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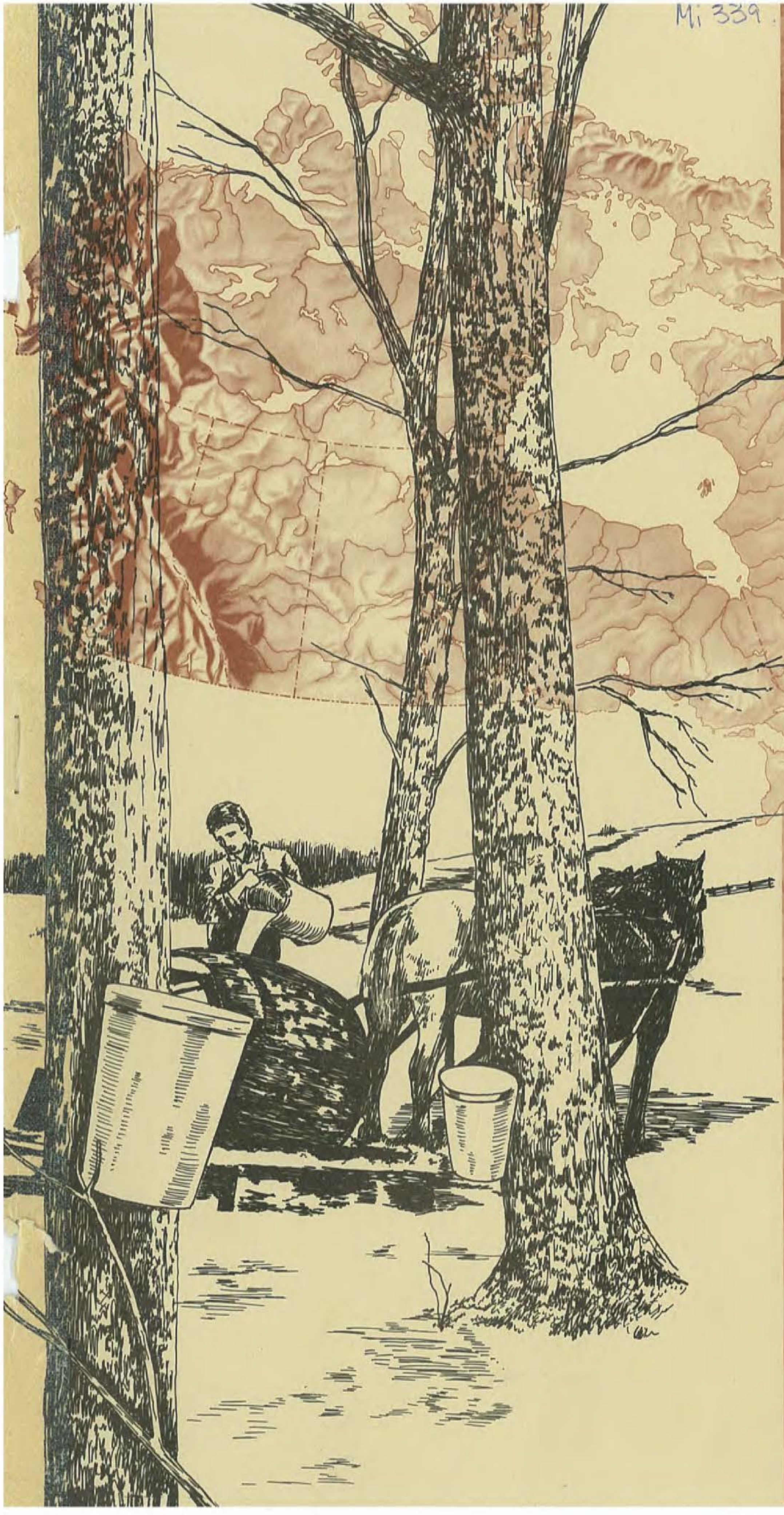

GUIDEBOOK TOURS 1-10

SOILS AND LAND USE OF EASTERN CANADA

THE ELEVENTH INTERNATIONAL CONGRESS OF SOIL SCIENCE

EDMONTON, CANADA

JUNE, 1978

GUIDEBOOK FOR A SOIL AND LAND USE

TOUR OF EASTERN CANADA

TOUR 1
TOUR 10

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PREFACE

The tour area is located mainly within the Appalachian Region, the Laurentian Highlands and the St. Lawrence Lowlands.

Originating in Charlottetown, Prince Edward Island, the tour 1 will run through the provinces of Nova Scotia and Quebec and will end in the south-western part of Ontario. Tour 10 travels in the reverse direction.

The guidebook presents a general view of the land across the Eastern Provinces. It contains soil descriptions of various sites and attempts to outline some of the various land use problems in national resource management.

The tours offer participants fifteen occasions to look at soils at specific sites and establish pertinent relationships to landscape features and land use practices. A fair number of analytical data will also enable soil scientists to better understand the behaviour of Eastern Canadian soils under various climatic regimes.

The guidebook presents the general information by regions, and the daily itinerary for the east to west traverse. Due to the length of the book it was not possible to present the west to east daily itinerary in sequential form. Readers are requested to make full use of the table of contents to quickly locate points on the tour 10 traverse.

GENERAL ITINERARY

TOUR 1 DAY 1 - THURSDAY JUNE 8. CHARLOTTETOWN.
TOUR 10 DAY 7 - TUESDAY JULY 4. QUEBEC TO CHARLOTTETOWN by air.
Assemble at Charlottetown, the starting point of Tour 1.

TOUR 1 DAY 2 - FRIDAY JUNE 9. CHARLOTTETOWN TO SACKVILLE.
TOUR 10 DAY 8 - WEDNESDAY JULY 5. CHARLOTTETOWN TO SACKVILLE.
Assemble at the Agriculture Research Station for the 100 mile trip to Sackville. The trip will feature examination of a Podzolic Gray Luvisol soil and erosion plots.

TOUR 1 DAY 3 - SATURDAY JUNE 10. SACKVILLE TO WOLFVILLE.
TOUR 10 DAY 9 - THURSDAY JULY 6.
The trip will feature examination of a Gleyed Brunisolic Gray Luvisol (Pseudogley).

TOUR 1 DAY 4 - SUNDAY JUNE 11. WOLFVILLE TO QUEBEC CITY.
TOUR 10 DAY 10 - FRIDAY JULY 7. WOLFVILLE TO HALIFAX. Tour ends.
The trip will feature a visit to Agriculture Canada Research Station at Kentville and examination of two Eluviated Dystric Brunisols on Station grounds.

TOUR 1 DAY 5 - MONDAY JUNE 12. QUEBEC TO DRUMMONDVILLE.
TOUR 10 DAY 6 - MONDAY JULY 3. DRUMMONDVILLE TO QUEBEC.
The tour will proceed northerly into the Laurentian Region where the Montmorency Forest is located. There will be an examination of a Humo-Ferric Podzol on acid till, followed by a visit to the Forest Research Station. Then the tour will proceed southerly and traverse marine and fluvio-marine sediments widespread in the St. Lawrence Lowlands south of the River. Podzolic, brunisolic and gleysolic soils are mostly encountered on the subdued landforms within the area.

TOUR 1 DAY 6 - TUESDAY JUNE 13. DRUMMONDVILLE TO MONTREAL.
TOUR 10 DAY 5 - SUNDAY JULY 2. MONTREAL TO DRUMMONDVILLE.
Area of nearly level to undulating topography including mostly fluvial and marine sediments. Some portions made of reworked tills and a few scattered organic deposits complete the landscape. The trip will feature the examination of two soil sites, an Orthic Humic Gleysol on marine clays in the St-Hyacinthe area and a Typic Mesisol on horizontal fen in the Huntingdon county. Most of the soils of the area are suitable for agricultural land use. However urban developments and land speculations are restraining agricultural emphasis in the vicinity of Montreal. Situated on a main inland water route, Montreal is an important diversified metropolis.

TOUR 1 DAY 7 - WEDNESDAY JUNE 14. MONTREAL TO OTTAWA.
TOUR 10 DAY 4 - SATURDAY JULY 1. OTTAWA TO MONTREAL.
Due to favourable climatic conditions, deciduous forest predominates in this portion of land within the St. Lawrence Lowlands. The wide variety of soils that can be observed in the Montreal area

range from Orthic Regosols to Melanic Brunisols and are commonly unforested. Passing by the MacDonald Agricultural College located on tip of Montreal Island, the tour will proceed along Deux-Montagnes Lake and Ottawa River, and through an undulating to level country where agricultural practices are still active. Two electric power plants, one at Carillon on the Ottawa River and the other at Beauharnois on the St-Lawrence River produce energy to partly meet Montreal's needs. In the province of Ontario, from Pointe-Fortune to Ottawa, agricultural land use is intensive on deep soils made of marine sediments and rather poor on thin veneer soils over bedrock. Transition from rural activities to urban development is a visible phenomenon in the Ottawa vicinity.

TOUR 1 DAY 8 - THURSDAY JUNE 15. OTTAWA TO GUELPH.
TOUR 10 DAY 3 - FRIDAY JUNE 30. TORONTO TO OTTAWA.

The 350 mile (580km) trip will feature examination of Gray Brown Luvisol and Eutric Brunisol soils. The first site will be located at Vivian York Regional Forest, and the second site will be made in a woodlot near Richmond Hill, not far from Toronto's northern extremity.

TOUR 1 DAY 9 - FRIDAY JUNE 16. GUELPH TO NIAGARA FALLS AND TORONTO.
TOUR 10 DAY 2 - THURSDAY JUNE 29. TORONTO TO NIAGARA FALLS AND TORONTO.

The 104 mile (167km) trip to Niagara Falls will feature agricultural land use in the fruit land region. An opportunity will be given to examine two soils (Gleyed Gray Brown Luvisol and Gleysol soils) which are intensively utilized for horticultural crops. Both sites are located on property of the Horticultural Research Institute of Ontario, Vineland, where research on fruit crops, vegetables and ornamental plants is being carried out. During the supper period, a sight-seeing tour of Niagara Falls will be possible. The tour will return, non-stop to Toronto a distance of approximately 116km.

TOUR 1 DAY 10 - SATURDAY JUNE 17. TORONTO TO EDMONTON.
TOUR 10 DAY 1 - WEDNESDAY JUNE 28. EDMONTON TO TORONTO.

SOILS AND LAND USE IN THE ATLANTIC PROVINCES

G.J. Beke and J.I. MacDougall

Introduction

The Eastern Tour sites in the Provinces of Nova Scotia and Prince Edward Island are representative of conditions in the Appalachian physiographic regions. Most of this area is in the form of a barrier between the Atlantic Ocean and the Gulf of St. Lawrence. A maritime climate characterizes all of Nova Scotia, Prince Edward Island, the coastal portions of Newfoundland and the southern portion of New Brunswick. Central and northern New Brunswick, the Gaspe Peninsula of Quebec and the core portion of Newfoundland tend to have a continental climate.

The climate, and consequently the vegetation and soils of the Appalachian region, is strongly influenced by the relief. The uplands are interspersed throughout the region. Few of the uplands are high, but they rise and fall and, hence, sharply exert a profound influence on the marine air masses. Most of the relief can be related to the bedrock geology of the region. Granites and ferromagnesian intrusives comprise most of the uplands. The lowlands are comprised of horizontally stratified sandstones, shales and conglomerates which are mostly of Triassic and Permo-Carboniferous age.

The region has been subject to severe glaciation. The relative resistance to glacial erosion of the bedrock materials is reflected in the glacial till deposits. For instance, shallow, stony soils are associated with granitic uplands.

The zonal soil of the Appalachian region is the Podzol. Humo-Ferric Podzols predominate in the lowlands while Ferro-Humic and Humic Podzols prevail above the 150m contour line. Indurated horizons such as ortstein, fragipan, or ironpan are of common occurrence. The main local soil pattern comprises Podzols on the better drained sites and Gleysols on the poorly drained sites.

Approximately 90 percent of the physiographic region is still covered by native forest vegetation. The forests of Prince Edward Island, Nova Scotia and southern New Brunswick are characterized by red spruce (*Picea rubens*), balsam fir (*Abies balsamea*), yellow birch (*Betula alleghaniensis*), and sugar maple (*Acer saccharum*), with some red pine (*Pinus resinosa*), eastern white pine (*Pinus strobus*), and eastern hemlock (*Thuga canadensis*). Northern New Brunswick and the Gaspe Peninsula have a forest characterized by the eastern white and the red pines, eastern hemlock, and yellow birch. The forests of Newfoundland are primarily coniferous, with white spruce (*Picea glauca*) and black spruce (*Picea mariana*) the characteristic species.

Physiography

The Eastern Tour sites in the Provinces of Prince Edward Island and Nova Scotia are situated within the Appalachian physiographic region. The Canadian section of this physiographic region encompasses the Atlantic Provinces, the Gaspe Peninsula and the Eastern Townships of Quebec (Figure 1). Most of this

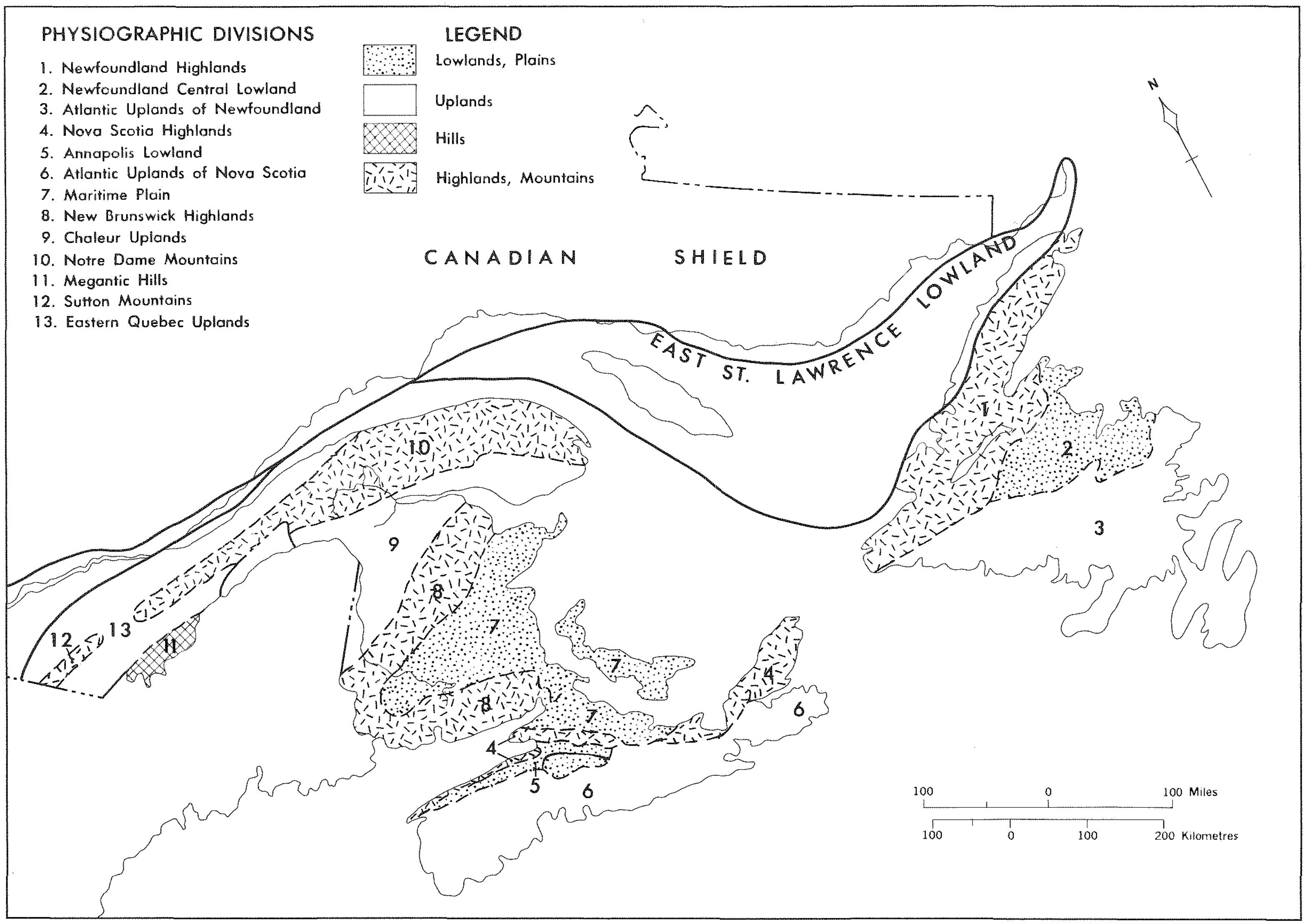


FIG. 1 APPALACHIAN PHYSIOGRAPHIC REGIONS

section is in the form of a barrier between the Atlantic Ocean and the Gulf of St. Lawrence.

Geology and Relief. The Appalachians form an extensive and complex belt of fold mountains consisting largely of flat-topped, rolling uplands, the main axis of which runs northeast-southwest. Three main belts of mountain-building activity run through the region. In the north and west, long parallel folded ridges of the Taconic uplift form the first belt of fold mountains. Thrust to the northwest, they extend through northwest Newfoundland and New Brunswick to the New England Uplands in the United States. The Caledonian uplift and Acadian orogeny form the second belt of mountains, which stretch through central Newfoundland, New Brunswick and Nova Scotia, leaving a complex zone of broad plateaulike uplands of folded sedimentary rocks intruded by domes of crystalline rock. Lastly, to the east, short intensely folded ridges intruded by small igneous bodies of crystalline rock extend from the Avalon Peninsula of Newfoundland south through Cape Breton to southern Nova Scotia.

The present summits of the fold belts are thought to be the remnants of a peneplain formed in Cretaceous times and since uplifted and heavily dissected. Its general aspect is a southeastwardly sloping peneplain, with a predominance of long, flat-topped or gently rounded ridges and uplands. Differential erosion has left a northeast-southwest trend of physiographic units composed of highlands and uplands separated by valleys and broad lowland areas developed on less resistant late Paleozoic sedimentary rocks.

The highlands and uplands of the Appalachian Region form a semicircle about the vast lowland area, almost entirely drowned by the Gulf of St. Lawrence. The lowland plain is underlain by late Paleozoic sedimentary rocks, which emerged in the southern section of the Gulf of St. Lawrence to form the Maritime Plain of mainland New Brunswick, Nova Scotia, all of Prince Edward Island, and the Magdalen Islands. Most of the Maritime Plain is below 400 ft (120m) in elevation and the surrounding uplands generally range between 500 and 2,700 ft (150 and 820m) with the exception of the Notre Dame Mountains where elevations exceed 4,000 ft (1220m).

Physiographic Subdivisions. The physiographic subdivisions of the Canadian section of the Appalachian region are illustrated in Figure 1. The island of Newfoundland, which constitutes the northernmost part of the Appalachian system, is divided into three major physiographic divisions` namely, the Newfoundland Highlands (1), the Newfoundland Central Lowland (2) and the Atlantic Uplands of Newfoundland (3). The Highlands and Uplands divisions extend across the whole island and encircle the Central Lowlands centered on Notre Dame Bay to the north.

