

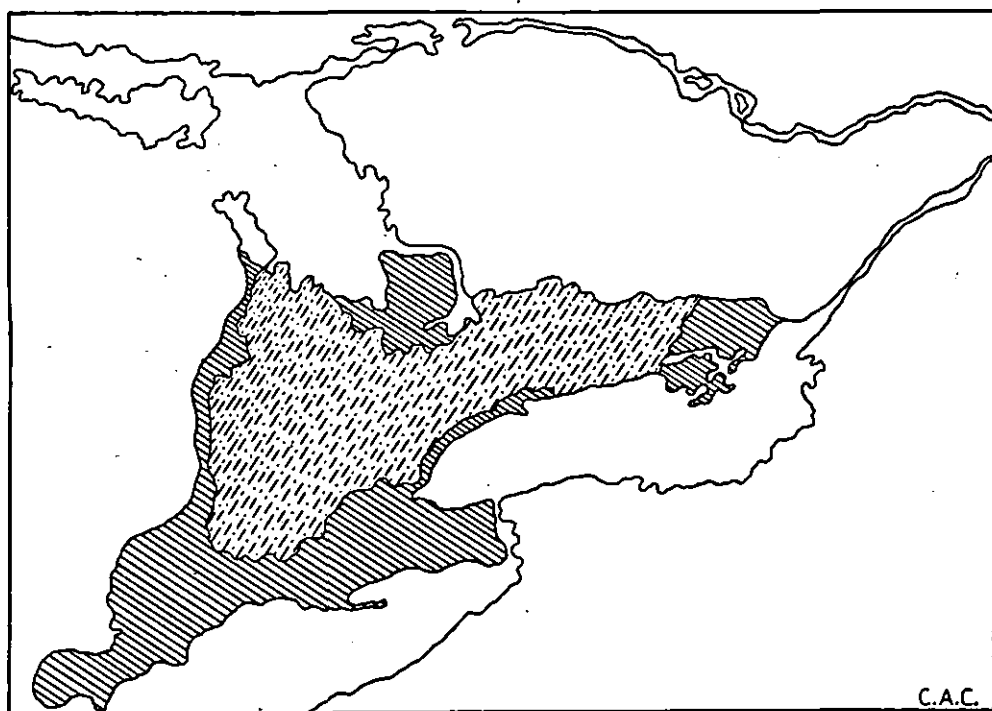


THE GLACIAL LIMESTONE GROUP.

(*Guelph and London Series.*)

The glacial limestone soils were formed by the weathering of ice-deposited calcareous material. The greater part of these soils is underlain by limestone and it is this underlying rock that has furnished most of the calcareous material which distinguishes these soils from other soils derived from ice-deposited material. There are, however, considerable areas where the underlying rock is shale and sandstone, but the soil was derived from calcareous material which was brought from a distance by the ice. In most places this calcareous material is

SOIL PROVINCES OF S.W. ONTARIO



 Glacial Lake & River Terrace Province
Series—*Dunkirk, Haldimand, Clyde, Warner, Hastings.*

 Glacial & Loessal Province
Series—*Guelph, Milton, London, Lockport.*

in the form of limestone fragments, but in northern Peel and in southern Simcoe counties there is an area where the soils contain a large amount of marl. At present there are large deposits of marl in Simcoe and in small lakes and marshes farther north. It is possible that similar deposits were formed in the same section during interglacial times, and that the advancing ice shoved this marly material before it and deposited it in the region previously mentioned.

The greater part of southwestern and central Ontario is covered by the glacial limestone soils. Only seven types were mapped but some of them are very extensive. These seven types are included in two series—the Guelph series and the London series.

GUELPH SERIES.

The Guelph series includes soils with reddish brown to chocolate brown surface soils and reddish brown to yellowish brown subsoils. In all the Guelph soils, gravel and small stones are found in the deeper subsoils, and, in many places, stratified sand and gravel. This coarse material in the subsoil gives excellent drainage and this has produced the rich brown colours of the Guelph soils.

Although the soils of the Guelph series are typical morainal soils, and are found on nearly all of the ice-laid terminal moraines in southwestern and central Ontario, they also occupy large inter-morainal areas, particularly in the northern and eastern parts of "Ontario island." It is probable that most of the material from which these soils were formed has been carried only a short distance from the places where the glacier picked it up. It is also likely that the greater part of the areas occupied by the Guelph soils is underlain by bed rock at a comparatively short distance below the surface. Small outcrops of bedrock were frequently observed, particularly in the Guelph stony loam. These outcrops are quite noticeable in northern Grey county and northwestern Wentworth county. In both sections there is a considerable area with the bedrock within three feet of the surface. These areas have the thorough drainage and rich brown colours of the Guelph soils and so they were included in that series.

The Guelph soils were formed by the weathering of glacial limestone drift under good drainage conditions. The material is practically the same as that from which the London soils were formed, but the latter soils were developed under poorer drainage conditions, which has produced soils with a lighter colour.

The surface of these soils varies from gently rolling to steep and hilly. The rougher topography is found along the stronger moraines and in places where rough preglacial topography has only been slightly modified by glacial action.