The remainder, but major portion, of the Canadian Appalachian region slopes southeast from the Gaspe Peninsula to the Atlantic shore of Nova Scotia and reveals a series of ridges and furrows. The ridges represent uplands and highlands which consist of Precambrian or old resistant Paleozoic rocks, while the furrows depict lowlands and valleys consisting of less resistant Permo-carboniferous sedimentary rocks.

The complex of mountains and uplands of Appalachian Quebec, in the extreme northwest of the region, are formed by highly folded Paleozoic sedimentary rocks whose axes strike parallel to the St. Lawrence River. The Notre Dame Mountains (10) (Figure 1) form the central core, extending from Thetford Mines northeast to the Gulf of St. Lawrence and comprising Mount Cartier (1270m), the highest elevation in the Canadian Appalachian Region. Topographically, the Notre Dame Mountains have a relatively flat surface which merges imperceptably with that of the Eastern Quebec Uplands (13) to the southwest. These uplands, which are broken in the south and east by the Sutton Mountains (12) and Megantic Hills (11), respectively, decrease in elevation towards the northwest, eventually merging with the St. Lawrence Lowlands region. The previously mentioned Sutton Mountains and Megantic Hills are residual outcrops, 610 to 1160m in elevation, consisting of resistant granites and basaltic lavas. They represent the northern extent of the Green Mountains of Vermont and the White Mountains of New England, respectively.

Southeast of the Notre Dame Mountains is a strongly dissected peneplain known as the Chaleur Uplands (9). These uplands are underlain by folded Paleozoic strata, 244 to 305m in elevation, consist of uniform summits broken by isolated ridges, and slope towards the southeast where they merge with the New Brunswick Highlands (8). The U-shaped New Brunswick Highlands division comprises the large granite batholiths reaching 610m in elevation, in central New Brunswick, the broken highlands consisting of flat-lying Paleozoic strata to the west of the St. John River, and the relatively low (305m) intrusive highlands along the Bay of Fundy.

East of the New Brunswick Highlands, the triangular Maritime Plain (7) forms the low surface of Prince Edward Island, eastern New Brunswick and north-central Nova Scotia. The plain is underlain by horizontally stratified Permian and Carboniferous rocks, shales, sandstones, and conglomerates -- which are almost entirely below 150m in elevation. The Maritime Plain is bounded on the east by the Nova Scotia Highlands (4) which is a range of low mountains having a northeast-southwest orientation and being nearly 570km long. It comprises numerous hills and low mountains which increase in elevation to the northeast, culminating at 510m. Topographically, the southern portion of the highlands are gently rolling, the central portion is strongly dissected and the northern portion is deeply dissected on the margins with large flat plateaux in the interior. The most southern part of the highlands is a long, narrow, volcanic sill of Triassic lava known as North Mountain.

East and northeast of this volcanic ridge is the Annapolis Lowland (5). This lowland is a U-shaped depression underlain by late Paleozoic and Triassic rocks. Southeast of the Annapolis Lowland and of the northern half of the Nova Scotia Highlands is a broad, low peneplain, referred to as the Atlantic Uplands of Nova Scotia (6). This peneplain has an inclined surface with a granite core, increasing in elevation towards the northeast at about 3m per km.

Glaciation. All of the Appalachian Region was covered by ice during the Pleistocene period and much of the preglacial surface has been scoured and subsequently covered with a layer of till and morainic deposits of varying thickness. These deposits are popularly attributed to Wisconsin Laurentide ice. There is no doubt about the presence of Laurentide ice in Newfoundland

and there is solid evidence of it in various parts of the Maritime Provinces. Nevertheless, at least with respect to the last glaciation, there is no actual proof of its presence throughout the entire latter region (Prest and Grant, 1969). It appears that, during the buildup of the last continental ice sheet, the growth of Appalachian glaciers was sufficiently early and extensive to bar Laurentide ice from some parts of the southern Canadian Appalachian physiographic region.

The rise in sea level during the deglaciation process has had a marked effect on coastal areas. There is a close relationship between geological structure and major coastal features along the Atlantic seaboard of Newfoundland and Nova Scotia, where bays coincide with drowned valleys and peninsulas with outcrops of resistant rock. Postglacial isostatic rebound has exposed large areas of marine and marine-modified deposits along the Bay of Fundy and the Gulf of St. Lawrence coast.

About one-third of Newfoundland's surface is bedrock, the remainder is covered with glacial drift, (organic) bogs, and recent alluvium. Large areas of ribbed moraine are found on the Central Lowland and Atlantic Uplands of Newfoundland. Areas of fluted and drumlinized terrain are largely confined to central Newfoundland.

A thin mantle of moderately coarse, stony till covers the Uplands and Highlands of Nova Scotia. The uplands show marked glacial lineations owing to the occurrence of groups of drumlins which are composed of sandy loam to clay loam till that is both texturally and mineralogically anomalous to the bedrock geology of the division. In general, however, the composition of the till reflects local geological deposits for instance, sandy light-coloured tills are found in areas underlain by quartzites and the till between the afore-mentioned drumlins is derived from local slates giving it an olive-gray colour. The northern or Cape Breton Island portion of the Highlands and Atlantic Uplands of Nova Scotia displays what seems to be proglacial laking.

The level to gently rolling Annapolis Lowland is covered by thicker and less stony till, as compared to that on the uplands and highlands, as well as glacio-fluvial and deltaic sands and gravels. On the Maritime Plain, reddish-brown tills of local origin predominate, except for the Miramichi watershed which has light-coloured sandy tills. The reddish-brown tills contain igneous stones from the Nova Scotia Highlands.

Very stony, sandy till deposits occurring frequently with rock outcrop exposures characterize the surficial features of the New Brunswick Highlands. The exception to this rule is the highlands to the southwest where deep gravelly tills have smoothed the rougher topography into a more rolling upland terrain. In contrast, the Chaleur Uplands have a far more rugged and deeply dissected topography on which the till deposits are very shallow. Although there are few rock outcrops, the till is stony to very gravelly. The Notre Dame Mountains exhibit the same surficial deposits and terrain features evident in the Chaleur Uplands.

Climate

The climate of the Appalachian region is unusually variable owing to the movement of most migrant low-pressure areas across this section of the continent.

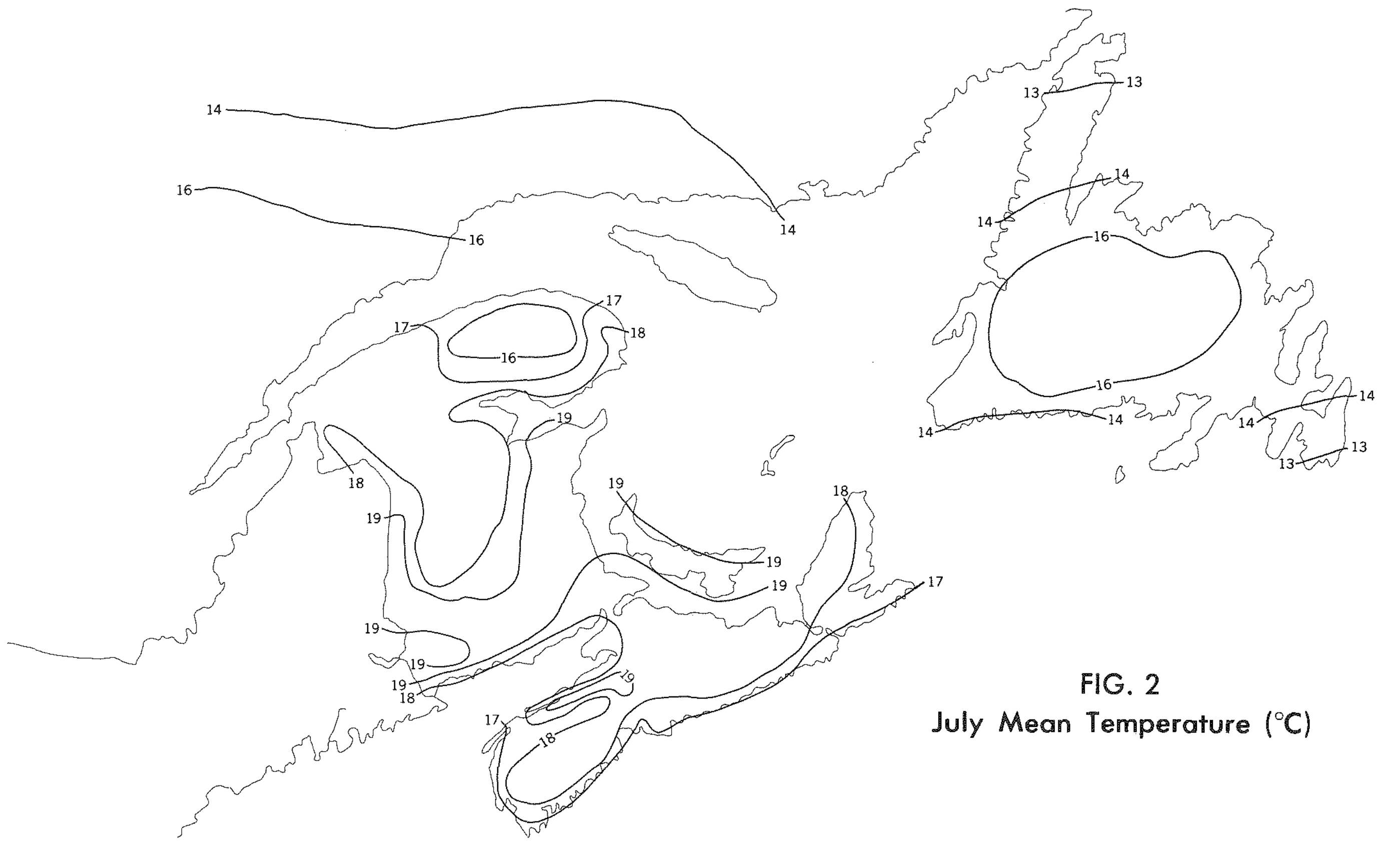


FIG. 2
July Mean Temperature (°C)

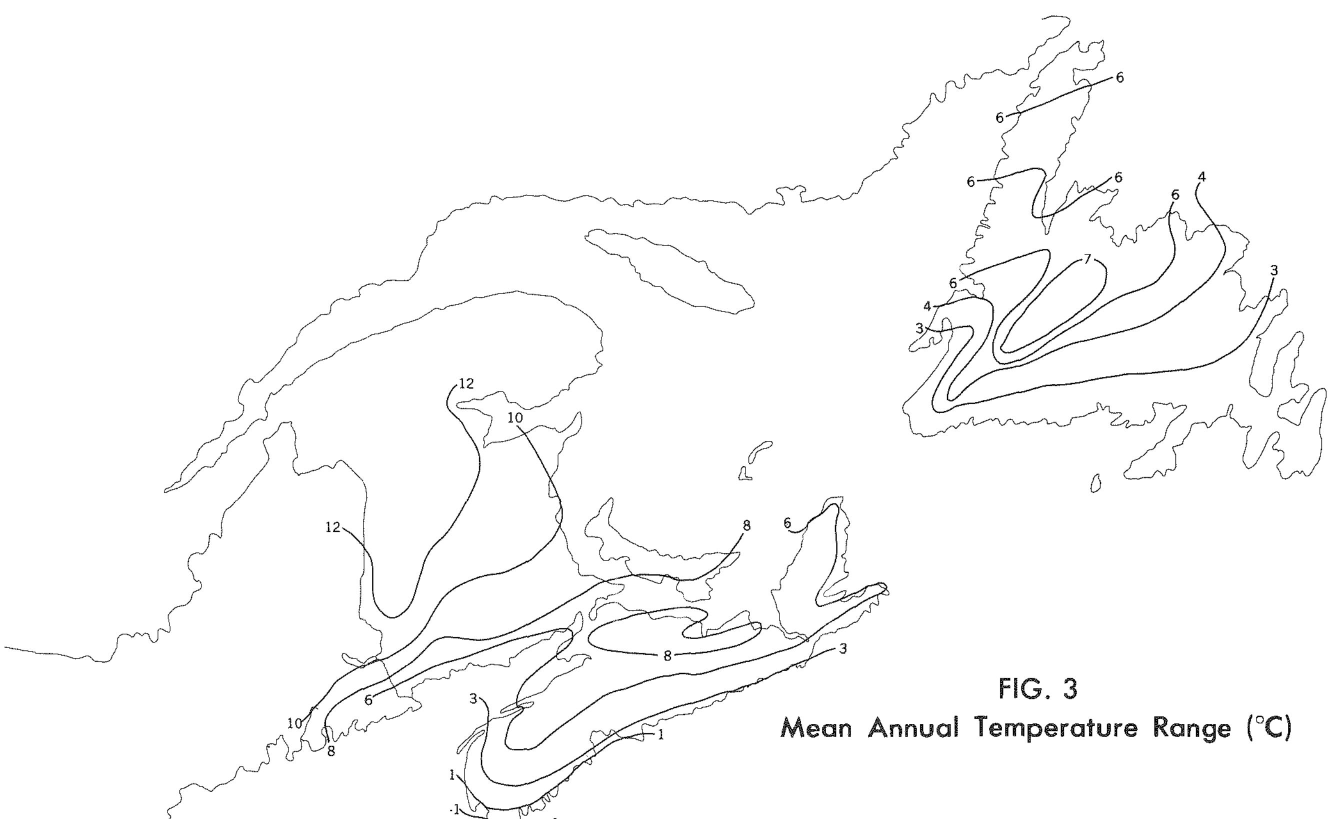


FIG. 3
Mean Annual Temperature Range (°C)

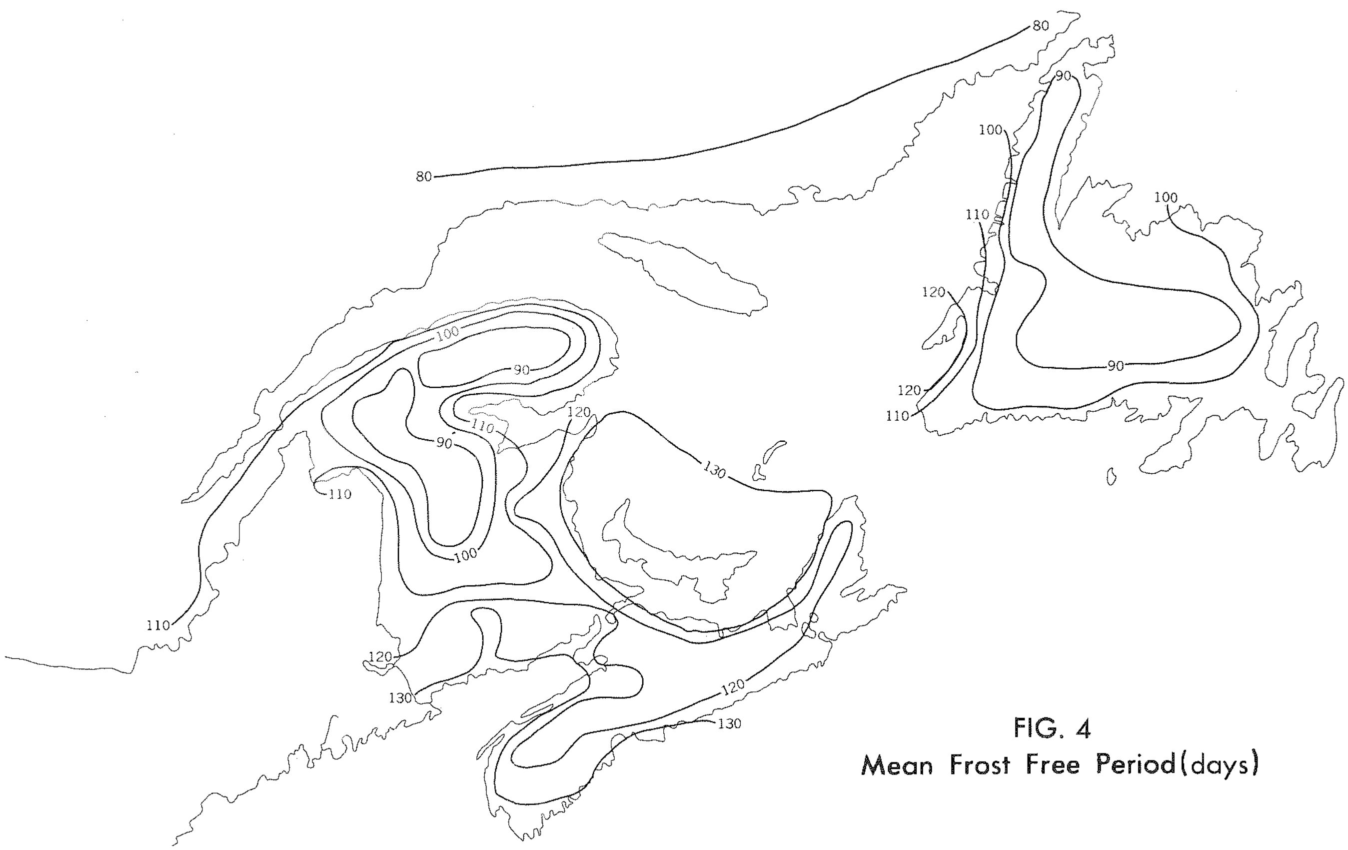


FIG. 4
Mean Frost Free Period (days)