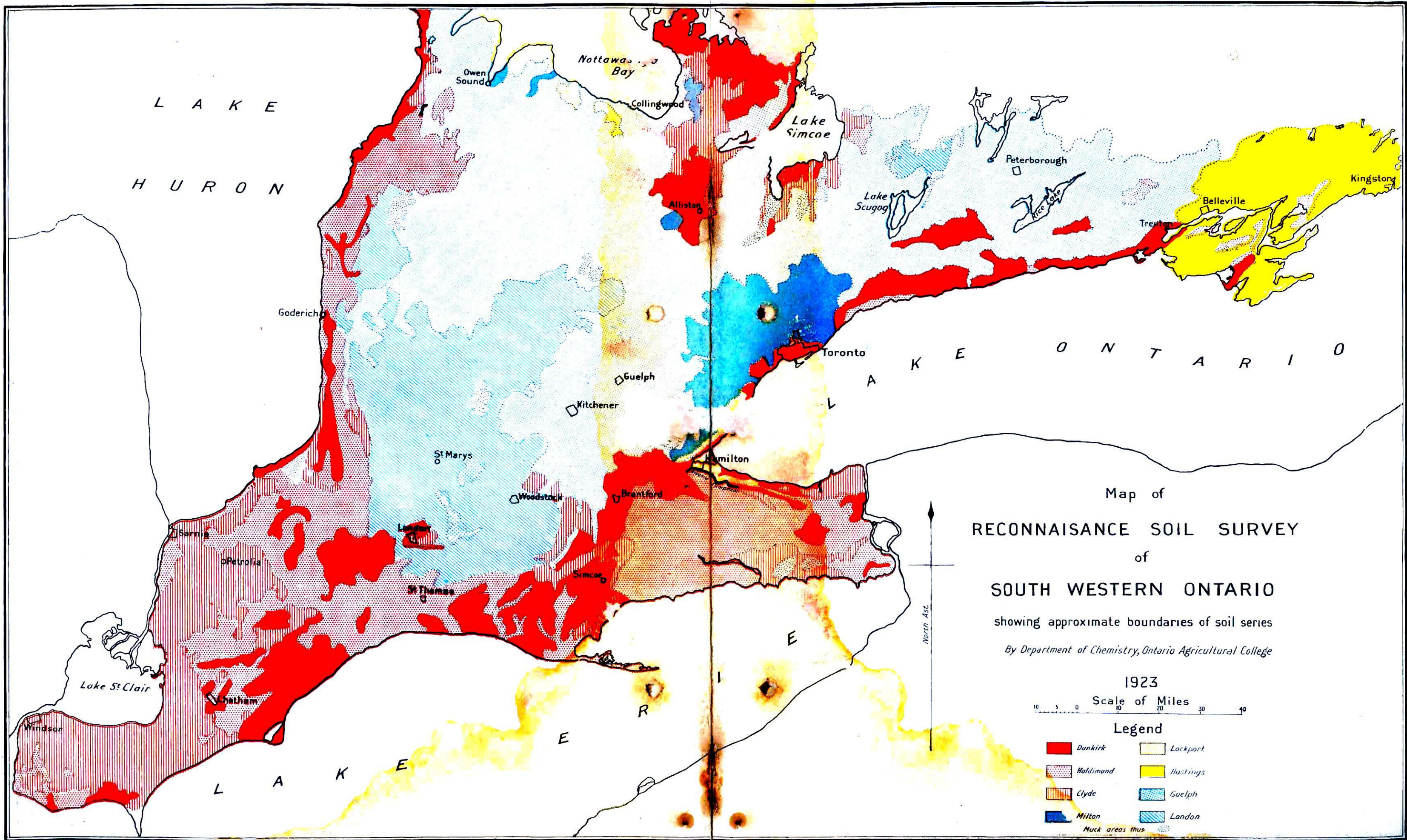
In this series three types were recognized, the Guelph stony loam, the Guelph sandy loam, and the Guelph loam.

GUELPH STONY LOAM.—The main difference between the Guelph stony loam and other types in the Guelph series is the large amount of stones in the former type. These stones vary in size from small pebbles to huge boulders. There are places where there is a large number of boulders and some smaller stones on the surface but comparatively few stones in the soil. When the surface stones are removed, these areas may be cultivated satisfactorily.

The greater part of the Guelph stony loam is found in two large areas: one covering the greater part of Grey county, and the other parts of Peel, Halton, Wellington, and Wentworth counties. Small areas are found in southern Bruce, northern Huron, and southwestern Victoria counties. All of these areas are strongly morainal and the greater part of the surface is rough and hilly.

Although the Guelph stony loam produces good crops, the large amount of stones and the rough topography make cultivation difficult. Where the amount of stones is not too great and the slopes moderate, good crops of grain and forage crops are produced. The greater part of the type, however, is best adapted to pasture.

GUELPH SANDY LOAM.—The Guelph sandy loam consists of a brown to light brown sandy loam underlain at about eight inches by a yellowish brown to reddish brown, sandy loam or sand. The sand is usually of the finer grades, fine and very fine sand predominating. Some pebbles are found in both surface and subsoil, but the amount is usually greater in the subsoil.



Map of
RECONNAISSANCE SOIL SURVEY
 of
SOUTH WESTERN ONTARIO
 showing approximate boundaries of soil series
By Department of Chemistry, Ontario Agricultural College

1923
 Scale of Miles
 0 5 10 20 30 40

- Legend**
- Dunkirk
 - Lockport
 - Haldimand
 - Hastings
 - Clyde
 - Guelph
 - Milton
 - London
 - Muck areas thus

West of Lake Simcoe and south of Barrie there is a large area with a sandy loam surface underlain, at twelve to fifteen or twenty inches, by a clay loam. This clay loam subsoil is similar to that found in the London clay loam. The Guelph sandy loam was formed of the unaltered glacial limestone material. There are indications, however, that in some places at least the material from which this soil was derived contains a larger percentage of non-calcareous material than is the case with the other limestone soils.

In some sections, particularly in southern Simcoe and northern Peel counties, the calcareous material is not limestone fragments, but marl.

The largest area is found in Northumberland, Hastings, Peterborough, Victoria, and Durham counties, and the other large areas around Hespeler and Preston in Waterloo county, and between Paris and Woodstock farther west. Smaller areas are found in Huron, Bruce, Grey, and Wellington counties.

The light texture and thorough drainage make the Guelph sandy loam a good soil for fruit and vegetables in the southern sections. Potatoes do well, and more of this crop should be grown. The steeper slopes erode badly and they should be kept in pasture.

GUELPH LOAM.—The Guelph loam consists of a brown to lightly reddish brown loam, changing to an average depth of ten inches to a reddish brown or yellowish brown loam. There are usually a few pebbles and small stones on the surface soil, but considerably more in the subsoil. The amount of pebbles usually increases with depth. In many places, pebbles are so thick within sixteen to twenty inches of the surface that it is impossible to bore deeper with a soil auger. This soil was formed by the weathering of glacial limestone drift under good drainage conditions.

This is the most extensive type of the Guelph series. It extends in a broad belt from Wingham and Walkerton on the west, to Creemore and Shelburne on the east, then turns south and extends in that direction past Guelph and Galt to the border of the old lake bed south and east of Paris. Other large areas are found between Lake Simcoe and Lake Scugog, between Lake Scugog and Lake Ontario and along the Trent River south of Campbellford. Smaller areas are found in Brant, Oxford, Middlesex, Perth, Wellington, Victoria, Peterborough, Durham, Northumberland and Hastings counties. Most of the smaller areas are found on small moraines and eskers, but the large area occupies intermorainal areas as well as the moraines.

The rough areas, which are found on the Wyoming, Waterloo, Paris, and Oak Ridges moraines, are rather extensive, yet they form only a small part of the type.

This is an excellent soil for all crops grown in this section. The light texture makes it easy to cultivate and the good natural drainage removes excess water quickly so crops may be planted early in the spring.

LONDON SERIES.

The London series includes soils with grayish brown to brownish gray surface soils. The dry surface soil in plowed fields appears quite gray, but the moist soil is always a grayish brown or brownish gray. Beneath the surface layer there is a subsurface layer of yellowish brown material which grades into a yellow brown and gray mottled heavy clay loam or clay subsoil. This impervious subsoil, which prevents adequate underdrainage and makes the soils wet and cold, is one of the distinguishing characteristics of the London soils. In all the London types, many limestone pebbles are found in both surface soil and subsoil,

the amount usually being greater in the subsoil. The amount, however, is not sufficient to materially affect the drainage.

The London series occupies the greater part of Middlesex, Perth, and Oxford counties. This series, like the Guelph series, was formed from glacial limestone material, but the differences in drainage in these two series have produced soils differing greatly in many respects. With the exception of a few rough, hilly morainal areas between Clinton and Wingham, where the soils have an impervious subsoil and so are classed with the London types, all of the London soils have gently undulating to rolling topography.

Four types were recognized in the London series: the loam, the silt loam, the clay loam, and the silty clay loam. The clay loam is the most extensive, having a greater area than all the other types combined.

LONDON LOAM.—The surface of this type is gently undulating to gently rolling. It is found associated with the Guelph loam and occupies depressions between ridges of that type. Many small areas are found in the section between Guelph and Fergus and east of Grand River. Only two of these areas were large enough to show on the map. The others are so small that they could not be shown separately, so they are included in the Guelph loam.

Although less desirable than the better-drained Guelph loam, this type is a good soil for general farming and stockraising.

LONDON SILT LOAM.—The surface is gently undulating to rolling. A large number of narrow morainal ridges are found. The higher part of these ridges is Guelph loam, while the lower slopes are occupied by London silt loam. With the exception of these ridges, London silt loam occupies the greater part of these areas, although there are a few small spots of London loam on the tops of some of the low ridges and some small areas of London clay loam in low places and on some of the higher ground where the surface has been washed away.

Typically, the London silt loam consists of a brownish gray to yellowish gray silt loam, changing at an average depth of eight inches to a light yellow to yellowish gray silt loam. At an average depth of fifteen inches, this subsurface layer is underlain by a gray, yellow, and brown mottled clay loam. Small limestone pebbles are found in the subsoil, and, in a few places, in the surface soil.

Two large areas of the London silt loam were mapped. The larger one, which lies between Stratford and Clinton, occupies a large part of McKillop, Logan, Ellice, Tuckersmith, Hibbert, and Fullarton townships, and a small part of Downie township. The other area occurs north of London and Missouri West townships.

Like the other types in this series, the London silt loam was developed by the weathering of glacial limestone drift, under moderately poor drainage conditions. Artificial drainage is needed to remove excess water during wet seasons. On account of the lighter texture, this type is easier to cultivate and is a little earlier than the London clay loam. Both are well adapted to the growth of grains and grasses and are good soils for general farming and stockraising.

LONDON CLAY LOAM.—The London clay loam consists of a grayish brown heavy loam to clay loam underlain at about eight inches by a yellow brown and gray mottled clay loam which gradually becomes heavier with depth grading into a bluish gray and brown mottled clay at sixteen to twenty-four inches. Some limestone pebbles are invariably found in the subsoil and they are frequently found in the surface soil. The dry surface soil, as it appears in ploughed fields, is quite gray, but the moist soil is a grayish brown.

Small areas of Guelph loam are found on narrow moraines and eskers within the areas of London clay loam. Although these ridges are quite distinct they

are too small to show on the preliminary map. Several of these areas are found in Arthur, Maryborough, Elma, Downie, and Oxford townships. Small areas of the London silty clay loam, which are included in the London clay loam, are found in Peel township.

The London clay loam, which is the most extensive of the London types, occupies the greater part of Oxford, Middlesex and Perth counties, a large part of Wellington and Huron counties, and small areas in Bruce, Waterloo, Dufferin, and Brant counties.

This type was derived from glacial limestone drift. With the exception of a few areas on the terminal moraines in Huron and Bruce counties, all of the London clay loam occupies ground moraine or inter-morainal country and the surface is gently undulating to rolling. Most of the type has sufficient relief for good surface drainage, but the heavy subsoil prevents rapid removal of the water in wet seasons. Artificial drainage will improve this condition but open ditches may be necessary in some places as tile may not draw in the heavy subsoil.

This type is best adapted to general farming and stockraising. Cereals and forage crops do well.

LONDON SILTY CLAY LOAM.—The London silty clay loam is a grayish brown silty clay loam changing at six to eight inches to a bluish gray mottled with yellowish brown silty clay loam or silty clay, which changes at an average depth of twenty inches to a bluish gray and yellowish brown mottled silty clay containing some white or light gray spots of partially decomposed limestone. Many undecomposed limestone fragments are also found, usually beginning at about twenty inches below the surface.

The material from which this soil was formed appears to have been deposited in a temporary lake which was formed during the early stages of "Ontario Island." In texture this soil resembles the heavier phases of the Clyde clay loam found in depressions on the upland, but, on account of the light-coloured surface and the large amount of lime present, its characteristics are similar to those of the London series and so it is classified with the London types.

This type appears in a large area in Mornington, Wellesley and Maryborough townships. The type was also encountered on the east side of the Conestogo River in Peel township, but the areas are so small that they could not be shown on the map, so they were included in the London clay loam.

The surface of this type is gently undulating. There is sufficient relief for fair surface drainage, but the heavy character of the soil makes artificial drainage necessary to remove excess water quickly.

This is a good soil for general farming and stockraising. Cereals and forage crops produce well.

GLACIAL SHALE AND SANDSTONE SOILS.

With the exception of a small area near Hamilton, where the ice deposited shale and sandstone material upon the limestone rock, all of these soils are underlain by shales and sandstones. These underlying rocks have furnished a large part of the soil material and the weathering of this material has produced soils which differ markedly from the glacial limestone soils.

The glacial shale and sandstone soils occupy a large area on the north side of Lake Ontario. This area lies south of the Oak Ridges moraine and extends from Hamilton to the York-Ontario county line. In this region the movement of the ice was from the Ontario basin inland, and the soil material was derived from the underlying rocks. Farther north the direction of ice-flow was south

to southwest, and, as already mentioned, a large part of the soil material is limestone from the Trenton limestone to the north and east; and marl, which probably came from deposits in shallow lakes and marshes similar to those found in central Simcoe county at the present time. In central and northwestern Simcoe county, a large area is underlain by shales and sandstone, but the glacial deposits were modified by glacial lake waters. On the north side of Niagara peninsula the greater part of the shale and sandstone material has been covered by lacustrine deposits, but a few small areas have been modified to only a slight extent, so they are included in the glacial shale and sandstone soils. Several large areas of these soils are found in Grey county just below the Niagara escarpment.

Two series, the Milton series and Lockport series, are included in the glacial shale and sandstone soils.

MILTON SERIES.

The soils of the Milton series were formed by the weathering of glacial shale and sandstone drift. There is a slight admixture of granitic material, and, in some places, a few limestone pebbles, but the greater part of the soil material came from the underlying shales and sandstones, and a large number of small fragments of these rocks are found in both surface soil and subsoil.

This series includes soils with light brown to brownish gray surface soils, and brown or drab, mottled with bluish gray, subsoils. The colours are similar to those found in the London soils, but, as a general rule, in the Milton series, the colours are not so bright as in the London soils. These soils generally have fairly good surface drainage but poor underdrainage.

The Milton soils occupy a large area in the central and southern parts of Halton, Peel, and York counties. Smaller areas are found in Grey, Simcoe, Wentworth and Ontario counties.

Three types are included in this series, the Milton loam, the Milton clay loam, and the Milton clay.

MILTON LOAM.—The Milton loam consists of a light brown heavy loam underlain, at an average depth of eight inches, by a yellowish brown or drab, mottled with bluish gray heavy loam. This subsoil layer becomes heavier with depth grading into a clay loam or clay at ten or twelve inches below the surface.