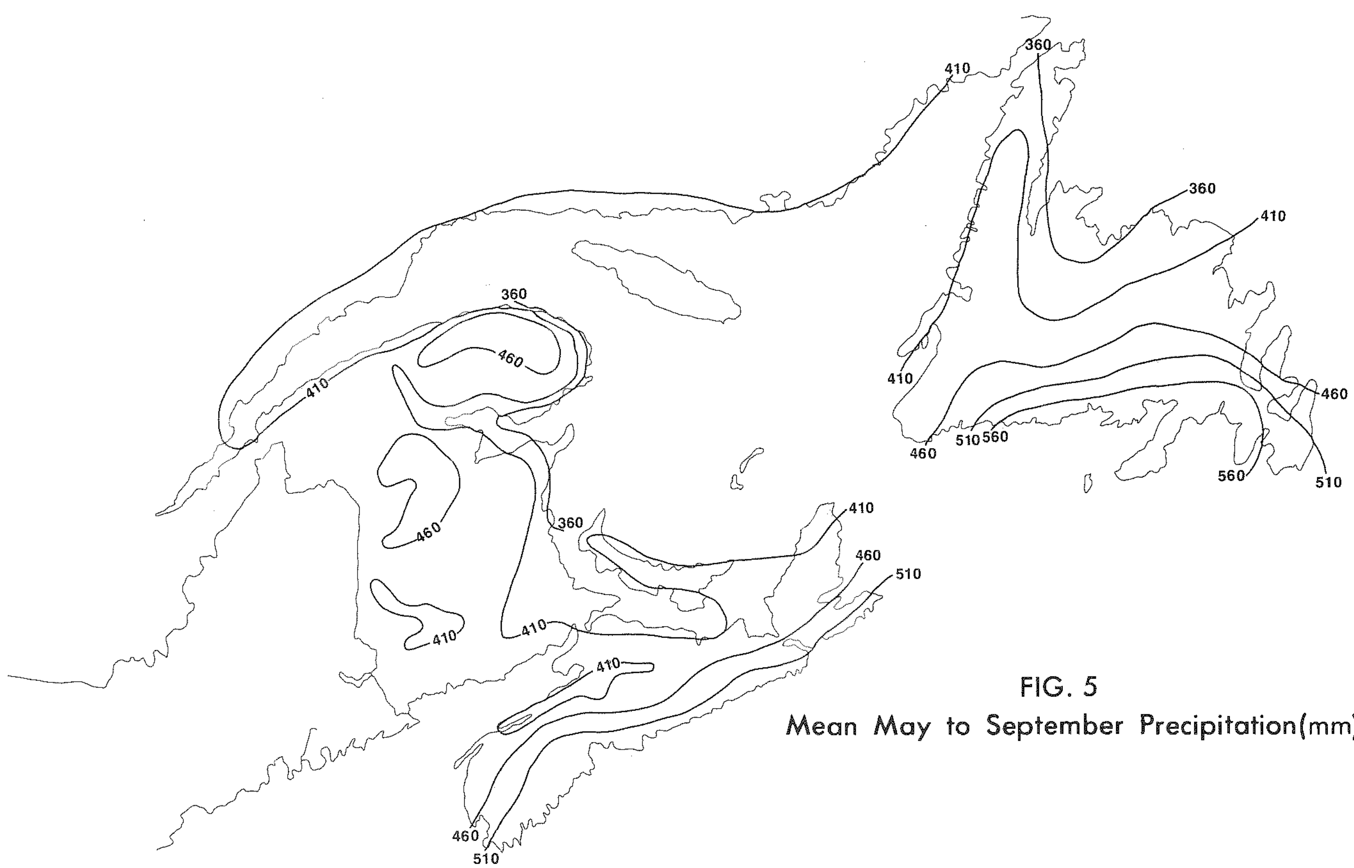


FIG. 5
Mean May to September Precipitation (mm)

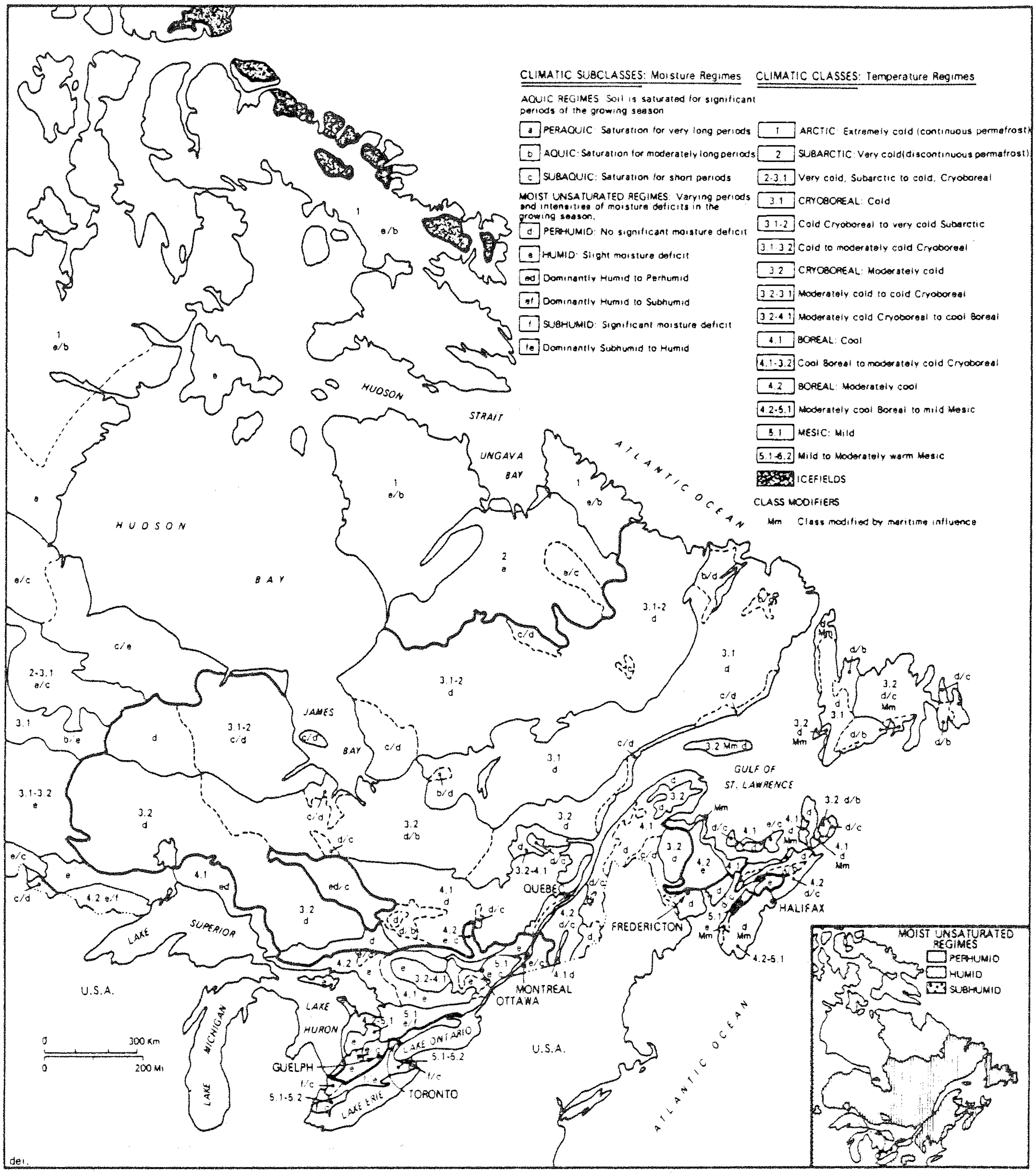


FIG. 6 CLIMATIC REGIONS OF EASTERN CANADA

As a consequence, this part of Canada has storms more frequently than any other portion of the country. In summer, the storms commonly pass to the north of the region, drawing with them the warm, humid air from the south and southwest while, in winter, storms tend to pass along the southern border, thereby inducing invasion by cold air from the interior of Canada. Hence, despite its maritime location, this region has a modified continental climate.

The farmlands of the Appalachian region lie between the 13^{o} and 19^{o} July isotherms (Figure 2). This is well below the 21^{o} July isotherm which used to be regarded as a northern boundary for grain corn and soybean production. The July isotherm map as well as the mean annual range of temperature map (Figure 3) do show the moderating effect of the Atlantic Ocean on the general easterly movement of air masses from the continent;s interior. Owing to the frequent influxes of moist ocean air along the Atlantic coast, which produce mild spells in winter and cool, foggy periods in summer, the mean annual range in temperature along the Atlantic coast is considerably lower than that in northern New Brunswick and the Gaspe Peninsula. The mean frost-free period (Figure 4) starts on May 24 or later and ranges from around 80 days in interior Newfoundland, northern New Brunswick, and the interior of the Gaspe Peninsula to 130 days in the coastal areas.

The Appalachian region usually receives ample precipitation during the growing season (Figure 5). Most of it is produced by cyclonic storms, thunderstorms occurring infrequently during summer. Fog and mist precipitation is quite common in coastal areas, and particularly so along the Atlantic seaboard and Bay of Fundy coast where it occurs on the average 15 to 25% of the year. Usually the month of July has the highest average occurrence of fog and mist but tends to be the driest month of the season. In general, the distribution of the total rainfall in the May-to-September season is similar to that of the total annual precipitation, which ranges from less than 90cm to over 150cm.

Soil Climate. The characterization of soil temperature and soil moisture regimes for use in climatic studies in Canada is based on consideration of temperature and moisture conditions for specific periods of biological significance. They involve definitions of a Growing Season >41^{o}F (>5^{o}C) with Mild >41^{o}F (>5^{o}C) and Warm or Thermal >59^{o}F (>15^{o}C) periods, and a Dormant Season <41^{o}F (<5^{o}C) with Cool >32^{o}F (>0^{o}C) and Frozen <32^{o}F (<0^{o}C) periods, based on soil temperature measurements. Temperature classes are based on characterization of these periods in respect to length, mean soil temperature, and accumulated degree-days (F) above or below the threshold values on which the periods are defined. Temperatures at 1.6 ft (50cm) are considered as standard for classification. This does not preclude the possibility of additional subdivisions for regional or local purposes being made on the basis of temperature regimes at other levels, e.g. at 0.3 ft (10cm) or less in Arctic classes where upper level soil temperature regimes may differ considerably from those at 1.6 ft (50cm).

Moisture subclasses are recognized on the basis of stated periods of saturation for Aquic regimes, and on calculations of intensity and degree of water deficits during the growing season for moist and submoist regimes.

The concept of Aquic subclasses was introduced to enable adequate characterization of the climatic regimes of map units with a dominant or subdominant

Table 1: Generalized Characteristics of Moisture Regimes and Subclasses.

Used for the Soil Climates of Canada and North America.

AQUIC REGIMES

Soil is saturated for significant periods of the growing season.

a Peraquic Soil saturated for very long periods. Ground water level at or within capillary research of the surface.
b Aquic Soil saturated for moderately long periods.
c Subaquic Soil saturated for short periods.

MOIST UNSATURATED REGIMES

Varying periods and intensities of water deficits during the growing season.

d Perhumid *** Soil moist all year, seldom dry.
** No significant water deficits in the growing season. Water deficits 0-<1 inch (<2.5cm) Climatic Moisture Index (CMI >84.

e Humid *** Soil not dry in any part as long as 90 consecutive days in most years.
** Very slight deficits in the growing season. Water deficits 1-<2.5 inches (2.5-<6.4cm) CMI 74-84.

f Subhumid *** Soil dry in some parts when soil temperature is >41F (>5C) in some years.
** Significant deficits within growing season. Water deficits 2.5-<5.0 inches (6.4-<12.7cm) CMI 59-73.

g Semiarid *** Soil dry in some parts when soil temperature is >41F (>5C) in most years.
** Moderately severe deficits in growing season. Water deficits 5.0-<7.5 inches (12.7-<19.1cm). CMI 46-58.

h Subarid *** Soil dry in some parts or all parts most of the time when the soil temperature is >41F (>5C). Some periods as long as 90 consecutive days when the soil is moist.
** Severe growing season deficits. Water deficits 7.5-<15 inches (19.1-<38.1cm) in BOREAL and CRYOBOREAL classes, 7.5-<20 inches (19.1-50.8cm) in MESIC or warmer classes. CMI 25-45.

j Arid *** Soil dry in some or all parts most of the time when soil is >41F (>5C). No period as long as 90 consecutive days when soil is moist.
** Very severe growing season deficits. Water deficits >15 inches (>38.1cm) in BOREAL and >20 inches (>50.8cm) in MESIC or warmer classes. CMI >25.

x Xeric *** Soil dry in all parts 45 consecutive days or more within the four month period (July to October) following the summer solstice in more than 6 years out of 10.
** Soil moist in all parts for 45 consecutive days or more within the four month period (January to April) following the winter solstice in more than 6 years out of 10.

Arid and Xeric subclasses are not believed to occur extensively in Canada but may be found in local areas of microclimate.

CMI -- Climatic moisture index is an expression of the percentage contribution of growing-season precipitation to the total amount of water required by a crop if lack of water is not to limit its production.

*** Primary classifier for subclass; in accordance with criteria established for the FAO/UNESCO Soil Climate Map of North America.
** Secondary classifier for Soil Climate Map of Canada.

CONVENTION

Temperature class → 3.1 Mx ← Class modifier
Moisture class-dominant → e/c ← Moisture class-subdominant

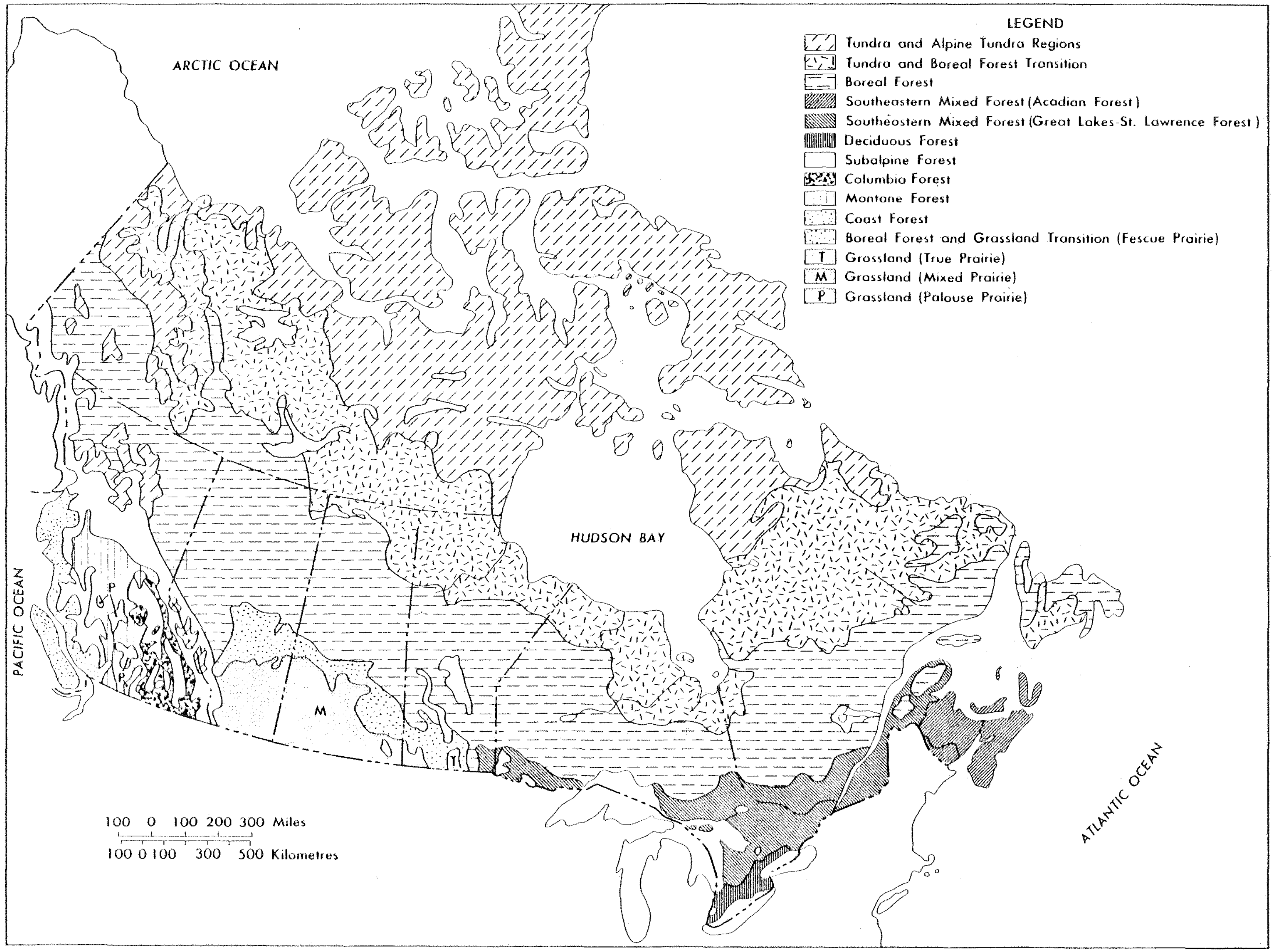


FIG. 7 VEGETATION REGIONS OF CANADA
(Modified after Rowe, Canadian Forestry Service).

occurrence of imperfectly to very poorly drained Gleysols or Organic soils. The extent of these subclasses was determined solely by subjectively estimating the length of the saturated period of these soils.

It is recognized that the occurrence of Aquic regimes depends on a number of independent factors, including:

a. the accumulation of surplus precipitation in excess of the absorptive capacity of the soil;

b. the ability of the soil to remove such surplus by internal drainage or runoff;

c. the characteristics of the topographic and drainage patterns of the landforms.

The Classification of Soil Climates for North America as used to characterize areas is based on varying combinations of seven major soil temperature classes and ten soil moisture subclasses. These parameters of class and subclass were devised to pragmatically relate the available data to acceptable concepts of the genetic relationship between climate, vegetation, and soils, and in addition to recognize in a more precise way the broad, regional, climatic separations already in use, which have stood the test of time and practical interpretation.

Table 1 gives short descriptions of the general characteristics and parameters of these class and subclass separations as used in Canada. In relating these climatic classes to the major areas of Canada, it is assumed that they refer to a continental type of climate characterized by wide diurnal and seasonal fluctuations. Modifications of these continental conditions are recognized as occurring in areas influenced by marine or mountainous conditions.

The Soil Climatic Map for Eastern Canada (Figure 6) indicates the occurrence of areas having maritime climatic types in the Appalachian region. The maritime climatic types have modified diurnal and seasonal fluctuations as compared to the extreme continental types. In general, they have comparable annual and seasonal temperatures and accumulative degree-days to the corresponding classes for the continental types, but the growing seasons are longer and the accumulative degree-days per day are significantly less.

Vegetation

Geographically, the natural vegetation of Canada may be best described on the basis of vegetative regions. These consist of large areas of apparently stable vegetation, each characterized by associations of distinctive plant communities or individual species, bearing a predictable relationship to regional climatic conditions, broad characteristics of physiography and landform, and to associated patterns of soil development.

These regional characterizations refer to the potential natural vegetation that would exist if man's influence was removed, as distinguished from the present vegetation, which may be natural, seminatural, or cultural depending on the degree and extent of man's influence. Much of the area of Canada is sparsely populated and undeveloped, and under such conditions the vegetation is essentially natural. It is only in areas of extensive agricultural or commercial forest activity, and in the more limited but intensively established urban communities that the vegetational pattern has been so changed that potential natural vegetation has to be partly inferred from association with relict areas.

The vegetative regions may be broadly grouped into three classes, the Tundra, Forest, and Grasslands. Their spatial distribution is determined largely on macroclimatic conditions. The Tundra areas are determined in relation to Arctic and Alpine climates; the Forest areas are associated with conditions warmer than the Tundra and generally more moist than that of the Grasslands. Within these general class separations, a number of regions or transitional regions have been established. These are indicated on the accompanying map and legend of the Vegetation Regions of Canada (Figure 7). The description of these regions and their relationships to the soils and soil climates of Canada have been derived from a number of sources, but mainly from Rowe (1972) for the Forest Regions; Coupland (1961) for the Grasslands; and from Bird (1967) for the Arctic Tundra.