The Milton loam occupies a large area of undulating to gently rolling land in southern York county. Smaller areas are found in Wentworth, Halton, Peel, Dufferin, Simcoe, and Grey counties.

This type produces good yields of grain and hay and is a good soil for general farming.

MILTON CLAY LOAM.—The Milton clay loam consists of a light brown to brownish gray clay loam underlain, at an average depth of eight inches, by a light brown or drab, mottled with bluish gray heavy clay loam to clay. The texture becomes heavier with depth and the bluish gray colour becomes more prominent. In some places ochreous yellow iron stains are found and occasionally some white or gray lime concretions. These lime concretions are usually found at thirty to forty inches below the surface.

The Milton clay loam occupies a broad belt extending across the southern and central parts of Halton and Peel counties and across the south central part of York county. Smaller areas are found in the northern part of Grey county and in central and southern Simcoe county.

Although the heavy subsoil is almost impervious to water, making the soil wet and cold in the spring, good yields of grain and hay are produced. This is a strong soil and it is adapted to general farming and stockraising.

MILTON CLAY.—The surface soil of the Milton clay, to an average depth of eight inches, is a grayish brown to brownish gray heavy, silty clay loam or clay. The subsoil is a bluish gray, brown, and drab mottled heavy, silty clay or clay. The surface is flat and poorly drained. Only two small areas of Milton clay were mapped and these include small areas of the Milton clay loam. These two areas are found along the Peel-York county line.

This soil is best adapted to the growth of grass.

LOCKPORT SERIES.

The Lockport series includes soils with reddish gray to reddish brown surface soils and Indian red subsoils. As a general rule, the soil material is thin and has been derived from the underlying shales, which are frequently within three or four feet from the surface. There is a slight admixture of the other material brought in by the ice or the glacial lake waters; but the amount is so small it has had only a slight influence on the character of the soil. In Ontario, the greater part of the area lies above the highest level of lake waters, so this series has been placed in the glacial shale and sandstone group.

Only one type, the Lockport clay, was mapped in southwestern and central Ontario.

LOCKPORT CLAY.—The Lockport clay consists of a reddish gray to reddish brown, heavy, silty clay loam to silty clay, underlain at six to eight inches by an Indian red, heavy, compact, unctuous, silty clay. Bedrock is usually near the surface, in some places within the three-foot section.

The principal areas of this type are found between Owen Sound and Collingwood. All of these areas are at a considerable elevation above Georgian Bay, and most of them are rough and hilly. A long, narrow strip extends from a few miles north of Owen Sound to a few miles west of Cape Commodore. Smaller areas are found along the north side of Niagara peninsula between the escarpment and Lake Ontario and north and east of Hamilton. The surface of these areas is undulating to rolling.

The Lockport clay is a rather poor soil, especially north of Owen Sound and between Owen Sound and Collingwood where the soil is very shallow. The heavy clay subsoil retains moisture for a long time, making the soil wet and cold in the spring. When it does dry out, it bakes and forms clods which are difficult to handle. There are some good vineyards on this type, but, as a general rule, it is not a good soil for grapes or any other kind of fruit. It is best adapted to grass, but, in the more hilly sections, the slopes are badly eroded and grass does not grow well on the heavy clay subsoil.

GLACIAL LAKE SOILS.

When the ice retreated, large lakes were formed, which covered a large part of southwestern and a smaller area in central Ontario. Large rivers were developed, and these streams gathered up large quantities of rock material from the dirty ice and carried it into these glacial lakes. Most of the coarse material, such as gravel and sand, was deposited as deltas near the mouths of the streams, while the finer material was carried farther away and deposited in quiet waters. Some coarse material was deposited as long, low ridges along the lake shores. Several of these beach ridges mark former shore lines. Some of the terminal moraines were deposited in the lake and were reworked to some extent by the water. Some sand dunes have been formed by the action of the wind on the

coarser material in deltas, moraines, and beach deposits. These, however, are not important except in some areas along the present lake shores. All of the soils derived from glacial material which has been reworked by water and deposited in the lakes, has been grouped in the glacial lake province.

The glacial lake soils include not only soils lying within the old lake bed but also some areas on the upland which were formerly ponds or marshes. Other areas, where the action of the wind has produced sand dunes, having characteristics similar to those in the lake bed, are also included with the glacial lake soils. A few smaller areas, within the old lake bed, are grouped with the glacial drift soils, because the soil material is glacial drift which has not been modified by lacustrine sediments. The most of these areas are in Huron and Bruce counties, where the surface is rolling. Only a few glacial streams emptied into the lake in this section, and the ice remained for a much longer time than farther south. On this account the waters remained for a comparatively short time, and areas at some distance from the glacial streams received only a thin deposit of sediments. The rolling topography has favoured erosion, which has since removed the lacustrine material from some areas, and exposed the drift material from which the soils have been formed.

The glacial lake soils are found in southwestern and central Ontario and include eleven types. These are grouped in five series: the Dunkirk, the Haldimand, the Clyde, the Warners, and the Hastings series.

DUNKIRK SERIES.

The Dunkirk series includes brown to light brown or yellowish gray soils with reddish brown, yellowish brown, or yellow subsoils. Although this series is classed as Glacial Lake series, there are some areas of dune sand on the upland which resemble the dune sand within the old lake bed so much that they are also included in the Dunkirk series. The lacustrine material, which has given rise to Dunkirk soils, was deposited along the present, or along previous, lake shores, in waterlaid moraines, and as deltas where the glacial streams emptied into the lakes. Some of this material, particularly in some sections along the present lake shores, has been reworked by wind.

These soils are found along the shores of Lakes Huron, Erie and Ontario, in places where large quantities of beach sand have been deposited, along former beaches in the old lake bed, along waterlaid moraines, and in delta deposits where glacial streams emptied into the lake. Large areas are found in Bruce, Huron, Middlesex, Lambton, Essex, Kent, Elgin, Norfolk, Brant, Wentworth, Lincoln, Welland, Simcoe, York, Ontario, Durham, and Northumberland counties. Most of the upland dune sand is found in east Dufferin, south Simcoe, north Peel, north central York, central Ontario, central Durham, and central Northumberland counties.

As the Dunkirk series includes only well-drained soils with thoroughly oxidized subsoils, only the lighter-textured types are found. Sand or gravel is usually found within three or four feet of the surface. Three Dunkirk types are mapped: the Dunkirk fine sand, the Dunkirk sandy loam, and the Dunkirk loam.

DUNKIRK FINE SAND.—The Dunkirk fine sand consists of a yellowish gray to light brown fine sand, changing, at four to eight inches, to a yellowish brown or reddish brown fine sand. Except near areas of other types, the subsoil is generally uniform in colour and texture to a depth of three feet or more. This soil is easily blown about by the wind where it is not covered with vegetation.

The greater part of this type was derived from glacial drift reworked by water. These areas were deposited as deltas, water-laid moraines, and beach ridges. Large areas of this type are found in Simcoe, Dufferin, York, Ontario, Durham, Northumberland, Peel, Welland, Brant, Norfolk, Elgin, Kent, Essex, Lambton, Middlesex, and Bruce counties.

The thorough drainage, and open, porous condition of the soil makes this type an excellent soil for vegetables, small fruits, beans and potatoes, wherever the topography is not too rough and there is sufficient organic matter present to bind the soil together. Apples and peaches also do well. There are, however, large areas where there is very little organic matter in the soil and it blows readily. In these sections, more organic matter will have to be incorporated in the soil. Sand-binding grasses should be planted and the surface kept covered with vegetation as much as possible. The rough topography along the sand dunes makes these areas hard to manage.

DUNKIRK SANDY LOAM.—The Dunkirk sandy loam consists of a brown sandy loam which changes, at six to ten inches, to a light brown or yellowish brown sandy loam. In many places the subsoil contains considerable gravel and small stones. This gravelly layer may appear within twenty inches of the surface, but frequently no stone or gravel is found within the three-foot section.

The dry surface soil, as it appears in ploughed fields, varies from yellowish gray to light brown, but the moist soil is always brown.

The principal areas of the Dunkirk sandy loam are found between Hamilton and Brantford, south of Brantford and Paris, southwest of London, south and west of Collingwood, in the Beaver and Bighead valleys in Bruce and Huron counties, in northeastern and south central Simcoe, northern Ontario, south Durham and south Northumberland counties.

This soil is best adapted to truck and fruit-growing. Apples, peaches, grapes, vegetables and potatoes are grown and all produce well on this soil.

DUNKIRK LOAM.—The surface soil of the Dunkirk loam is a light brown to brown friable loam, varying in depth from six to ten inches. The dry soil, as it appears in ploughed fields, is yellowish gray, but the moist soil is always a light brown or brown. The texture varies from a heavy loam or silty loam to a light loam. In Bruce county, considerable stone is found in this type.

The principal areas of the Dunkirk loam are found south and east of Collingwood, in the Beaver and Bighead valleys, southwest of Owen Sound, near London, around Brantford, south and west of Hamilton, along the north side of Niagara peninsula, partly above and partly below the escarpment, around Lake Simcoe and along the north shore of Lake Ontario, west of Port Hope.

Although this is a good soil for general farming, it is best adapted to truck and fruit-growing. Good crops of vegetables, potatoes, apples, peaches and grapes are produced.

HALDIMAND SERIES.

The Haldimand series includes soils which have grayish brown to brownish gray surface soil; and gray to bluish gray, mottled with brown, subsoils. These soils were formed from glacial lake sediments deposited in quiet water. Although the surface has sufficient relief for fair surface drainage, thus preventing an accumulation of organic matter, the subsoil is so heavy that water does not move through it readily. On this account these soils are wet and cold in the spring.

These soils occupy the greater part of the Niagara peninsula, and a large part of the old lake bed in Bruce and Huron counties. Large areas of Haldimand soils are also found in Lambton, Middlesex, Elgin, Kent and Essex counties.

Two types in this series were recognized, the Haldimand clay loam, and the Haldimand clay.

HALDIMAND CLAY LOAM.—The Haldimand clay loam consists of a grayish brown to brownish gray clay loam, underlain, at six to nine inches, by a gray to bluish gray, mottled with yellowish brown, clay loam, which becomes heavier with depth, and changes, at fifteen to twenty-two inches, into a bluish gray and yellowish brown mottled clay. On account of this heavy clay subsoil, water drains away very slowly, making the soil cold and wet even where the slopes are moderately steep. With the exception of a few places where stream erosion has formed steep slopes, all of this type has a gently undulating to rolling surface.

The Haldimand clay loam occupies large areas in Bruce, Huron, Middlesex, Lambton, Essex, Kent, Elgin, Brant, Wentworth, Lincoln, and Welland counties.

On account of the impervious subsoil, this is a wet, cold soil and artificial drainage is advisable to remove the excess water. This type is best adapted to the growth of cereals and forage.

HALDIMAND CLAY.—The Haldimand clay consists of a grayish brown, heavy clay loam to clay underlain, at six to eight inches, by a bluish gray mottled with yellow and brown unctuous clay. In general, the texture gradually becomes heavier with depth and the yellow mottlings are replaced by brown. In some sections there are white limestone spots at thirty to forty inches below the surface. Very little sand is found in either surface soil or subsoil.

As a general rule there is a great depth of lacustrine sediments in all the areas of Haldimand clay, but in a few places, such as that near Hagersville, there are only a few inches of soil material upon the solid limestone rock. These areas are a gradation toward Hastings stony clay loam.

This type was formed from glacial lake deposits, and, like the Clyde clay, includes only the fine sediments. The surface, however, is not flat like the Clyde clay, but gently undulating to rolling, except in eroded areas near the streams where the slopes are steep and broken. Although the soil material is largely limestone, some shale and sandstone material is included. The presence of the latter is especially noted in Bruce county along the Saugeen river, where material from the Cataract formation has given a distinctly reddish tinge to the subsoil. There are also a few places in Welland county where Medina shale material has given a reddish tinge to the soil.

This type occupies almost all of Haldimand county and the greater part of Welland county. Large areas are also found in Lincoln, Wentworth, Elgin, Essex, Lambton, Middlesex, Huron, and Bruce counties.

The heavy texture makes this soil difficult to work. It retains water for a long time after it becomes wet, and, when it does dry out, soon becomes so hard that the plough turns up great clods. Artificial drainage is advisable and more organic matter should be incorporated in the soil to improve its physical condition. This type is best adapted to the growth of forage crops. In some places alfalfa does well.

CLYDE SERIES.

The Clyde series includes soils with dark gray to black surface soils, and yellowish gray, and blue to bluish gray and drab mottled subsoils. As a general rule, the lighter-textured members of the series have the yellowish gray and gray subsoils, and the heavier-textured ones the bluish gray and drab.

Like the Dunkirk and Haldimand types, these soils were derived from reworked glacial drift material deposited as sediments in glacial lakes. The different conditions under which they were formed, however, has produced soils

with markedly different characteristics. In the Dunkirk, the undulating surface and the porous subsoil have produced soils with the rich brown colours which show good drainage and thorough oxidation. The undulating to rolling surface and the heavier subsoil of the Haldimand series have produced the gray and dead-brown colours found in poorly-drained soils which are low in organic matter. The Clyde soils, however, were developed in flat areas where water stood for a large part of the year. This has favoured the accumulation of a large amount of organic matter which gives the dark colour to the surface soils of the Clyde series. On the upland, many depressions, which were formerly lakes or ponds, have been partially filled by an accumulation of organic matter mixed with more or less inorganic material washed in from the surrounding slopes. In some of these areas the amount of organic matter is very high, forming muck or peat, but, in others, there is only sufficient organic matter to produce eight to twelve inches of dark gray to black material on the surface. In the latter areas the soil does not differ greatly from the Clyde soils in the old lake bed, so they are included with those in the Clyde series.