In the following descriptions of the vegetation regions, an attempt has been made to evaluate them in terms of general use and productivity as well as by plant association. The forest lands in particular have been described in generalized terms of productive and non-productive woodland, based on a broad evaluation of mesophytic upland sites as compared to hydrophytic lowland sites within each region as made by professional staff of the Canadian Forestry Service and Canada Land Inventory (1971). The criteria applied are those used by the Canadian Forestry Service in land capability studies for the Canada Land Inventory (1970) and are as follows:

1. Productive Woodland. Wooded land with trees having over 25% canopy cover and over approximately 20 ft (6m) in height. Plantations and artificially reforested areas are included regardless of age. Productivity will usually be over 30 ft^3/ac ($2m^3$/ha) per year, and will include most forested lands rated as Class 5 or better for Forestry in the Canada Land Inventory. Assuming a rotation age of 100 years, yields are usually greater than 25 cords/ac ($224m^3$/ha) for low productivity Class 5 land. High productivity, Class 1, Forest Land in Canada can be expected to provide from 111 to over 190 ft^3/ac (7.5 to $13m^3$/ha per year).

2. Nonproductive Woodland. Land with trees or bushes exceeding 25% crown cover and shorter than approximately 20 ft (6m) in height. Much cutover and burned-over land is included. Productivity will usually be less than 30 cu ft/ac ($2m^3$/ha) and frequently less than 10 cu ft/ac ($0.7m^3$/ha) per year and will include most lands classified as Classes 6 and 7 for Forestry in the Canada Land Inventory. Yields are frequently less than 25 cords/ac ($224m^3$/ha) and usually 10 to 12 cords/ac (90 to $107m^3$/ha).

As evident from Figure 7, the Appalachian physiographic region comprises several vegetation regions, or portions thereof. The Boreal Forest region includes part of the Gaspé Peninsula and the greater part of the island of Newfoundland. The remainder of Newfoundland constitutes a part of the Tundra and Boreal Forest Transition. The Southern Mixed Forest Region includes all other parts of the Appalachian physiographic region.

Boreal Forest Region. This region, which occupies almost 1,000,000 sq mi (2 589 000km^2) is the most widespread of the forest region in Canada. It forms a continuous belt south of the Tundra-Forest Transition, extending from Newfoundland west to the Rocky Mountains and northwestward to the Alaskan border. In Eastern Canada, the southern border of the Boreal Forest merges transitionally with the Southeastern Mixed Forest of the Maritime Provinces (Acadian Forest region) and the Great Lakes -- St. Lawrence Forest region in Ontario and Quebec. As its name implies, the Boreal Forest is associated with Boreal temperature regimes, mainly occurring within the colder Cryoboreal climatic regions and in areas of subaquic, perhumid, humid, and some areas of transitional humid to subhumid moisture regime, where neither excess periods of soil saturation nor growing-season moisture deficits are considered as significant limitations to forest growth.

Although many separate sections of the true Boreal Forest region in Canada have been recognized and described, there is a general relationship of vegetative pattern that characterizes the region as a whole. A dominance of conifers, with white and black spruce (*Picea glauca* (Moench) Voss and *P. mariana* Mill. B.S.P.) as the main species, is most common. Other less prominent but characteristic conifers are tamarack (*Larix laricina* (Du Roi) K. Koch), balsam fir (*Abies balsamea* L. Mill.), and jack pine (*Pinus banksiana* Dougl.) intrude into the western sections of the Boreal Forest from the mountain regions. Although dominantly coniferous there is a wide distribution of broad-leaved trees, particularly white birch (*Betula papyrifera* Marsh.) and aspen and balsam poplar (*Populus tremuloides* Michx. and *P. balsamifera* L.). These latter species, particularly aspen, are most numerous in the central and southern boreal sections, especially in subhumid climatic areas transitional to the Prairie Grasslands. The wide distribution of aspen is partly due to its ability to quickly regenerate after fire, cutting, or other disturbances. Black spruce and tamarack increase in dominance within the more northerly section bordering the Tundra and Boreal Forest transition. Along the southern borders of the eastern sections there is a considerable mixing of species intruding from the moderately cool, Southeastern Mixed Forest region, including white and red pines (*Pinus strobus* L. and *P. resinosa* Ait.), yellow birch (*Betula alleghamensis* Britton), sugar maple (*Acer saccharum* Marsh.), black ash (*Fraxinus nigra* Marsh.), and eastern white cedar (*Thuja occidentalis* L.).

Within all sections there are general relationships of vegetation association with soil and moisture site characteristics. Jack pine with associated xero to xeromesophytic shrub and forest floor species, which are most prevalent on rapidly to well-drained soils in dry and fresh forest sites, are frequently found in areas of coarse-textured or sandy Podzols and Brunisols. White spruce, birch, and aspen poplar with associated mesophytic species have a wide range of distribution in rapidly to imperfectly drained, fresh, moist, and very moist forest sites, but dominate in well to imperfectly drained loamy to clayey soils. They are particularly associated with Gray Luvisols and Brunisols.

Balsam poplar and balsam fir favor somewhat more poorly drained sites, whereas black spruce and tamarack and their associated meso-hydrophytic and hydrophytic forest floor are most frequent in very moist and wet forest sites with subaquic or aquic moisture regimes. Black spruce and balsam poplar are characteristically found with gleyed phases of Luvisols and Brunisols and black spruce and tamarack usually dominate treed areas of peaty Gleysols and Organic soils.

The greater proportion of the Boreal Forest sustains a reasonably productive forest cover with growth rates from 30 to over 90 ft^3/ac (2 to over 6m^3/ha) per year. A number of exceptions to this generalization are significant. Nonproductive forest growth is general on Rockland and soils with shallow regolith, and stony or lithic phases. Production is also low on very dry or rapidly drained jack pine sites associated with coarse-textured Podzols and Brunisols, where forest growth is usually sparse and stunted.

Most of the very poorly drained or wet sites are nonproductive, particularly where associated with peaty Gleysols and Organic soils. Where a peaty cover is present, growth is frequently limited by excess moisture or by prolongation of very cold or frozen conditions. Productivity is somewhat higher on a number of Gleysol areas developed on finer-textured lacustrine deposits.

Extensive lumber and pulpwood operations have been undertaken in the more accessible parts of the Boreal Forest region and in particular in areas where favorable transportation facilities have been made available.

Hunting and trapping have been continuing activities within the Boreal Forest since the earliest developments of the fur trade in Canada and constitute a significant use of this resource. This has been followed recently by an increasing development of the forest for recreational activities. Agricultural development has made some inroads into the fringe of the Boreal Forest particularly in Western Canada and to a lesser extent in local areas of Ontario and Quebec, but the main use of this vast region is still associated with the preservation and maintenance of forest vegetation as a sustaining resource.

Tundra and Boreal Forest Transition. The Newfoundland portion of this Transition Region consists of sparsely forested heath-and-moss barrens; owing their existence, in part, to wind exposure, perhumid conditions, and temperature limitations.

Tundra is essentially a treeless vegetation characterized by the absence of tall woody species. The tundra vegetation of the Newfoundland Barrens consists of two main tundra types or plant associations: Lichen-Moss and Heath. Lichen-Moss tundra forms a virtually continuous vegetative cover and is usually found in apparently well-drained upper slope positions. The characteristic species are the lichen, particularly reindeer moss (*Cladonia rangiferina* and C. *alpestris*). Heath tundra occupies more humid and imperfectly drained sites than the Lichen-Moss association. It is characterized by the occurrence of numerous ericaceous species, including arctic blueberry (*Vaccinium uliginosum* L.), rhodora (*Rhododendron canadense* L.) and sheep laurel (*Kalmia angustifolia* L.) as well as crowberry (*Empetrum nigrum L.*).

The forest vegetation within this particular transition area consists mainly of dwarfed coniferous species with occasional good stands of trees in sheltered, well-drained and usually upper slope positions. Black spruce (*Picea mariana* Mill B.S.P.) and balsam fir (*Abies balsamea* L. Mill.) are the dominant species, tamarack (*Larix laricina* (Du Roi) K. Koch) occurring less frequently.

Southeastern Mixed Forest. In central and eastern Canada from the Ontario-Manitoba border on the west to the Maritime Provinces on the Atlantic Coast lies the Southeastern Mixed Forest region. It represents in many ways a transition between the Boreal Forest of northern Canada, dominated by conifers, and the Deciduous Forest extending from the milder climatic regions of the eastern United States northward into the relatively mild regions of southern Ontario. This area of Mixed Forest can be conveniently divided into two regions in Canada, the Great Lakes -- St. Lawrence Forest and the Acadian Forest, which extends throughout the Maritime Provinces of Eastern Canada, including Prince Edward Island but exclusive of Newfoundland.

Great Lakes - St. Lawrence Forest Region. This region of approximately 140,000 sq mi (362 460km^2) extends north of the United States border from the Lake of the Woods region of Manitoba and western Ontario eastward to Thunder Bay on Lake Superior. It continues from the southeastern shore of Lake Superior north of Lake Huron and eastward through southern Ontario and Quebec and along the south shore of the St. Lawrence River as far as the plateau highlands of the Gaspe Peninsula.

Climatically it is more closely identified with moderately cool Boreal, humid to perhumid conditions, rather than with the colder Cryoboreal climates of the coniferous Boreal Forest. In southwestern Ontario and along the Central St. Lawrence Lowland where it merges with the Deciduous Forest regime, the associated temperature regime is transitional, changing from moderately cool Boreal to the milder temperatures of the Mesic climate.

This forest is of a very mixed nature, characterized by white and red pines (*Pinus strobus* L. and P. *resinosa* Ait.), eastern hemlock (*Tsuga canadensis* (L.) Carr.), and yellow birch (*Betula alleghaniensis* Britton). Associated with these are many other species common to both the Deciduous and Boreal forests including in the former various maples (*Acer* spp.), elms (*Ulmus* spp.), and oaks (*Quercus* spp.); and in the latter, spruces (*Picea* spp.), jack pine (*Pinus banksiana* Lamb.), poplars (*Populus* spp.), and birch (*Betula* spp.). Podzols, Brunisols, and Luvisols are associated soils on well to imperfectly drained sites and the forest growth on these is generally productive except on associated Rockland areas. Eastern white cedar (*Thuja occidentalis* L.), black ash (*Fraxinus nigra* Marsh.), red maple (*Acer rubrum* L.), and elm (*Ulmus americana* L.) are found in mesohydrophytic and hydrophytic sites. Black spruce (*Picea mariana* (Mill.) B.S.P.) and tamarack (*Larix laricina* (Du Roi) K. Koch) are found in very moist and wet sites grading towards cooler Boreal conditions. Forest growth on all Organic and on some of the colder peaty Gleysolic soils is largely unproductive, but in milder temperature regimes Gleysols support a reasonably productive growth.

The clearing involved in the early extension of agricultural development in this region, together with past and present forestry operations, has diminished and modified the forest resources in this area. A number of forest reserves have been established for protection of these resources as well as to accommodate the increasing demands of recreational use and development.

Acadian Forest Region. This region of approximately 45,000 sq mi (116 505km^2) constitutes the eastern part of the Southeastern Mixed Forest region of Canada and includes all of the Maritime Provinces south of the Chaleur Uplands of New Brunswick, including Prince Edward Island and Cape Breton Island. The Acadian Forest is closely related to the Great Lakes - St. Lawrence region with the occurrence of characteristic elements of Deciduous and Boreal Forest associations. It is also climatically similar in that much of the area is under the influence of moderately cool, Boreal perhumid to humid climate, with the exception of higher elevations within the New Brunswick and Cape Breton highlands where colder Cryoboreal conditions occur. In parts of southern Nova Scotia, under the modifying influences of maritime temperatures, climatic conditions transitional between those of Boreal and Mesic climates occur.

Red spruce (*Picea rubens* Sarg.), balsam fir (*Abies balsamea* (L.) Mill.), yellow birch (*Betula alleghaniensis* Britton), and sugar maple (*Acer saccharum* Marsh.) are characteristic species with red and white pine (*Pinus resinosa* Ait. and *P. strobus* L.) and hemlock (*Tsuga canadensis* (L.) Carr.) occurring to a lesser but significant degree. The Boreal Forest element is represented by the occurrence of black and white spruce, poplar, and birch. Jack pine and poplars are prominent on sandy soils and in areas of regrowth after fires. Black spruce, tamarack, black ash (*Fraxinus nigra* Marsh.), cedar (*Thuja occidentalis* L.), and red maples are common constituent species in very moist and wet forest sites.

Forest growth is generally productive on most upland Podzols and Luvisols and nonproductive on Rockland and on stony or lithic phases. An exception occurs on the higher elevations of the Cape Breton Plateau where the forest cover becomes discontinuous and moss or heath vegetation dominates. Most lowlands associated with Gleysols are reasonably productive, but areas of Organic soils generally support poor, nonproductive growth. In many coastal areas under maritime conditions, the effect of wind exposure has resulted in stunted growth and low productivity. These effects are particularly noticeable in Nova Scotia, Cape Breton Island, and some coastal areas of New Brunswick.

Throughout the Acadian Forest region, early agricultural settlement, characterized by intensive lumbering and clearing, accompanied by extensive forest fires, has modified much of the original forest cover. This has been followed by considerable abandonment of cropland in areas of marginally productive soils and rough topography, which is now reverting to natural forest cover. Reforestation is being undertaken on former croplands and in some areas where modern commercial forestry operations are practiced on a sustained yield basis.

In Prince Edward Island, which has a pattern of extensive agricultural development, little original forest vegetation remains. In Nova Scotia and New Brunswick, where agricultural development is scattered or concentrated in local districts, larger tracts of forest land remain and many of them are being used for commercial operations. Maintenance of forest lands for wild-life habitat, watershed control, and to meet an expanding demand for recreational use is receiving increasing attention throughout the Acadian Forest region.

Deciduous Forest Region. A small part of the deciduous forest that is widespread in eastern United States continues northward into southwestern Ontario between Lakes Huron, Erie, and Ontario. It occupies an area of about 1 000 sq mi (2 590km^2) extending eastward in a narrow belt from the Detroit-Windsor area for approximately 250 mi (402km) and including the Niagara Peninsula and most of the shoreline of Lake Ontario. Climatically it relates to the warmest portions of the Mesic subhumid to humid area of southwestern Ontario.

At the time of settlement in the late eighteenth century, this area was clothed in deciduous forest vegetation. Very little, if any, natural forest remains today, and the relationship of the present to the original vegetation is largely inferential. Most of the area is closely settled and the forest vegetation is mostly reduced to farm wood lots, hedge rows, and remnant stands on nonarable soils. Modification of both natural and cultural vegetation has been further intensified by the rapid spread of urban and industrial development into rural areas.

Many of the broad-leaved species common to the Great Lakes - St. Lawrence region can be found, such as sugar maple (*Acer saccharum* Marsh.), beech (*Fagus grandifolia* Ehr.), white elm (*Ulmus americana* L.), basswood (*Tilia americana* L.), and red and white oaks (*Quercus rubra* L. and *Q. alba* L.). There are also a number of other species that are more common in warmer areas to the south, but reach their northern limit in this area. Among these are tulip tree (*Liriodendron tulipifera* L.), pawpaw (*Asimina triloba* (L.) Dunal), red mulberry (*Morus rubra* L.), black gum (*Nyssa sylvatica* Marsh.), sassafras (*Sassafras albidum* (Nutt.) Nees), and pignut hickories (*Carya tomentosa* Nutt. and *C. glabra* (Mill.) Sweet). Black walnut (*Juglans nigra* L.), sycamore (*Platanus occidentalis* L.), and swamp white oak (*Quercus bicolor* Willd.) are also found in this region.

In wood lots, parks, and in most remnant stands where adequate protection and maintenance are provided the forest growth is generally vigorous and productive.

Soils

The zonal soils in the Appalachian region are Podzols, belonging to the Podzolic order of the Canadian System of Soil Classification. Soils of this order have B horizons in which the dominant accumulation product is amorphous material composed mainly of humified organic matter combined in varying degrees with Al and Fe. Typically, Podzolic soils occur in coarse to medium textured, acid parent materials, under forest or heath vegetation in cool to very cold humid climates. Generally, they are characterized by: organic surface horizons; a light-coloured eluvial horizon, Ae, although this may be absent; a reddish-brown to black B horizon with an abrupt upper boundary; lower B or BC horizons with colours progressively yellower in hue and lower in chroma with depth, except in reddish-coloured parent materials.

Deviations from the zonal soil conditions in the Appalachian region are common owing, in part, to soil disturbance by uprooting of trees and to the generally highly compact nature of the till parent material as well as the extensive occurrence of fragipans. The former cause results in dynamic rejuvenation of the soil's morphological expression whereas the latter causes favour pseudogley formation.

Soils (Cann and Millette, 1960) in the uplands, highlands and mountains divisions of the Appalachian region are generally coarse textured, stony, acid, and shallow to bedrock. The highlands and uplands soils in Newfoundland, which lies within the Boreal Forest vegetation region, as well as those in the Cape Breton Highlands section of the Nova Scotia Highlands and the soils along the Atlantic coast of the Nova Scotia Uplands frequently contain ortstein and ironpan (placic) horizons. All other uplands and highlands Podzolic soils contain more organic matter in the B horizons than their lowland counterparts.

The soils of the Maritime Plain and the Annapolis Lowland generally have sandy loam to sandy clay loam textures, reddish-brown colours, and firm to compact subsoils, frequently with fragipan. Till deposits predominate with minor inclusions of alluvial, glacio-fluvial and marine deposits. The latter two deposits are fairly extensive in the Annapolis Lowland. Zonal soil development is podzolic in nature, regardless of the nature and origin of the parent material.

Land use

The disposition of lands for agriculture, forestry, urban, and other uses is outlined in Appendix B. Clearly, the lands in the Appalachian region are primarily unimproved lands. Except for the island of Newfoundland, the greater part of these unimproved lands is suitable for forestry, principally pulpwood.

Agricultural land is presently restricted to the Annapolis Lowland, the Maritime Plain, the Eastern Quebec Uplands, the portion of the New Brunswick Highlands to the west of the St. John River, and to alluvial plains and terraces in uplands and highlands. Dairy or mixed farming is the most important agricultural enterprise in Newfoundland and the Eastern Quebec Uplands. The portion of the New Brunswick Highlands to the west of the St. John River is known for its potato production. Tree fruits, cash crops and mixed farming mark the agriculture carried out in the Annapolis Lowland. The growing of grain, potatoes, and tobacco as well as dairy farming occupy most of the cleared land in the Maritime Plain.

SOIL CAPABILITY

Soil capability pertains to interpretive groupings of soils according to their potentialities and limitations for a particular objective.

Agriculture. The soil capability classification for agriculture, as used in the preparation of the soil capability maps made for the Canada Land Inventory (C.L.I.), consists of seven classes and eleven subclasses. The capability class indicates the general suitability of the soils for agricultural use while the subclass provides information on the kind of conservation problem or limitation within each of the classes other than Class 1.

The aforementioned soil capability maps show that mineral soils suitable for general arable use (Classes 1 to lV) cover 14.1 million acres or 24% of the Appalachian land area, excluding the Quebec portion of this physiographic region. A large part of this arable acreage is under forest as is evident from Appendix B. This acreage suitable for fieldcrops would be increased if the 6 million acres of organic (peat) soils had been included in the compilation.

The dominant soil limitation to agricultural production in the Atlantic Provinces is low fertility. Generally, lime and fertilizers need to be applied on an annual basis as residual effects of such inputs are usually short lived.