Nearly all of Essex county and a large part of Kent and Lambton counties are included in this series. Large areas are found in northern York, western Simcoe, western Bruce, southwestern Huron, and central Perth counties, and in the Niagara peninsula.

CLYDE SANDY LOAM.—The Clyde sandy loam consists of a dark brown to black sandy loam, which changes, at six to twelve inches, to a yellowish gray sandy loam. This subsurface layer is underlain at about fifteen to twenty inches by a yellow brown and gray mottled subsoil, which varies in texture from a clay loam to a sand. In some places the subsoil is a gray sand.

The dry surface soil is brown, but when moist it is a dark brown to black. The darker areas are found where a thin layer of muck has been mixed with the underlying sandy loam material, thus forming a black sandy loam.

The texture varies, in the surface soil, from a fine sandy loam to a sandy loam, in the subsurface soil, from a sandy loam to a clay loam. Part of the area south of Windsor has considerable gravel in the subsoil.

This soil is derived from glacial drift material which has been reworked by water. It occupies small depressions and larger flat areas where poor drainage has favoured the accumulation of organic matter. Small ridges of Dunkirk sand and Dunkirk sandy loam are often included in this type, as they are too small to show separately. Near Lake St. Clair there is an area mapped as Clyde sandy loam. A large part of it is uncultivated, and has from four to six inches of muck on the sandy loam material. The cultivated part is a brown to black sandy loam and cultivation will soon bring the other part into the same condition, so the entire area is mapped as the Clyde sandy loam.

This type occurs in Essex, Kent, Lambton, Huron, Bruce, Middlesex, Elgin, Norfolk, Simcoe, York, Haldimand, Welland, and Lincoln counties.

When drained, this is an excellent truck soil. It is especially well adapted to the growth of onions and celery. An area at Hepworth, near Warton, is devoted to the growing of potatoes.

CLYDE LOAM.—The Clyde loam is a dark brown loam underlain, at six to twelve inches, by a bluish gray and yellowish brown mottled loam which changes, at sixteen to twenty-four inches, to a bluish gray and yellowish brown mottled heavy loam to clay loam containing some sand pockets and, in some places, a few pebbles.

The principal areas of Clyde loam are found in western Simcoe county and

in the Niagara peninsula. Small areas are found in other sections of the old lake bed.

This type is adapted to general farm crops and, when well drained, is a good truck soil.

CLYDE CLAY LOAM.—The Clyde clay loam consists of a dark gray to almost black clay loam underlain, at six to twelve inches, by a bluish gray mottled with yellowish brown clay loam which becomes heavier with depth, grading into a clay at fifteen to twenty-four inches below the surface. In many of the larger areas there is a narrow border of this Clyde clay loam surrounding an area of muck. In some, however, the muck has been burned off, leaving a dark gray to black clay loam which is almost heavy enough, in some places, for a clay. All the larger areas of Clyde clay loam include some small areas of muck. In all cases, the chief characteristics are the poor drainage and the high percentage of organic matter.

Large areas of this type are found in Perth county. Smaller areas are found in various places in the old lake bed and in areas of the London clay loam. Small depressions in the London clay loam invariably have Clyde clay loam, while similar depressions in areas of the Guelph loam are occupied by muck. Seepage from the well-drained Guelph loam has kept the low places wet, thus forming a sufficiently large accumulation of organic matter to form a muck.

All of the areas of Clyde clay loam are in need of drainage. Many cannot be cultivated until drained. This is a rich soil and when well drained produces good crops of grain and hay.

CLYDE CLAY.—The Clyde clay consists of a dark gray to almost black heavy, silty clay loam to silty clay underlain, at six to ten inches, by a bluish gray to drab heavy clay or silty clay which is sometimes mottled with red and yellowish brown spots. The amount of mottling may become greater or less with depth but the change is gradual.

Nearly all of Essex and a large part of Kent and Lambton counties are included in the Clyde clay. Other areas of this type are found in Huron, Elgin, Middlesex, Haldimand, Welland, and Lincoln counties.

This is a rich soil, but the flat surface and heavy soil makes artificial drainage necessary if maximum yields are to be produced. Some areas are so very wet that they cannot be cultivated until they are first drained. A large area south of Lake St. Clair is only slightly higher than the lake and the water can be removed only by pumping from the drainage canals into the lake. When drained, the Clyde clay produces good yields of corn and hay.

WARNERS SERIES.

The Warners series includes soils with dark brown to black surface soils and gray, marly subsoils. These soils occupy flat, marshy areas where there has been a large accumulation of marl, in part by the deposition of calcium salts by plants and in part by the accumulation of shells of snails and other land animals. There is also a large accumulation of organic matter which gives the dark colour to the surface.

Only one type, the Warners loam, has been mapped in southwestern and central Ontario.

WARNERS LOAM.—The Warners loam is a dark brown to black loam underlain, at an average depth of eight to twelve inches, by a layer of white or gray marl.

The typical subsoil is almost a pure marl, but, near areas of other types,

considerable sand, silt, and clay has been mixed with the marl. The depth of marl is more than forty inches in most places, but is frequently only a few inches deep near areas of other types. In a few places, several inches of marl were found immediately below the surface soil, then a layer of clay loam, and then another layer of marl.

This soil was derived from marl deposits mixed with a small amount of lacustrine sediment and a large accumulation of organic matter.

The only areas of this type found in southwestern and central Ontario are in Simcoe county near the Nottawasaga river. One of the areas surrounds a small lake known as Marl Lake. The shores of this lake are covered with marl, and it is quite evident that the surrounding area was once a part of the lake. The lake has been gradually filled by the deposits of marl and the sediments washed in from the surrounding higher ground. Plants have grown in the shallow water along the border of the lake, advancing farther and farther from the shore as the water has gradually become shallower. The partly decomposed remains of these plants give the dark colour to the surface soil. The history of the other areas has probably been similar except that the process has gone farther and the lakes have become entirely obliterated.

HASTINGS SERIES.

The Hastings stony clay loam includes gray to brown soils which were derived from a thin layer of lacustrine sediments deposited on limestone rock. The soil material varies from six to fifteen inches deep, and the underlying rock is partially decomposed in many places, and many rock fragments are found in both soil and subsoil. It seems quite certain that the soil material is partly residual material from the underlying rock and partly lacustrine sediments.

We have mapped large areas of this soil series in Lennox and Addington, Hastings, Prince Edward, and Bruce counties. Apparently these soils were formed where the ice removed almost all of the unconsolidated material, and the lake waters, which afterwards covered them, deposited only a slight amount of lacustrine material. Only one type, the Hastings stony clay loam, was mapped on the preliminary survey. There are, however, areas which are fairly light in texture, and it is probable that a more detailed investigation will show some small areas of Hastings loam.