The second serious limitation is poor structure, which affects approximately one-third of the arable soils. The difficulty stems from dense, compact subsoil layers, such as ortstein, fragipan, and basal tills, which resist penetration of plant roots and percolation of rainfall. Effects include the persistence of excess moisture and consequent low trafficability as well as shallow rooting of crops and consequent nutrient and moisture deficiencies. Tile drainage and, more recently, mole drainage and subsoiling are being applied in attempts to overcome these effects of poor structure.

Excessive stoniness, steep topography, and wetness other than that produced by dense subsoil are the other limitations. Stoniness and wetness can be ameliorated to some extent by mechanical stone removal and ditching and under drainage respectively, if economically feasible. Steep slopes and complex relief pattern seriously impede the use of very large areas for some crops owing to the difficulty of operating machinery and the hazard of erosion.

Climatic factors impose a ceiling on the productivity of all soils in the region. The marine influence ensures lower summer maximum temperatures and, except for the Annapolis Lowland and Maritime Plain, less accumulated heat than is desirable for cereal crops and certain fruit. Spring arrives one month too late and is cool. Monthly rainfall during the growing season varies widely from its mean, affecting crop production. Fog limits crop growth and farm operations along the Atlantic and Bay of Fundy coasts.

Agricultural productivity is also greatly affected by certain socio-economic constraints. The division of fields by too many fences and the fragmentation of farms as well as patchwork acquisitions hamper farm operations. The geographical pattern of farming areas in the region does not lend itself readily for efficiency in marketing. The true productive potential of many soils is undetermined. Substantial attrition of agricultural productive potential is represented by perennial and permanent loss of good agricultural soils to urban and other nonagricultural uses. In addition, a large area of good soils is tied up in retirement and recreational properties. Many of the latter belong to nonresidents while the former represent idle lands of veterans and ex-farmers who are not ready to sell. Federal freight assistance on western feed grains has hastened much former productive cropland into idleness.

Forestry. The land capability classification for forestry, as used for the Canada Land Inventory, consists of three categories: the capability class, the capability subclass, and the indicator species. The capability class indicates the general suitability of the environment -- soil, climate, landform -- to tree growth. Factors which limit tree growth are shown as subclasses for all except Class 1. The indigenous tree species that can be expected to yield the volume associated with each class are shown as part of the symbol.

The modal capability class for forestry in the Atlantic region is Class lV: i.e. lands having moderately severe limitations to the growth of commercial forests. The soils are commonly moderately well drained. In addition to the regional limitations of climate and soil fertility, these soils have bedrock, or fragipan, or compacted basal till usually within 60cm of the land surface. Productivity is usually from 51 to 70 cubic feet per acre per annum (3.5-5 m^3/hyr).

Regional limitations to tree growth are climate and soil fertility. Climate is limiting owing to the cool, short growing season and to wind exposure. Low levels of soil fertility are characteristic for the soils of the region.

Soil limitations to rooting depth and transmission of moisture are next in importance. Specifically, these are shallowness to bedrock or to a compacted or cemented layer or horizon. Their effect on forest productivity is deemed adverse if they occur within 60cm of the land surface.

SOUTHERN QUEBEC

R. Marcoux and G. Bourbeau

Environment, Soils and Their Use

PHYSIOGRAPHY

Southern Quebec may be divided into three main physiographic regions: the Canadian Shield, the St. Lawrence Lowlands and the Appalachian Plateau. The Laurentian Plateau, north of the St. Lawrence, forms part of the Canadian Shield. It is 300 to 550m high and constitutes an old, undulating erosion surface, broken up by many lakes and streams which flow towards the St. Lawrence Lowlands. The geological substratum is made up of Precambrian formations, granites and especially diorites which have occasionally been metamorphosed. The Abitibi Upland (mean altitude: 270 to 370 m) to the northwest, with its rolling to hilly relief and mantle of clay and lacustrine silt sediment, drains into James Bay. In the east, this Precambrian crystalline area merges gently into the Laurentian Plateau which, in turn, abruts more abruptly on the St. Lawrence Lowlands in the south.

St. Lawrence Lowlands

The St. Lawrence Lowlands extend from the Laurentian Highlands to the Appalachian region (Fig. 8). They form roughly a triangle with the apex near Quebec City and the base along the southwestern border of the province between Missisquoi Bay and Portage-du-Fort. The Lowlands are generally less than 120m above sea level. The terrain is generally flat or gently rolling (except for the seven Monteregian hills of intrusive origin) and occurs at two different levels: the higher level corresponds to areas where marine clay sediments have been preserved as originally deposited in the Champlain Sea. The high north terrace stretches from the Laurentian Plateau to a very steep talus which marks the former north shore of the Ottawa and St. Lawrence Rivers. Wherever there is a thick layer of clayey sediment, the talus is very pronounced but becomes less so in areas where the till and bedrock have resisted the erosive action of the water. The talus decreases in size from west to east, i.e., 90m at Portage-du-Fort and 30m at Trois-Rivières). The high terrace in the south extends from the Appalachians to the talus south of the St. Lawrence. This talus is most pronounced east of the Richelieu River between St. Hilaire and St. Denis and at Baieville and Nicolet, as far as Gentilly (Nicolet County). It rises to 30m in its western segment and 23m in its eastern portion. The lower level, or Central Lowlands, corresponds to areas where the Ottawa and St. Lawrence Rivers in their former channels have eroded away a significant layer of marine sediments with the result that the terrain in these places is approximately 8 to 23m lower than in non-eroded areas. The lower level makes up a substantial portion of the Lowlands as, for instance, around Lac St. Pierre where the former banks of the St. Lawrence are approximately 30 km apart. This zone is rarely over 15 to 25m above sea level. Along the Ottawa River, the lower central low terrace rises 30 to 60m above sea level.

The Lowlands rest on a horizontal Paleozoic base made up of sandstone, dolomite, limestone and shale. The Ottawa and St. Lawrence Rivers plus several other large rivers from the Laurentian Highlands or the Appalachians cut through

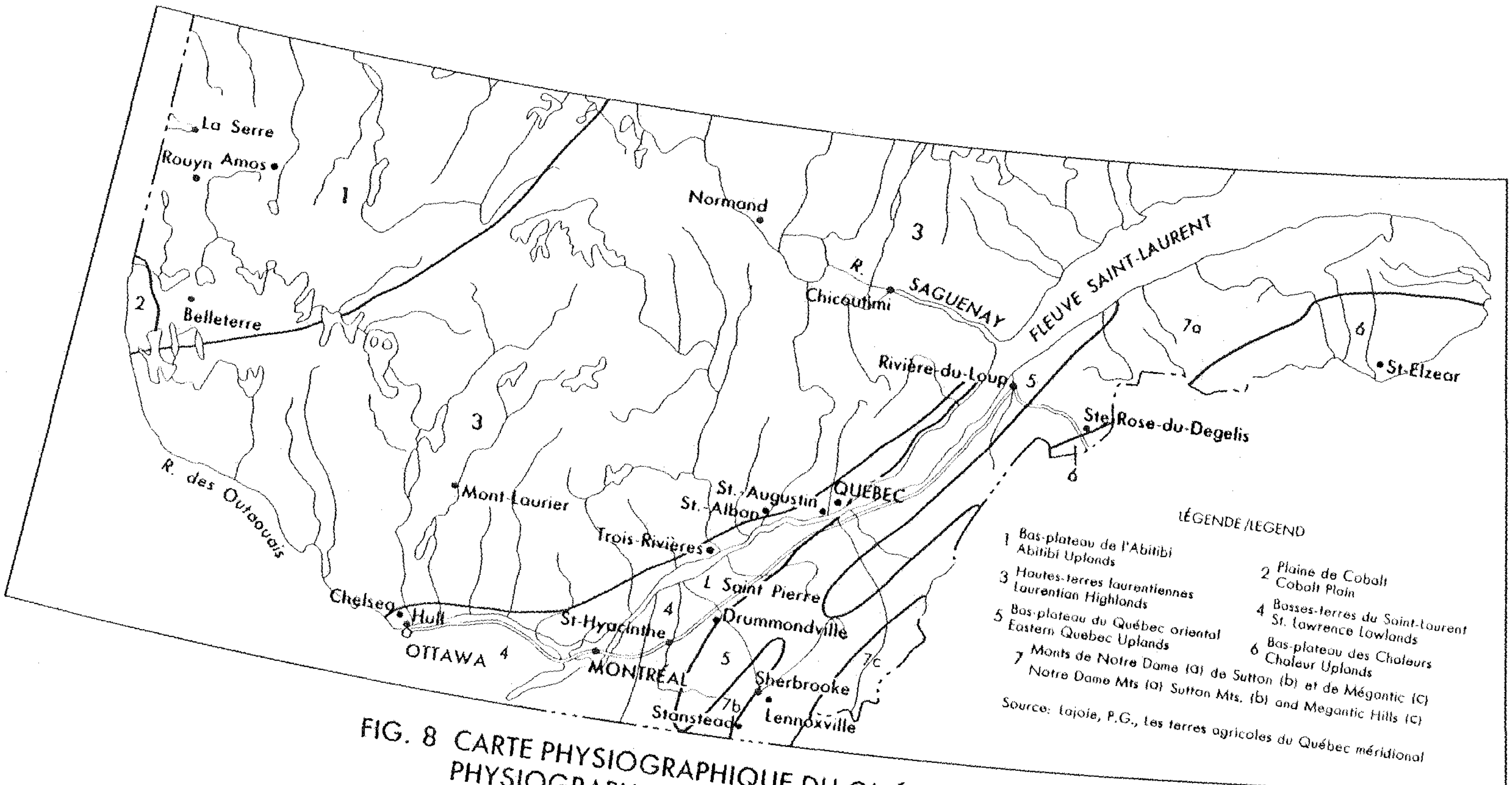


FIG. 8 CARTE PHYSIOGRAPHIQUE DU QUÉBEC MÉRIDIONAL
PHYSIOGRAPHIC MAP OF SOUTHERN QUEBEC

the area. Deep gullies have been gouged out on the high terrace by these rivers and their tributaries. The deepest cuts in the clayey soil are to be found on the north side of the Ottawa and St. Lawrence Rivers due to the steeper slope resulting from a greater isostatic uplift as compared to the south side. In addition, the difference in uplift is responsible for the very slow flow of drainage water from the Missisquoi Bay area on the southern edge of the Lowlands.

Appalachian Region

The Appalachian region is made up of a central mountain range (Notre Dame Mountains), the Eastern Quebec Uplands and the Chaleur Uplands area, separated from the Lowlands by the Champlain (Logan) fault. The Eastern Québec Uplands extend upward to the St. Lawrence from Missisquoi Bay, then run along the river from Lévis to Mont Joli.

The Uplands generally rise from the Lowlands to a piedmont zone, reaching a height of approximately 300 to 370m at the foot of various mountains. The landscape is essentially one of fairly uniform highlands which are separated by valleys approximately 240m in altitude. The Paleozoic base underlying the Uplands consists of a series of folds and roughly parallel overthrusts forming hills running in a northeasterly direction. These Cambrian and Ordovician bases are mainly made up of slate, phyllite and crystalline schist. The rivers are deeply embanked and often follow an erratic course before emptying into the St. Lawrence. The Chaleur Uplands cover the southern third of the Gaspé peninsula and form a narrow strip (mean altitude: 430 to 550m) along the Baie des Chaleurs. The land is crisscrossed by a number of rivers flowing at the bottom of deep gullies in a southerly direction. The rock formation is mainly Silurian and Ordovician and made up of shale, sandstone and limestone.

The central mountain range consists mainly of the Notre Dame Mountains which occupy two-thirds of the Gaspé Peninsula and Mount Sutton and Mount Megantic in the southwest, both of which are over 600m in height. The slate, schist and granite bedrock has undergone considerable volcanic activity.

SURFACE DEPOSITS

Except for the Abitibi Uplands and the Lac St. Jean enclave (with deltaic and lacustro-marine deposits), most of the Appalachian region and Canadian Shield has a mantle of moraine deposits whereas in the St. Lawrence Lowlands, the deposits are of marine and deltaic origin.

At the end of the last (Wisconsin) ice age, marine waters flooded the Lowlands leaving vast stretches of clay deposits. As Lake Champlain receded and the area readjusted isostatically, the rivers and streams from the Highlands renewed their erosive activity, thereby increasing the depth and breadth of the already existing sandy stretches until more than half of the marine deposits were covered over. This is the origin of the large sandy areas that are mainly located south of the St. Lawrence between Lévis and Drummondville and between Trois Rivières and Shawinigan on the north shore. Alluvial deposits at the edge of the rivers and especially organic deposits also exist in large areas of the Lowlands.

Moraine material from the last Ice Age covers the entire Laurentian Highlands and Appalachian region except for a few narrow valleys which are covered with glaciofluvial or lacustrine deposits. The till differs depending on the nature of the underlying rock and local geology. Moraine deposits in the Lowlands were largely covered over by marine sediment but some moraine was re-exposed in areas where the waters from the Ottawa and St. Lawrence Rivers eroded away marine clays. In addition to moraine and glaciofluvial deposits, there are also small stretches of eolian deposits in certain specific areas in the Laurentian Highlands.

CLIMATE

Southern Quebec has a temperate continental subhumid climate in which winters are cold and summers hot. Precipitation is fairly evenly spread out over the year. For the purposes of agriculture, the climate may be divided into three sections. First, there is the area which imposes few restrictions on farming, except for corn or wheat along its fringes. This agroclimatic region encompasses part of the St. Lawrence plain ending slightly downstream from Quebec City near the river. There are 120 or more frost-free days a year and over 3,000 degree-days. Farming is riskier further downstream in the western portion of the Appalachian Plateau and on the edge of the Laurentian Plateau (Lac St. Jean included) because of more severe weather conditions. The frost-free period is one month shorter and the lower range of degree-days is approximately 2,250. Lastly, the climate is even harsher in the Abitibi Upland where the frost-free period is not quite three months and the number of degree-days a year is under 2,000. Production of the forage crops associated with animal husbandry presents some risks. The map in Figure 6 shows the different classes of soil temperature measured 50 cm below a cut grass surface and defines these same climate zones in somewhat different terms. It also shows that farming remains marginal on cold boreal and moderately cold cryoboreal zones.

VEGETATION

Except for the northwest portion of the province in the boreal forest zone, most of the inhabited region of Quebec belongs to the Great Lakes-St. Lawrence forest zone. The Montreal area has been almost entirely cleared of its maple stands interspersed with hickory trees but there are still traces of these stands with oaks (tills) and elms (clay or thin overlay of sand on clay). Fragments of succssion stands made up of silver maple, white birch, red maple and trembling aspen are still to be found.

The range of the Laurentian maple grove (Fig. 9) includes the sandy and gravelly terraces of the plain, and in the north, the rim of the Laurentian Plateau, and the western portion of the Appalachians, extending roughly as far as the Chaudière River basin. The forest has been largely decimated and transformed by man and large stretches are currently undergoing reforestation. In addition to the typical maple stand, white birch, red maple and trembling aspen are also to be found. Larch and black spruce grow along the fringes of the peat bogs.

Maple-yellow birch associations border on the Laurentian maple zone in the north and east. They also contain beech, mountain maple, striped maple, fir and white birch. The domain covers a large portion of the south shore of the

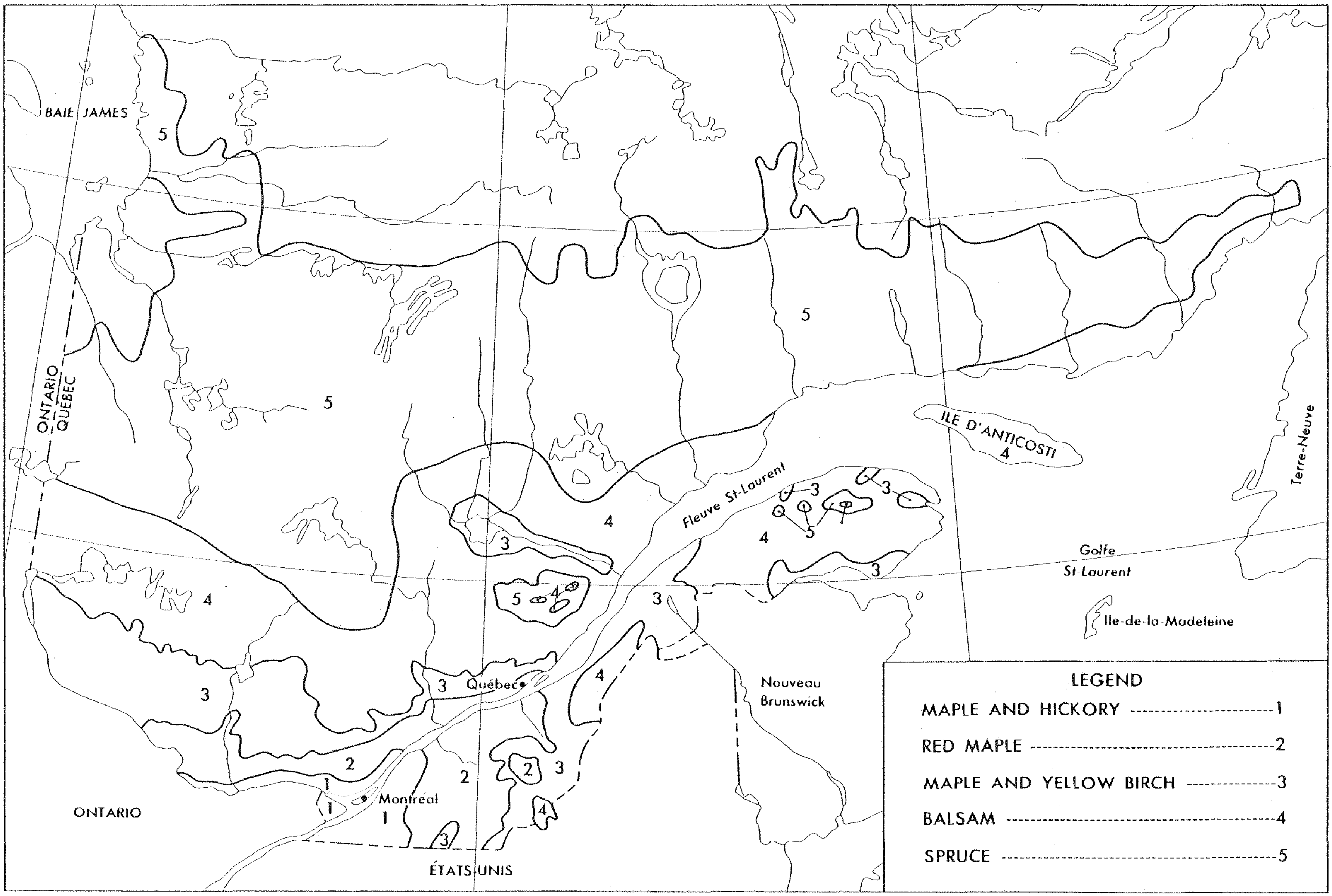


FIG. 9 FOREST VEGETATION ZONES OF QUEBEC

Table 2. Southern Quebec: Characteristics of Climate

	Station	Altitude m	Avg. Yearly Temperature C	Avg. Temp May-Sept. C	Yearly Avg. ppt mm	Avg. May-Sept. C	Degree -Days >5C	Frost-free Period days	Avg. Climate Classification
Abitibi Uplands	La Sarre	267	0	12	833	18.6	2000	80	6L
Laurentian Highlands	Normandin	137	1	13	805	16.9	2250	110	5L
	Belleterre	322	0	13	927	1916	2250	100	6L
	Mont-Laurier	244	4	15	919	18.1	2500	110	5L
Chaleur Uplands	St-Elzéar	198	3	12	1092	18.6	2250	110	6L
Eastern Québec Uplands	St-Rose du Dégelis	151	3	14	927	17.3	2250	100	5L
	Stanstead	312	5	15	1074	19.3	2750	110	4L
	Magog	267	5	16	1110	18.4	2750	110	4L
St. Lawrence Lowlands	St-Alban	55	4	15	1115	20.6	2750	110	4L
	Chelsea	112	5	16	902	15.4	3250	130	3H
	Drummond-ville	82	5	16	942	16.9	3000	120	3L
	St-Hyacinthe	31	6	17	985	17.1	3250	130	3K

Agricultural Lands in Southern Québec (Lajoie, 1975).

Table 3. Characteristics of Soil Temperature in Different Zones

Class or Zone	Geographic Distribution	Mean Annual Temp. C	Mean Summer Temp. C	Growing Season days >5C	Degree-days >5C	Thermal Days >15C
Mild Temperature (5.1)	Lowlands west of Lac St-Pierre	8-15	15-22	200-240	1720-2220	<120
Moderately Cold Boreal (4.2)	Lowlands east of Lac St-Pierre; Appalachian Piedmont; Valleys such as Gatineau Lièvre, Massawipi, St. François	5-8	15-18	<220	1388-1720	<120
Cold Boreal (4.1)	Abitibi; Southwest portion of Laurentian Highlands; Uplands of eastern Quebec; Chaleur Uplands with exception of Shickshocks	5-8	15-18	>170	1250-1388	<60
Moderately Cold Cryoboreal (3.2)	Northeast portion of Laurentian Highlands; Shickshock Mountains	2-8	8-15	<220	1110-1250	Insignificant

Agricultural Lands of Southern Québec (Lajoie, 1975).

St. Lawrence, except for a few hills with conifer stands in the hinterland, and ranges as far as Rivière-du-Loup. On the Laurentian Plateau, the northern boundary of this mixed forest zone extends from Baskatong Lake to the area just south of Temiscamingue. As a result of cuts and the appearance of new growth, balsam fir, spruce and aspen have temporarily invaded the area.

Lastly, further east and north, an increasing number of fir trees is to be found in the maple-yellow birch association to the extent that they now dominate the forest. A notable exception to this is a few high plateaus, such as the Shickshocks or Laurentian Park, where the stands are made up of black spruce.

QUEBEC'S PEDOLOGICAL REGIONS

Quebec's physiographic differences are also reflected in its soil (Baril, 1974), for here too, the same major regions, i.e., Lowlands, Appalachian, Laurentian and Canadian Shield, apply.

Lowlands Pedological Region

Pedologically, the Lowlands may be divided into three subregions: Montreal, Lake St. Pierre and the mouth of the St. Lawrence. The Montreal pedological subregion is made of 5 soil associations. The two most important ones are made up of Humic Gleysols and Melanic Brunisols. The former are uniform in relief, have a clayey texture with poor drainage conditions. The Melanic Brunisols, on the other hand, are rolling to hilly in relief and made up of stony loam. The soil is very fertile. There are also some Gleyed Humo-Ferric Podzols that are very sandy and uniform in relief. Gravelly Dystric and Sombric Brunisol soils on terraces are to be found around the Monteregian Hills. The fertility level of the Brunisols and especially the abovementioned Podzols is rather low. Lastly, the region contains large areas of moderately well-decomposed organic soils which are very well suited to market gardening.

The pedological subregion embracing Lac St. Pierre and Quebec City constitutes a wide strip of land including both shores of the St. Lawrence River downstream from Sorel to Quebec City. It is bound on the southeast by the Appalachians and on the northwest by the first foothills of the Laurentian Mountains. The boundaries of this plain correspond roughly to the former Champlain Sea at its largest. This region is made up of 4 soil associations. A Humic Gleysol on clay occurs in some parts of this prolongation of the Montreal plain but is quickly replaced with a Humo-Ferric Podzol on sand. The thickness of the latter varies and it is often cemented in a tenacious ferruginous ortstein. Nearer to Quebec City and the Appalachian and Laurentian foothills, the soil forms a thin layer over rock or till modified by the waters of the Champlain Sea. In general, the so-called "water's edge" land is good (class 2 and 3) and should be reserved for farming.

The subregion of the St. Lawrence estuary covers a relatively narrow band of land with an average width of approximately 5 km. The materials and resulting soils form a series of strips that are parallel to the axis of the river. Well-drained Humo-Ferric Podzols have formed on the stringers and sandy or gravelly terraces which are arranged in tiers rising 15 to 168m above sea level. The bedrock is quite often less than 2 to 3m below the surface. Gleysols are found in the first plains whereas slightly acid Humic Gleysols with highly mineralized humus are found in the basins of the Appalachian folds which were filled with clay from the Champlain Sea. The latter soils are amongst the most fertile in Quebec, whereas the Humo-Ferric Podzols on schist gravel (St. André series) are poor although less so than the Humo-Ferric Podzols on sand which are occasionally cemented in discontinuous ortstein.

Appalachian Soil Region

This region covers the area that was not flooded by the Champlain Sea. It is bound on the south by the Canadian-U.S. border, on the east by New Brunswick and on the north by the Gulf of St. Lawrence. Counting an enclave at the Baie des Chaleurs, this area includes 4 soil associations made up of Gray Luvisols and Melanic Brunisols. Dystric Brunisols on well-drained sites predominate in the southern portion and Humo-Ferric Podzols are found mainly in the north. Occasionally Humic Gleysols, especially in the catchment basin of the St. Jean River in the south, occur in the poorly drained areas. Due to calcareous formations in the Gaspé area, there are Gray Luvisols, Melanic Brunisols, Podzolic Gray Luvisols and Luvisolic Humo-Ferric Podzols. Except in a few rare instances, there has been no pedological study of this region based on the Canadian taxonomic system.

Laurentian and Canadian Shield Soil Region

This vast region engulfs the entire segment northwest of the St. Lawrence as far as latitude 50°. There are 4 associations with distinct landscapes, i.e., Southern Laurentian, Lac St. Jean, Abitibi and the Laurentian and Canadian Shield region between latitude 48° and 50°. The latter region has not been studied. The most southern reaches of the Laurentians contain a large proportion of Dystric Brunisols which do not seem unrelated to the presence of deciduous trees and Grenville limestone deposits; Humo-Ferric Podzols on well-drained sandy material and Gleysols predominate throughout the region. The Podzols form a deep horizon cemented in incipient fragipan which may help to maintain the humidity in soils that are too sandy.

There are some large stretches in the Lac St. Jean region which may be classified as acid Rego Gleysols and Humic Gleysols because of the clay and silty clay material deposited in the former Laflamme Sea, a sort of arm of the Champlain Sea. These Gleysols tend to become boggy even on calcareous material. The other soils on sandy material and are mainly made up of highly developed Ferro-Humic and Humo-Ferric Podzols. The thin solum Humo-Ferric Podzols cover dry, deltaic sandy material in the "mini-Saharas" and on the dunes and are poorly to well developed. Ortstein may also found in soils with slow or poor drainage. The presence of Jack pine (*Pinus banksiana*) or cypress generally marks the boundary of these sandy spaces (sand barrens) which have been destroyed by fire and subsequently overrun with blueberry bushes.

There have been virtually no studies done on soil associations in the Abitibi area and the vaster region encompassing Matagami and James Bay. This enormous northern region is made up of Gray Luvisols, Brunisolic Gray Luvisols, Luvisolic Podzols, Gleysols as well as permeable dryish and slightly developed Humo-Ferric Podzols on gravel and vast stretches of Organic soils in various degrees of decomposition. However, farming is limited to the Abitibi region.

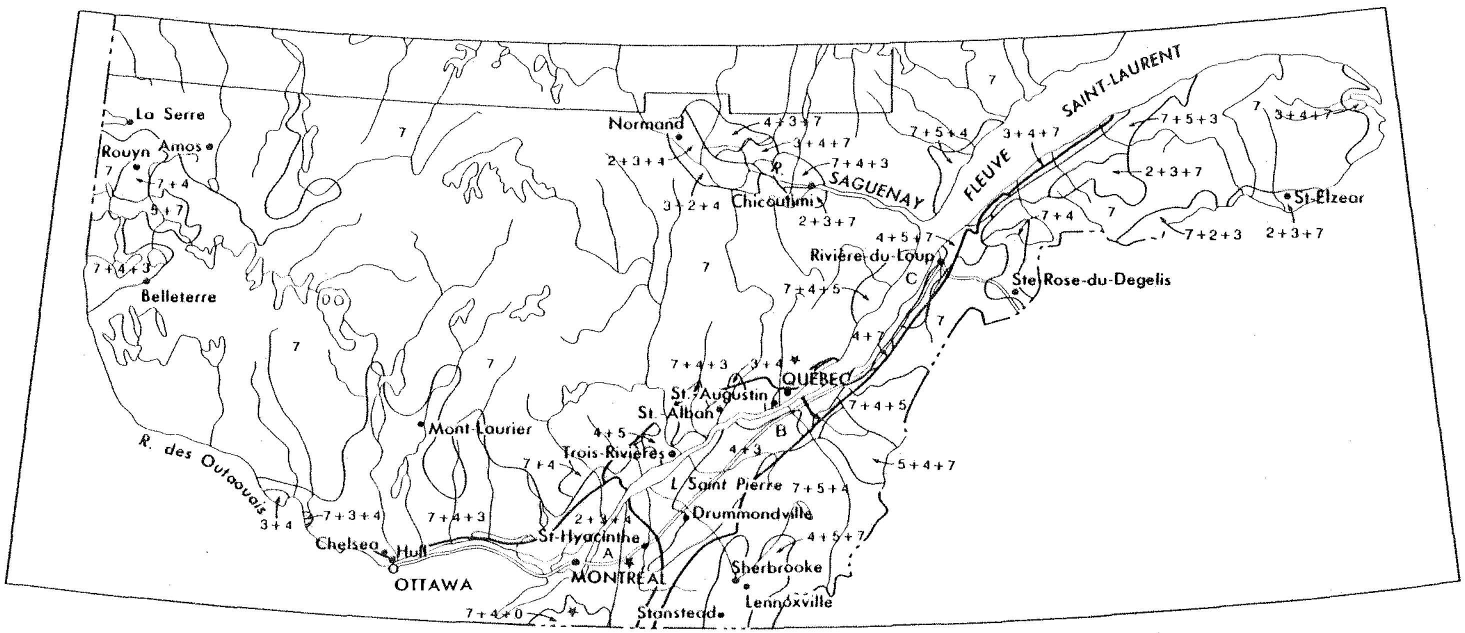


FIG. 10

SOIL CAPABILITY FOR AGRICULTURE

LEGEND

CLASSES

1 Soils in this class have no significant limitations in use for crops

2 Soils in this class have moderate limitation that restrict the range of crops or require moderate conservation practices

3 Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices.

4 Soils in this class have severe limitations that restrict the range of crops or require special conservation practices, or both

5 Soils in this class have very severe limitations that restrict their capability to producing perennial forage crops, and improvement practices are feasible

6 Soils in this class are capable only of producing perennial forage crops, and improvement practices are not feasible

7 Soils in this class have no capability for arable culture or permanent pasture

0 Organic soils (not placed in capability classes)

PEDOLOGICAL REGIONS OF THE LOWLANDS

A - Montreal Region

B - Lake St-Pierre Region

C - Estuary Region

* ISSS Sites

FIG. 10

POSSIBILITES AGRICOLES DES SOLS

LÉGENDE

CLASSES

1 Sols ne comportant aucune limitation importante dans leur utilisation pour les cultures

2 Sols comportant des limitations qui restreignent quelque peu le choix des cultures ou imposent des pratiques modérées de conservation

3 Sols comportant des limitations modérément graves qui restreignent le choix des cultures ou imposent des pratiques spéciales de conservation

4 Sols comportant de graves limitations qui restreignent le choix des cultures ou imposent des pratiques spéciales de conservation

5 Sols qui sont l'objet de limitations très graves et ne conviennent qu'à la production de plantes fourragères vivaces, mais susceptibles d'amélioration

6 Sols qui sont l'objet de limitations très graves; inaptes à produire d'autres plantes que des plantes fourragères vivaces et non susceptibles d'amélioration

7 Sols inutilisables soit pour la culture, soit pour les plantes fouragères vivaces

0 Sols organique.

REGIONS PEDOLOGIQUES DES BASSES TERRES

A - Région de Montréal

B - Région du Lac St-Pierre

C - Région de l'Estuaire

* Sites ISSS

Well-drained clay loam soils may be acid or calcareous. In the latter instance, the soils are well-developed Gray Luvisols and are calcareous less than 20 to 38 cm below the surface. Generally calcareous brown clays are to be found in the lowest regions such as near Abitibi Lake.

Further north, very little notice has been paid to soil associations of the northern regions. Podzols apparently do not exist in Quebec's Far North, at least not at latitude 60°N. Instead, there are Dystric Brunisols and Cryosols (Baril and Payette, 1968). The term Cryosol designates soils with a permafrost layer.

LAND CAPABILITY

The arable land of southern Quebec, i.e., land in the first three classes (Fig. 10) of the ARDA system of classification, represents a total of approximately 2.3 million ha (5.7 million acres) (Lajoie, 1975). Most of this land is to be found in the St. Lawrence Lowlands (51%) and Appalachian region (28%). The remainder represents approximately 0.4 million ha (1 million acres). Forty-four percent of the latter is in the Chicoutimi-Lac St. Jean area and 26% in the Abitibi region. There are also narrow strips of arable land in the Laurentian valleys (Rouge, Lièvre, Gatineau, etc.).

In the Lowlands, class 2 and 3 soils are essentially made up of flat or slightly rolling clays with excess humidity, impermeable subsoil and other minor problems as their principal drawbacks. For some class 3 soils, the major restrictions are low fertility or inadequate natural drainage. Less often the topography or rocky nature of the soil constitutes the major obstacle to use. Class 4 soils are soils on material overlying clays with or without microrelief. In this instance, the fertility as well as the drainage which is rendered variable by microrelief must be improved.

Over 60% of the land in the Appalachian region has no farming potential (class 7) due to different limiting factors acting either singly or in combination, i.e., steep slopes, thin soil on rock, outcroppings, poor drainage, etc. Arable land exists in narrow strips along the Baie des Chaleurs, in the plateau valleys (Matapedia, Coaticook, etc.) and in the piedmont zone along the Lowlands from Missisquoi Bay to Lévis and along the St. Lawrence from Lévis to Matane. These better quality zones are mainly composed of class 3 and 4 soils but also contain a high percentage of class 2 soils. Their main limitations are acidity and low fertility but the rocky nature of the soil, drainage and relief, shallowness, outcroppings, etc., are also factors.

In the Laurentian Highlands, 90% of the area is unsuitable for farming. Only a few narrow strips at the bottom of some of the valleys can be cultivated. The soils in these valleys are mainly sandy or loamy and their main drawbacks are poor water retention, low fertility, poor drainage or different combinations of these factors. A small percentage of soils is made up of silty clays or silty clay loams which provide restricted use due to inadequate drainage resulting from the poor permeability of the subsoil. Lastly, the lacustrine soils which cover approximately one-third of the Abitibi Low Plateau have a low agricultural potential due to the cold climate, the massive structure of the subsoil and the high degree of humidity. The tills and glaciofluvial materials are unsuitable for field crops due to stoniness, frequent outcrops, relief, poor water retention, etc. (Table 4).

Table 4. Agricultural Capability of Quebec Soils*

Classes	1	2	3	4	5	6	7	Total
				Mineral soils(1)				
000 ha	60	925	1333	2788	1610	9	21300	28025
Percentage	0.19	2.9	4.2	8.8	5.0	0.03	67.0	88.0
				Organic Soils				
000 ha								1252
Percentage								4.0
				Others				
Bodies of water (2)								2538
Percentage (2)								8.0
Urban zone (in part)								63
Percentage								0.2
Total area 000 ha or 100%								31878

(1) Preliminary data for Canada land inventory, by ARDA. It should be noted that the area studied by ARDA in southern Quebec more specifically concerned agricultural Quebec and is smaller (32 million hectares, compared to 40 million) than that covered by the pedological map (south of latitude 50^{o}C); this accounts for certain discrepancies.

(2) The waters of the St. Lawrence, Saguenay and Lac St. Jean have not been included. On the other hand, several small lakes have been included in the areas of class 7 soils.

*Data supplied by Paul Lajoie, agronomist and pedologist and compiled by ARDA.

Table 5. Agriculture in Quebec (1951-1971)

Year	Total Population	Rural	Agricultural	No. of Farms	Gross Farm Product in % of Gross Provincial Product	Farm Labor Force in % of total Labor Force
1951	4 056 000	1 326 883	782 756	134 300	6.1	15.7
1971	6 028 000	1 116 520	334 579	61 257	2.0	4.7

LAND USE

Agriculture

Quebec's farm population today represents less than 6% of its total population. At the same time, the number of farms has steadily decreased since 1951 as shown in Table 5.

It should be noted, however, that in many cases the disappearance of marginal farms has coincided with a definite shift towards larger units. The mean cultivated area per farm, in fact, has climbed from 17 to 28 hectares, an increase of 62%. In addition, there has been a general improvement of the land, and management with the emphasis placed on productive investments, etc. All in all, farming still remains an important activity in Quebec from various points of view although it holds a relatively lesser place in the general economy. While the gross farm product is not significant compared to the total gross provincial product, it nonetheless represents close to half (48%) of the gross production for the entire primary sector with sales totalling $1.4 billion in 1974. Furthermore, farming generates a number of jobs via industries involved in food processing and distribution. Farm production also implies a large-scale consumption of goods, e.g., building materials, petroleum products, machinery, etc. If one takes into account the industries and services related to farming, agriculture may be said to mobilize half the rural population of Quebec. In terms of area also, farming is important since farmland represents approximately two-fifths of the entire Lowlands, i.e., 4.3 million hectares, 60% of which is cleared. There are two types of agrarian structures in Quebec: the range and the township systems. The range system is found throughout the St. Lawrence valley and the township system is used in the Eastern Townships and northwestern Quebec. The bulk of farmland is located in the Montreal clay plain and its extension around Lac St. Pierre. There is also a narrow strip of marine clay at Lac St. Jean and on the south shore of the St. Lawrence. Farming in the Lowlands provides over 60% of the cash income of Quebec farmers (Statistics Quebec, 1974) and in the case of the best commercial farms, this figure climbs to 70%. According to estimates based on the 1971 census, the area accounts for 78% of receipts from field crops, 60% from cattle raising and 75% from egg and chicken sales. Lastly, the region has 40% of the province's farm labor force, half of which lives in the Montreal plain. This region has been largely cleared and produces almost all the market garden crops for the province with over 90% of the area used for this purpose, bringing in over 90% of sale receipts. Due to favourable market and weather conditions, the local commercial farms are more diversified and include dairy, animal husbandry, market garden and field crop operations. In the province as a whole, however, animal husbandry accounts for 89% of cash receipts, the remainder going to vegetable production.