HASTINGS STONY CLAY LOAM.—The Hastings stony clay loam consists of a gray to brown clay loam underlain, at an average depth of eight inches, by a brown to drab heavy clay loam. Both soil and subsoil contain a large amount of limestone fragments, and solid limestone rock appears within ten inches to fifteen inches of the surface. In many places, however, the underlying rock is partly decomposed. This condition was noted in a large part of Prince Edward county and in some parts of Hastings and Lennox and Addington counties.

There is a considerable variation in the amount of stones in both surface and subsoil. As a general rule, the larger amount of stone is found where the soil has a brown colour and considerable decomposition has taken place in the underlying rock. The smaller amount of stone and the gray soil is found where there has been little decomposition in the underlying rock.

This soil was derived, in part, from residual limestone material, and, in part, from lacustrine sediments. During the glacial period, the ice apparently removed all decomposed rock in some places and only part in others. On the withdrawal of the ice, glacial lake waters covered this area, and a small amount of lacustrine material was deposited. Where these lacustrine sediments are

deep, either Dunkirk or Haldimand soils have developed; the former on well-drained, the latter on poorly-drained areas. But where the lacustrine deposits were shallow, the Hastings soils have developed. The grayer areas are derived mainly from lacustrine material and are a gradation towards the Haldimand soils, while the brown areas contain much more residual material.

This soil occupies large areas of gently undulating to rolling land in Prince Edward, Hastings, Lennox and Addington counties. Where the undecomposed rock is near the surface, this soil is only fit for pasture, but where the underlying rock is partly decomposed, good crops of grain and fruit are grown.

MUCK AND PEAT.

When the ice disappeared from southwestern Ontario, it left a level surface which had many depressions with no natural drainage outlets. These depressions filled with water, forming lakes and ponds, some of which are still in existence. Others have gradually filled by the accumulation of organic matter mixed with more or less inorganic matter washed in from the surrounding slopes. In some of these depressions, the amount of organic matter is only sufficient to give a dark brown colour to the surface soil. These areas are included in the Clyde series. Other areas have a large amount of organic matter, frequently three or more feet in depth, in all stages of decomposition. These areas are classed as muck and peat.

The term peat is frequently applied to all of this material, but there is a difference in agricultural value between the brown fibrous material and the black, thoroughly decomposed portion, and it seems best, as Coffey suggests (Reconnaissance Soil Survey of Ohio), to confine the term peat to the former and to call the latter muck. There is, however, no sharp line of division between the two, all gradations being found from undecomposed plant remains to thoroughly decomposed organic matter. In many places organic matter in all stages of decomposition are found intimately mixed together.

Muck and peat are formed under very wet conditions, which have prevented the rapid decomposition of organic matter. They are found to some extent in the old lake bed, but their chief development is in depressions on the upland, particularly in morainal sections. Depressions surrounded by well-drained soils like the Guelph types invariably contain muck and peat, as seepage keeps these areas constantly wet. In depressions surrounded by soils with poor underdrainage, like the London clay loam, there is often only a slight accumulation of organic matter around the border and the muck and peat is surrounded by a narrow border of Clyde clay loam.

The depth of the muck and peat in the different areas varies from a few inches to as much as twenty feet. In East and West Luther townships part of the area is twenty feet or more in depth and is covered with certain types of grasses and sedges but does not produce large tree growth. A similar condition is found in the large area in Ellice township. In Greenock township, however, there is a large area that is comparatively shallow and it is covered with trees. Some areas classed as Clyde clay loam were formerly covered with muck and peat, but this material has been burned off, leaving a dark gray to black soil. Where the depth of organic matter is less than eight inches, it is classed with the Clyde soils, as cultivation mixes the organic matter with the underlying material and soils of that series are formed.

Large areas of muck and peat are found south of Welland, south of Brampton, north of Stratford, west of Walkerton, northeast of Dundalk and Arthur, and

south of Lake Simcoe. Many small areas are found in the last section as well as in all parts of the country.

All areas of muck and peat require drainage before they can be cultivated. Quite frequently a layer of varying thickness of greyish marl is found in muck areas. It may occur a few inches below the surface or down in the subsoil at three feet or more. If it is practical to remove some of this marl and apply it to the top-soil, the texture and fertility will be improved. (Marl is high in calcium carbonate.)

Muck soils respond to treatment with phosphatic and potassic fertilizers. They are often quite acid and require liming. There is usually an abundance of nitrogen.

When well drained they are excellent soils for celery, onions, sugar beets and all kinds of truck crops.

WORK ON DEMONSTRATION PLOTS.

A soil survey includes: First, mapping and classification of the soils; second, a determination of the amount of plant food, in the soil by physical and chemical analyses; and, third, the laying down of cultural and fertilizer experiments.

The mapping and classification of the soils has been treated in a previous part of this bulletin. Nearly two hundred samples of soils representing all of the series and types found in the Province have been analyzed, but as even this is not sufficient to give an average composition that would be really representative they are not included in this report.

We have, however, made use of the Survey in establishing three demonstration plots, and we have laid down a large number of co-operative experiments, all of which have been placed on definite types of soils. This is important because the results obtained from these experiments will be applicable to the same type wherever it may be found.

The demonstration plots are at Guelph, Simcoe and Welland, and it may not be out of place in this bulletin to outline the plan of the experiments undertaken on these plots.

THE GUELPH PLOT.

The Guelph Plot is on a Guelph Loam (see description under Guelph Series), and consists of three acres, part of the College Farm. The plot was started in 1915, and was planned with the double purpose of studying the soil type and securing data for classroom work. A three year rotation is followed: Mangels, Barley and Hay. A fourth range is devoted to fertilizer experiments on permanent pasture to ascertain the influence of the different fertilizer constituents on the growth of grasses.