In contrast, the Appalachian region has only 20% of the province's commercial farms and the Laurentian region, not quite 10%, the Saguenay-Lac St. Jean enclave counted with the Lowlands. In the western Appalachian, Laurentian and Abitibi regions, animal husbandry often provides a better income than dairy farming. In addition, earnings from part-time work outside the farm are often greater than the total farm revenue (Statistics Quebec, 1974). Outside work, in fact, becomes increasingly important as agro-forestry agriculture becomes more marginal. Due to the more rigorous conditions of the environment, crops related to animal husbandry operations are limited to hay, oats and, more locally, alfalfa. The principal special crops are potatoes and turnips. Another characteristic of the region resides in the larger wooded areas found on the farms where 25% to 50% of the land remains wooded. In the Gaspé peninsula, Témiscouata and on a good portion of the south shore, the percentage rises to over 50%. Marginal farming is generally less specialized and retains some traits - namely, diversified production - which are reminiscent of the days when farmers were largely self-sufficient.

The above outline of agriculture in Quebec is based on a characteristic group of farms which may be portrayed as follows: in 1971, the average typical farm was a 72 hectare dairy farm. Twenty eight hectares were used for crops, 12 for pastureland and the remainder as woodland. The farm had a herd of 20 dairy cows producing some 68 000 kilos of milk a year, which represented approximately 45% of the gross farm revenue, estimated at a total of approximately $12,000 a year. Then, in decreasing order of revenues per product, came poultry farming with 20% of total sales, followed by hog raising (16%) and stock raising. The proportion varied from county to county, depending on the degree of specialization. Dairy farms, for instance, represented over 75% of commercial farms in Nicolet, Richelieu and Lac St. Jean counties. Although figures varied somewhat, the yield for hay was approximately two tons per hectare (except for the Laurentians and northwestern Quebec), 1545 kg/ha for oats and mixed grain, 15 tons/ha for potatoes. Grain corn, due to its climatic requirements, was restricted to the Montreal plain where the yield was approximately 48 tons/ha. In terms of investments, the average farm was worth approximately $35,000; $7,000 of this amount was in equipment and machinery. These figures seem very conservative compared to the realities of 1976 where the smallest piece of average-quality land often has a market value of over $50,000. As a result of the high cost of buying and setting up a profitable farm operation, compounded by the difficulties in obtaining credit and the demanding conditions of some types of farm production (e.g., dairy farming) compared to non-agricultural jobs, many farmers's sons are turning away from farming. The problem of finding young people to take over the farms explains why farmers, 85% of whom own their own land, constitute an increasingly older age group. In fact, the largest percentage of farmers are to be found in the 45 to 54 age bracket. The average farm family (5 people) is continuing to dwindle in size, thereby increasing manpower needs as well as farming costs.

In conclusion, the best soils and the most prosperous farming are to be found in the St. Lawrence valley, near the river, in the main corridors for population distribution, commerce and communications. With its dispersed members, a primary industry such as farming is in no position to protect itself from land speculation and the degradation of the land to be converted into building lots which soon require the introduction of the tertiary sector. A recent study by the Quebec Department of Agriculture (February 1976) concluded that close to 400 000 ha in the Lowlands has probably been given over to land speculation. This represents one-seventh of the area and more than 30% of the arable land (classes 1, 2 and 3) of this region. This takeover by speculators demonstrates the need to rapidly define a zoning policy so that the best land can be reserved for farming.

Tableau 6. Grandes Cultures: Superficie, rendement et production totale au Québec, 1975
Table 6 Field crops: Area, yield and total production in Quebec, 1975.

Culture Crop	Superficie area	Rendement Yield	Production totale Total production
	'000 ha	kg/ha	'000 tonnes/tons
Blé, total/ Wheat, total	34,4	2080	71,5
Avoine/ Oats	253	1530	387,1
Orge/ Barley	22	2060	45,3
Seigle, total/ Rye, total	0,8	1415	1,1
Grains mélangés/ Mixed grains	51	1910	97,4
Mais-grain/ Grain corn	60	5400	324,0
Sarrasin/ Buckwheat	4,0	1160	4,6
Pois secs/ Peas, dry	0,2	1165	0,2
Haricots secs/ Beans, dry	0,4	1480	0,6
Pomme de terre/ Potatoes	2,0	16 364	327,3
Fruits et petits fruits/ Fruits and small fruits			
Pomme/ Apples			116,590
Fraises/ Strawberries			3,295
Framboises/ Rapsberries			330
Bleuets/ Blueberries			3,409

Statistiques du Québec, 1974.

Unlike agriculture, forest resources and primary industries related to forestry operations are to be found more in the Laurentian and Appalachian regions. Approximately 40% of the labor force engaged in forestry-related activities works in the Laurentian area and 35% in the Appalachian region. While private forests are located mainly in the Lowlands, they represent only 8% of the province's forestland and provide approximately 20% of the needs of the sawmills and pulp and paper industry. It is the public forests, located chiefly on the plateaus, that provide 80% of the yearly volume of wood. Forestry operations are conducted essentially in the Quebec portion of the Ottawa River drainage basin, Temiscamingue, Saguenay-Lac St. Jean, St. Maurice and north shore. Forty nine million ha of forestland are suitable for regular production. In 1975, the productive forest was estimated at 16 million ha and pulpwood (conifers) production at 29 million m^3. In 1973, there were 15,600 forest workers and over 60,000 people employed in the forestry industry as a whole.

The peat moss industry also takes on a special significance in the area east of Quebec City on the shores of the St. Lawrence where the major organic deposits are found. The yearly production reaches 180 000 tonnes and comes from several bogs with a total developed area of 3320 hectares. A large percentage of the peat moss produced, i.e., over 90%, is earmarked for export, mainly for the U.S. market.

As regards the other major sectors of the economy (manufacturing, transport and communications, commerce, social and cultural services, etc.), the Lowlands account for 75% of the labor force (15 years and over) engaged in these activities and the Appalachian district, approximately 15% (Census Canada, 1971). In addition, some documents included with this guidebook (Québec touristique, 1976) discuss the potential and existing facilities for tourism and recreation in Quebec.

In conclusion, the St. Lawrence region definitely leads with respect to the number of jobs and business volume in most sectors of the economy with the exception of a few; namely, mining and forestry. The total labor force is about 1,600,000 (74%) for the Lowlands (Chicoutimi-Lac St. Jean included), 350,000 (16%) for the Appalachian region and 220,000 (10%) for the region north of the St. Lawrence and east of the Ottawa River. In terms of area, approximately 40% of the Lowlands is given over to farming, whereas in the Appalachian region, farming represents close to 10% of the area and in the Laurentians and Abitibi district, less than 1%.

ENVIRONMENT, SOILS AND LAND USE OF ONTARIO

C.J. Acton

PHYSIOGRAPHY

The St. Lawrence Lowland and the Canadian Shield are the major physiographic regions of Ontario through which the tour passes (Figure 11). This discussion therefore will relate predominantly to these regions.

The St. Lawrence Lowlands

The St. Lawrence Lowlands are a narrow northeastern extension of the American Central Lowlands, underlain by flat-lying, gently warped Paleozoic strata bounded by the Canadian Shield to the north and the Appalachian Mountains to the southeast. The Western and the Central St. Lawrence Lowland are separated by the Frontenac Axis, a narrow band of resistant Precambrian rock that crosses the St. Lawrence Valley between Kingston and Brockville to connect the Precambrian Shield in Ontario with the Adirondack Mountains in the United States.

West St. Lawrence Lowland. The West St. Lawrence Lowland is bounded by lakes Ontario, Erie, and Huron on the south and west and by the Canadian Shield to the north and the Frontenac Axis to the east. The underlying sandstones, shales, limestones and dolomites have been gently warped so that they overlap onto the Shield to the north and dip gently to the southeast. The softer shale rocks on the lowland have been eroded into depressions and the harder limestone and dolomite stand out as escarpments. The boundary of the Shield east of Lake Simcoe is marked by a low escarpment of Ordovician limestone rising some 50 to 100 ft (15 to 30m) above the Shield surface. The more prominent Niagara Escarpment of resistant Silurian dolomite, resting on weaker red shales, rises from 200 to 1000 ft (61 to 305m) above the surrounding lowland. The escarpment bisects the lowland, stretching over 370 mi (595km) from the Niagara River northwestward to the Bruce Peninsula and Manitoulin Island. West of the escarpment, the surface slopes southwest to lakes Huron and Erie. East of the escarpment, the land rises gently northward from Lake Ontario.

Central St. Lawrence Lowland. The flat plains on the Ottawa and St. Lawrence rivers constitute the central lowland, ranging from a low of 125 ft (40m) above sea level at the Ontario-Quebec border to levels between 300 and 400 ft (90 and 120m) around the outer margins of the lowland. Paleozoic rocks underlie the lowland, and are either faulted against, or lie upon the crystalline rocks of the adjoining Shield, which rises as an escarpment 200 to 300 ft (60 to 90m) above the lowland surface in some areas.

GLACIATION

Glacial erosion and deposition during the Pleistocene ice age left a wide range of glacial and glacial lacustrine deposits covering almost the entire St. Lawrence Lowlands region. The last Wisconsin glaciation was responsible for the formation of most of the characteristic relief features and minor landforms visible at the present time.

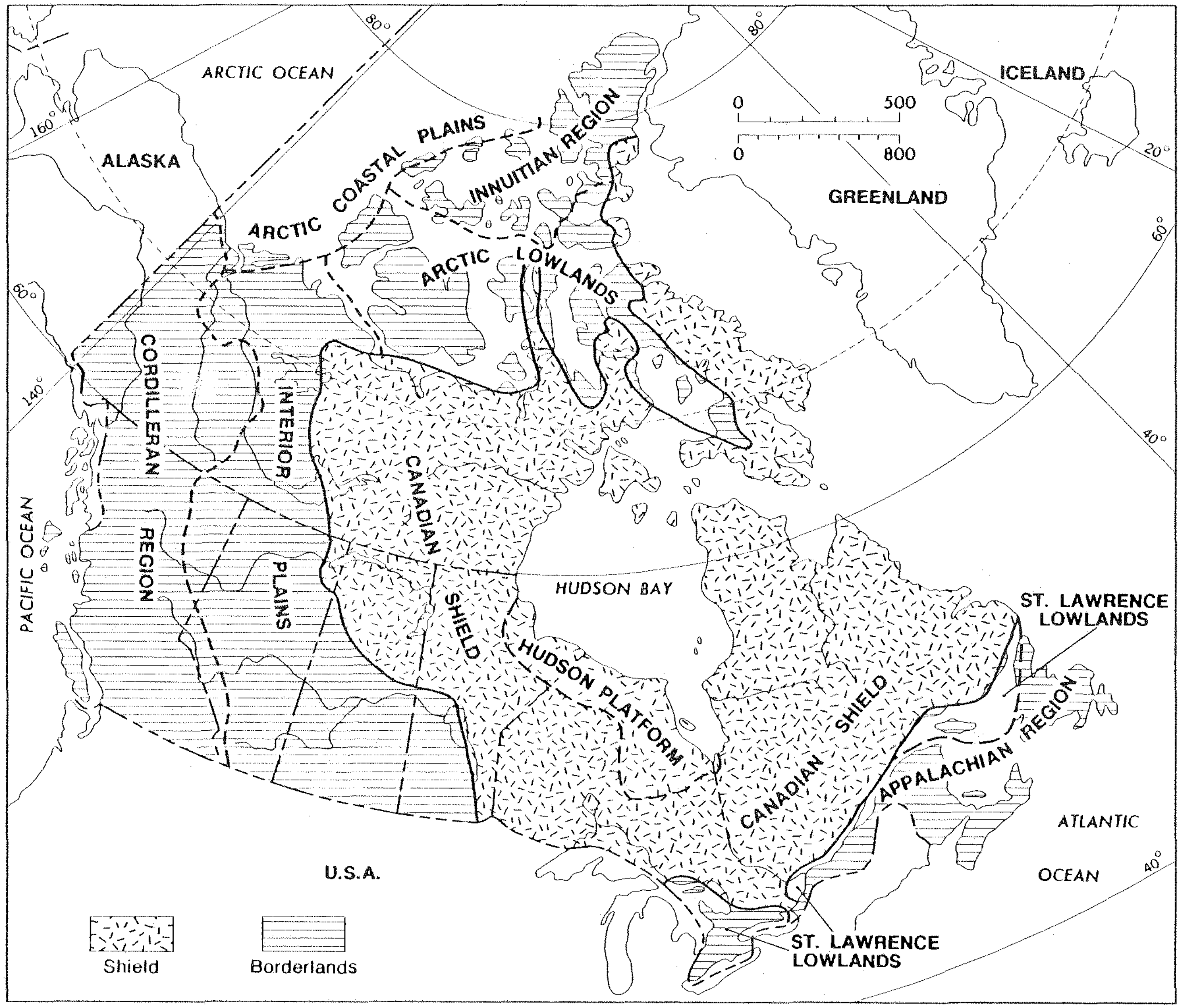


FIG. 11 PHYSIOGRAPHIC REGIONS OF CANADA

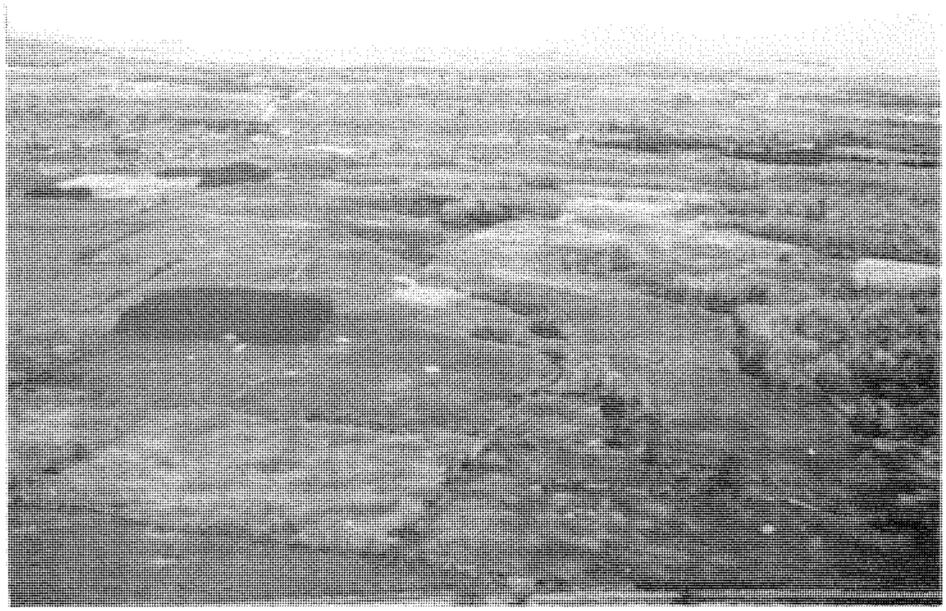


FIG. 12 ST. LAWRENCE LOWLAND REGION UNDULATING TO ROLLING TILL PLAINS

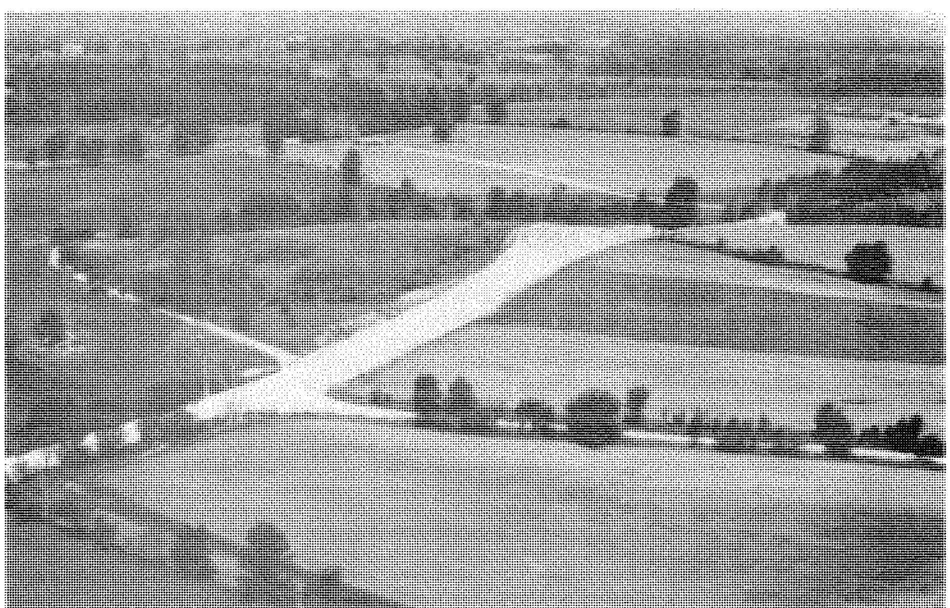


FIG. 13 DRUMLINS IN THE GEORGIAN BAY—LAKE ONTARIO AREA

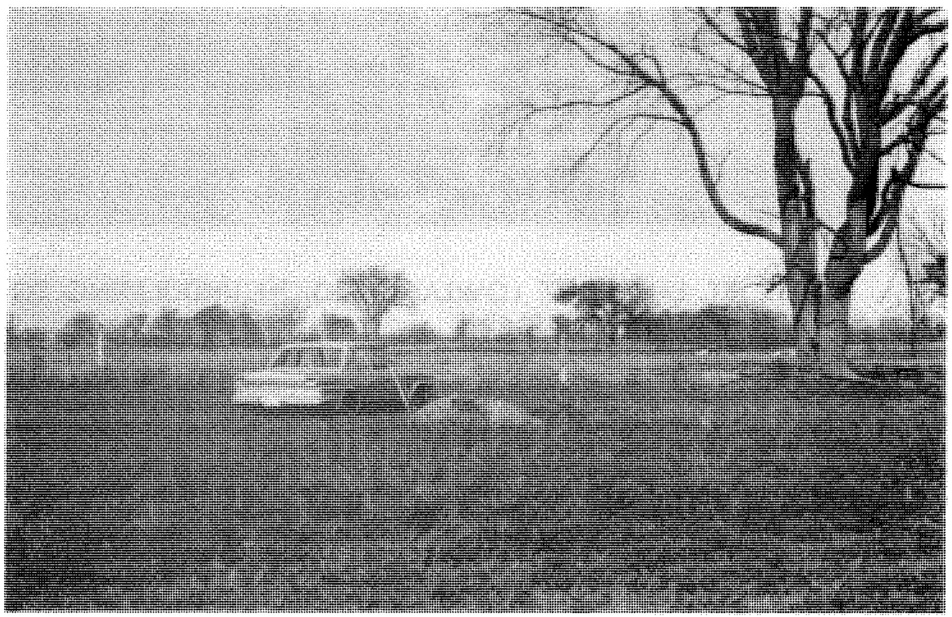


FIG. 14 SILT AND CLAY LACUSTRINE PLAINS BORDER LAKES ONTARIO AND ERIE

About half the region is covered by undulating to rolling till plains consisting of boulder clay, sands, or silts, and rugged, stony moraines (Figure 12). The largest of the till plains lies between the Niagara Escarpment and the shores of Lake Huron. The undulating to hilly surface has been cut by deep spillways, and small tracts of clay occupy the bottoms of scattered depressions. In the area south of the Bruce Peninsula the tills are stony and contain a higher percentage of carbonates. Scattered throughout the area are narrow gravel eskers. The relief west of the escarpment is accentuated by the horseshoe moraines, rugged areas of unsorted boulders, sands, and fine sediments, which partially encircle the till plains.