The plan of the experiment is as follows:—

Plot No.	Fertilizer Applied	Lbs. per acre	Plot No.	Fertilizer Applied	Lbs. per acre
101	No Fertilizer.....	...	116	Nitrate of Soda (3 dressings).	500
102	Sulphate of Ammonia.....	200	117	Sulphate of Ammonia.....	400
	Superphosphate.....	400	118	No fertilizer.....	...
	Muriate of Potash.....	200	119	Sulphate of Ammonia.....	200
103	Superphosphate.....	400		Basic Slag.....	400
	Muriate of Potash.....	200		Muriate of Potash.....	200
104	Sulphate of Ammonia.....	200	120	Sulphate of Ammonia.....	200
	Muriate of Potash.....	200		Bones.....	325
105	Sulphate of Ammonia.....	200		Muriate of Potash.....	200
	Superphosphate.....	400	121	Sulphate of Ammonia.....	200
106	No Fertilizer.....	..		Rock Phosphate.....	1,200
107	Nitrate of Soda (2 dressings).	250		Muriate of Potash.....	200
	Superphosphate.....	400	122	No fertilizer.....	...
	Muriate of Potash.....	200	123	Sulphate of Ammonia.....	200
108	Nitrate of Soda.....	250		Superphosphate.....	400
	Superphosphate.....	400		Potassium Sulphate.....	200
	Muriate of Potash.....	200	124	Sulphate of Ammonia.....	200
	(Radio-active fertilizer—5 lbs. per plot.			Superphosphate.....	400
109	Blood Meal.....	300		Drury's Feldspar.....	1,400
	Superphosphate.....	400	125	Drury's Feldspar.....	2,000
	Muriate of Potash.....	200	126	Sulphate of Ammonia.....	200
110	Calcium Cyanamide.....	250		Superphosphate.....	400
	Superphosphate.....	400		Kelp to be applied later.....	1,000
	Muriate of Potash.....	200	127	No fertilizer.....	...
111	Calcium Nitrate (2 dressings).	250	128	Sulphate of Ammonia.....	200
	Superphosphate.....	400		Superphosphate.....	400
	Muriate of Potash.....	200		Muriate of Potash.....	200
112	No fertilizer.....	...		Radio-active fertilizer.....	500
113	Nitrate of Soda (2 dressings).	125	129	Sulphate of Ammonia.....	200
	Sulphate of Ammonia.....	100		Superphosphate.....	400
	Superphosphate.....	400		Common Salt.....	400
	Muriate of Potash.....	200	130	Sulphate of Ammonia.....	200
114	Nitrate of Soda (2 dressings).	125		Superphosphate.....	400
	Calcium Cyanamide.....	125		Muriate of Potash.....	200
	Superphosphate.....	400		Common Salt.....	400
	Muriate of Potash.....	200	131	No fertilizer.....	...
115	Nitrate of Soda (2 dressings).	85	132	Sulphate of Ammonia.....	400
	Sulphate of Ammonia.....	70		Superphosphate.....	800
	Blood Meal.....	100		Muriate of Potash.....	400
	Superphosphate.....	400			
	Muriate of Potash.....	200			

Some interesting results have been obtained, one of which is the superiority of Nitrate of Soda as a source of Nitrogen for mangels.

THE SIMCOE PLOT.

This plot consists of six acres near the town of Simcoe. The soil is a Dunkirk sand in very poor condition. (See description of this type under Dunkirk Series.) The plot was taken over in the Fall of 1919. After discussing the matter with the farmers in the neighbourhood the following rotation was decided on:—1. Peas, 2. Hay, 3. Hoe Crop, 4. Wheat. Since canning peas are an important crop in this locality and on this soil it was thought desirable to sow to clover after the peas were taken off. By this method a cash crop was secured and, at the same time, a catch of clover for hay for the next season. The field was divided into five ranges with ten 1/10 acre plots in each. The fifth range was devoted to Market Garden Crops.

The fertilizer scheme for all ranges is as follows:—

Plot No.	Fertilizer Treatment	Rate per acre	Constituents.
		Tons	
1.	No Treatment.....	Check
2.	Manure.....	10	Manure only
3.	Manure and Lime.....	Lime at 2 tons	M+Lime
4.	Manure+Lime+Acid Phosphate 16 per cent.	Lbs. Acid Phos. = 350	Phosphorus
5. a.	M+L+10 p. cent. Rock phosphate+sulphur	Rock Phos. = 1,000 Sulphur = 500	Phosphorus +Sulphur
b.	M+L+10 per cent. Rock Phosphate.....	Phosphorus
6.	M+L+Basic Slag 10 per cent.....	560	Phosphorus
7.	M+L+ Sulphate Ammonia.....	200	Nitrogen+ Phosphorus +Potash
	Acid Phosphate.....	350	
	Muriate of Potash.....	150	
8.	M+L+ Acid Phosphate.....	350	Phosphorus +Potash
	Muriate Potash.....	150	
9.	M+L+ Sulphate Ammonia.....	200	Nitrogen+ Potash
	Muriate Potash.....	150	
10.	M+L+ Sulphate Ammonia.....	200	Nitrogen+ Phosphorus
	Acid Phosphate.....	350	

It will be seen on perusal of this table that provision is made to try out the three common forms of phosphorus, and also to check a complete fertilizer against its various constituents.

Some very interesting data has been obtained with peas and potatoes, but it is too soon to make positive statements regarding the results.

THE WELLAND PLOT.

The object of this Demonstration Plot was to observe the effect of various forms of lime and chemical fertilizers together with a system of underdrainage on the Haldimand Clay. The plot consists of twenty acres situated on the Niagara Falls Road about a mile and a half from Welland, Ontario. The soil is a heavy Haldimand Clay, typical of the Crowland District. Operations were commenced on September 1st, 1920.

After consultation with representative farmers, keeping in mind the fact that this is a thickly populated district in which dairying is important, the following rotation was decided on: 1. Wheat, 2. Hay, 3. Oats, 4. Corn, 5. $\frac{1}{2}$ Hay, $\frac{1}{2}$ Fallow. The fifth range was divided, because, while a number of men on large farms could afford to fallow, others, on smaller places, had to use such acreage for hay. This gives an opportunity to compare sod plowed down and Summer Fallow as a preparation for wheat.

In the Spring of 1921, a complete underdrainage scheme, laid out by the Drainage Department at the College, was installed on 15 acres. A five-acre portion at the north end of the field was left undrained to act as a check. The ranges were planned to cross both the drained and undrained portions and each range was divided into 14 plots of $\frac{1}{5}$ acre in size.

The Fertilizer Scheme for Ranges 1, 3, 4, 5, and 6 is as follows:

Plot 1.	Acid Phosphate	400 lbs. per acre.	
" 2.	Rock Phosphate	500 lbs. S. per acre	} 1,000 lbs.
" 3.	Lime	2 tons Limestone Screenings	
" 4.	Acid Phosphate	400 lbs. per acre,	} 80 lbs.)
" 5.	Rock Phosphate	1,000 " "	
" 6.	Basic Slag	600 " "	} 120 " "
" 7.	Sulphate of Ammonia	100 " "	
	Acid Phosphate	400 " "	} 80 " "
	Muriate of Potash	100 " "	
" 8.	Acid Phosphate	400 " "	} 80 " "
	Muriate of Potash	100 " "	
" 9.	Sulphate of Ammonia	100 " "	} 20 " "
	Muriate of Potash	100 " "	
" 10.	Sulphate of Ammonia	100 " "	} 20 " "
	Acid Phosphate	400 " "	
" 11.	Check		
" 12.	Lime only	2 tons Limestone Screenings	
" 13.	Check		
" 14.	Lime and Manure	2 tons Limestone Screenings	

All plots were manured at the rate of 10 tons to acre.

RANGE 2.

This range was reserved for experiments with lime.

Plot 1.	} Barn	
" 2.		
" 3.	Check	
" 4.	Limestone Screenings	2,000 lbs. per acre
" 5.	Slaked Lime	1,500 " "
" 6.	Limestone Screenings	4,000 " "
" 7.	Check	
" 8.	Slaked Lime	3,000 " "
" 9.	Limestone Screenings	8,000 " "
" 10.	Slaked Lime	6,000 " "
" 11.	Check	
" 12.	Limestone Screenings	4,000 " "
" 13.	Check	
" 14.	Slaked Lime	3,000 " "

Only one crop has been obtained from these plots.

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