East of the Niagara Escarpment, extensive moderately stony till deposits cover the lowland surface between the north shore of Lake Ontario and the Shield boundary. The relief is much more varied due to the widespread distribution of numerous drumlins, eskers, and large moraines. The east-west Oak Ridges moraine forms the watershed between Lake Ontario and Georgian Bay. This sand- and gravel-covered moraine is an 80 mi (130km) wide belt of rugged hummocky knob and kettle topography rising to 1,300 ft (400m). Unlike Oak Ridge, the Dummer recessional moraine to the north is covered by a thin discontinuous layer of till containing angular limestone blocks.

The outstanding feature of the till plains is the over 6,000 drumlins (Figure 13) scattered between Georgian Bay and Lake Ontario. The more spectacular concentrations occur in the Peterborough area. The inter-drumlin depressions are usually poorly drained and swampy.

Widespread till plains are found east of the Frontenac Axis between the Ottawa and St. Lawrence rivers, to the south of Ottawa. Here significant areas of limestone bedrock are covered by less than 12 in (30cm) of drift and frequently the surface is either stony or has exposed bedrock. North of the St. Lawrence River, till deposits occur in rolling morainic or drumlinized areas rising 100-150 ft (30-50m) above the lowland.

The deposition of finer lacustrine and deltaic sediments and their modification of drift deposits is the result of a long and complex glacial history involving fresh-water proglacial lakes and marine transgression. West of the Frontenac Axis, in the Great Lakes region the thinning of the Labrador sector of the Laurentide ice sheet led to the retreat of the ice margin from south of Lake Michigan northward to the Lake Erie basin. Fluctuations of the ice front and differential uplift of the land resulting from removal of the ice load led to the ponding of meltwater between the basin rim and ice front, forming a complex system of lakes and spillways. East of the Frontenac Axis meltwater ponded between the Appalachian Highlands, including the Adirondack Mountains, and the ice front to form glacial Lake Vermont with discharge south through Lake Champlain and the Hudson Valley. Before the final oscillations of the Wisconsin ice front, the recession of the ice front allowed glacial Lake Vermont to drain to sea level. Subsequently an arm of the Atlantic Ocean, the Champlain Sea, occupied the upper St. Lawrence and Ottawa River Valleys. Thereafter differential uplift resulted in the gradual recession of the Champlain Sea and the development of the present-day Ottawa and St. Lawrence rivers system.

In the West St. Lawrence Lowland, fine silt and clay lacustrine plains (Figure 14) are found bordering lakes Ontario and Erie, in the extreme southwest of the Ontario Peninsula, in the Niagara Peninsula, and in a narrow belt along the north shore of Lake Ontario near Kingston. As the glacial lakes receded during deglaciation, rivers advanced steadily and formed deltas, spreading sheets of sand over the lacustrine silts and clays along the north shore of Lake Erie and the south shore of Georgian Bay between the Niagara Escarpment and Canadian Shield. Near the Shield the sandy deposits are acidic and of granitic origin; southward the deposits become less acidic and grade into a more clayey texture.

In the Central St. Lawrence Lowland, along the Ottawa and St. Lawrence rivers, are level to undulating plains of water-laid silty clay to clay interrupted in places by small thin deposits of sand and Precambrian outcrops. Abandoned shorelines left by the Champlain sea are represented by coarse-textured terraces parallel to the St. Lawrence River.

CLIMATE AND VEGETATION

The classification of soil climate in Ontario follows the system given in the Canadian System of Soil Classification (Agriculture Canada, 1976). The climatic regions are illustrated in Figure 6.

The effect of the Great Lakes and Hudson Bay on the climate of Ontario is clearly evident. The mildest regions of the province are located in the West St. Lawrence Lowland, in the Niagara peninsula, and in the extreme southwest of the province. Both are mild to moderately warm in terms of their length of growing season, and growing season temperatures. Most of the remaining portion of southwestern Ontario including a large part of the West and Central St. Lawrence Lowlands has a mild climate.

The northern, settled portion of the province is in the Boreal region with cool to moderately cool climates, the latter occurring adjacent to Lake Huron and Lake Superior. The Cryoboreal region dominates the extreme northern areas with a cold to moderately cold climate. It also extends a considerable distance southward, coinciding somewhat with the Canadian Shield physiographic region, extending the region of moderately cold climate into east-central Ontario.

The moisture regimes of Ontario also are depicted in Figure 6. These regimes are defined in terms of periods of saturation, as well as periods and intensities of water deficit during the growing season (Agriculture Canada, 1976).

These are several regions in Ontario with subaquic soil moisture regimes, i.e. the soil is saturated for short periods during the growing season. This condition is confined to areas of fine textured soils as occur in the Clay Belt of Northern Ontario, the Ottawa Clay Plain, the Iroquois Plain south of Lake Ontario, and the St. Clair Plain in the extreme southwest. The dominant situation in most of the southern portion of the province, however, is a water deficit during the growing season. The deficit is greatest in the subhumid region of southwestern Ontario, where 5-10cm deficit is estimated to occur. In the northern and eastern parts of the province this deficit becomes

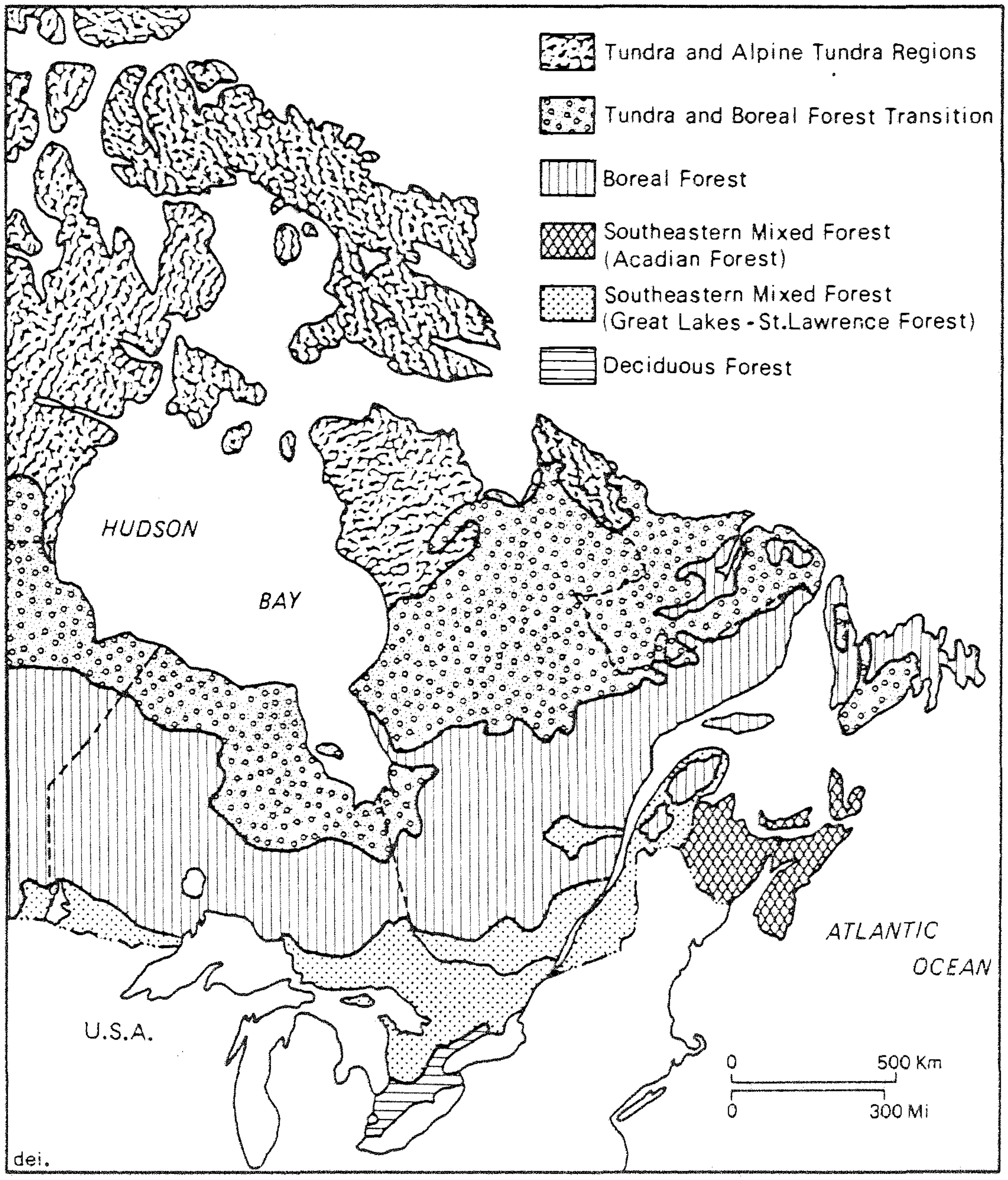


FIG. 15 THE NATURAL FOREST REGIONS OF EASTERN CANADA

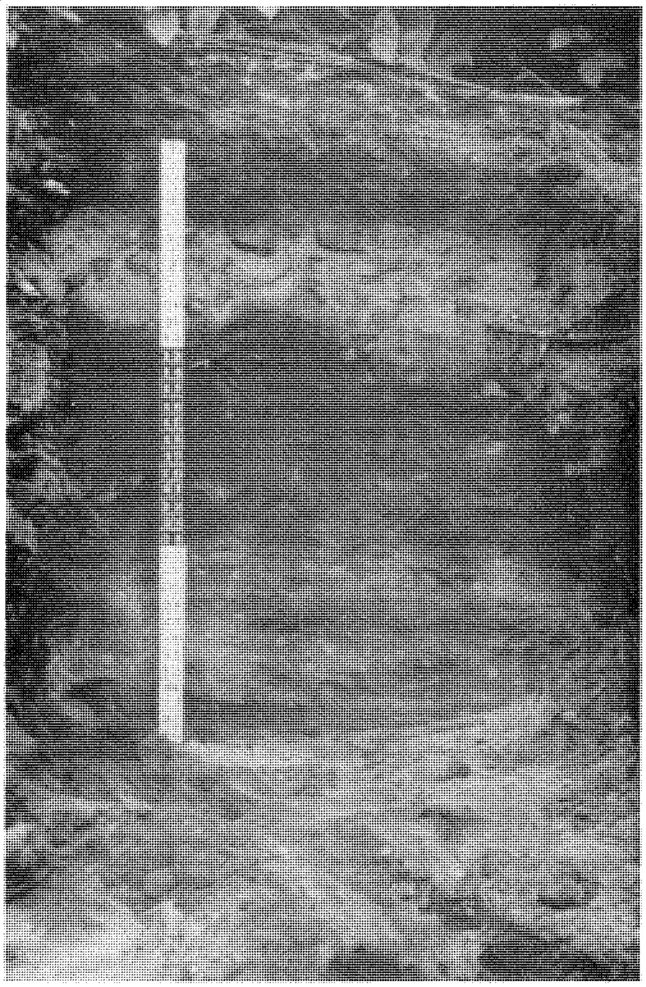


FIG. 16 A HUMO-FERRIC PODZOL SOIL

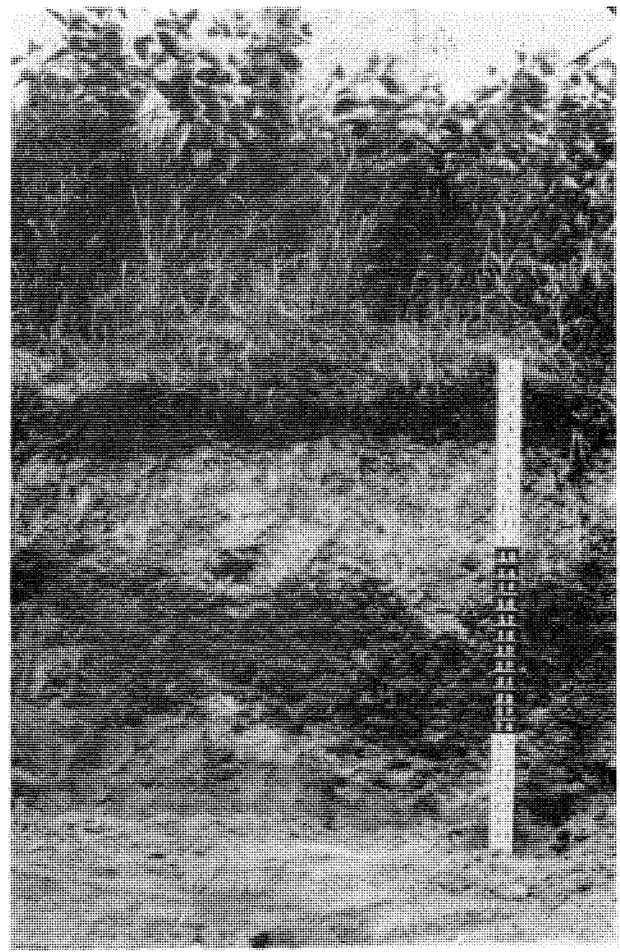


FIG. 17 A GRAY BROWN LUVISOL SOIL

progressively lower. In the humid region which comprises much of central and eastern Ontario, as well as parts of northwestern Ontario, the water deficit is very slight, estimated at 2.5-5.0cm. Most of the unsettled areas in the north are in the perhumid region with no significant water deficit.

The natural forest vegetation regions of Ontario range from the Tundra-Boreal transition of the north, the true Boreal Forest, the Great Lakes - St. Lawrence Forest region, and in the southwestern part of the province, the Deciduous Forest (Agriculture Canada, 1977). The extent and location of these regions are shown in Figure 15.

As the tour route traverses only through the latter two regions in Ontario, only these are described herein.

The Great Lakes - St. Lawrence Forest region is associated with the moderately cool Boreal temperature region, with humid to subhumid conditions. Where it merges with the Deciduous Forest regime in southwestern Ontario and along the Central St. Lawrence Lowland, the associated temperature regime is transitional changing from moderately cool Boreal to the milder temperature of the Mesic climate. The forest is of a very mixed nature, characterized by white and red pine (*Pinus strobus* and *P. resinosa*), eastern hemlock (*Tsuga canadensis*), and yellow birch (*Betula lutea*). Associated with these are many other species common to both the Deciduous and Boreal forests including in the former various maples (*Acer* spp.), elms (*Ulmus* spp.), and oaks (*Quercus* spp.); and in the latter, spruces (*Picea* spp.), jack pine (*Pinus banksiana*), poplars (*Populus* spp.), and birch (*Betula* spp.). Podzols, Brunisols, and Luvisols are associated soils on well to imperfectly drained sites and the forest growth on these is generally productive except on associated Rockland areas. Eastern white cedar (*Thuja occidentalis*), black ash (*Fraxinus nigra*), red maple (*Acer rubrum*), and elm (*Ulmus americana*) are found in mesohydrophytic and hydrophytic sites. Black spruce (*Picea mariana*) and tamarack (*Larix laricina*) are found in very moist and wet sites grading towards cooler Boreal conditions. Forest growth on all Organic and on some of the colder peaty Gleysolic soils is largely unproductive, but in milder temperature regimes Gleysols support a reasonably productive growth.

The clearing involved in the early extension of agricultural development to this region, together with past and present forestry operations, has diminished and modified the forest resources in this area. A number of forest reserves have been established for protection of these resources as well as to accommodate the increasing demands of recreational use and development.

The Deciduous Forest region is related to the warmest portions of the Mesic subhumid to humid area of southwestern Ontario.

At the time of settlement in the late eighteenth century, this area was clothed in deciduous forest vegetation. Very little if any natural forest remains today, and the relationship of the present to the original vegetation is largely inferential. Most of the area is closely settled and the forest vegetation is reduced to farm wood lots, hedge rows, and remnant stands on nonarable soils. Modification of both natural and cultural vegetation has been further intensified by the rapid spread of urban and industrial development into rural areas.

TABLE 7: GENERAL CHARACTERISTICS OF SOIL ORDERS OCCURRING IN ONTARIO

Soil Order	General Characteristics	Soil Types	Map Symbol	Area $ha \times 10^6$
Podzolic	Well and imperfectly drained soils developed under coniferous and mixed forest in cold to cool climates on acidic parent material.	sandy Podzolic	Ps	2.28
		stony Podzolic	Pst	1.37
		stony Podzolic -rock complex	Pst-R	39.36
Luvisolic	Well and imperfectly drained soils developed under deciduous, mixed deciduous-coniferous, or boreal forest in mild and cool climates, on neutral to alkaline parent materials.	sandy Luvisolic	Ls	0.64
		loamy Luvisolic	LI	2.98
		clayey Luvisolic	Lc	5.53
		clayey Luvisolic -rock complex	Lc-R	2.54
		Rock-clayey Luvisolic complex	R-Lc	4.07
Brunisolic	Well and imperfectly drained soils with brownish-coloured B horizons developed under forest, mixed forest and grass, grass and fern, or heath and tundra vegetation.	loamy Brunisolic	BI	0.93
		clayey Brunisolic	Bc	0.13
		shallow Brunisolic	Bsh	0.90
		shallow Brunisolic -organic complex	Bsh	0.32
		loamy Brunisolic -Rock complex	BI-R	0.35
Gleysolic	Soils which are saturated with water and are under reducing conditions continuously or during some period of the year, unless artificially drained.	sandy Gleysolic	Gs	0.15
		clayey Gleysolic	Gc	1.67
		clayey Luvisolic complex	Gc-Lc	1.14
		clayey Gleysolic rock complex	Gc-R	0.88
		clayey Gleysolic Muskeg complex	Gc-M	2.87
Organic	Soils developed dominantly from organic deposists and contain 30% or more organic matter.	Organic soils	O	0.88
OTHER LAND TYPES				
Muskeg	Organic terrain composed of peat and associated gleysolic mineral soils	Muskeg	M	20.36
		Muskeg-clayey Luvisolic -Rock complex	M-Lc-R	1.62
Tundra	Treeless plains of Arctic regions having permanently frozen subsoil	Tundra	T	1.50
				92.46

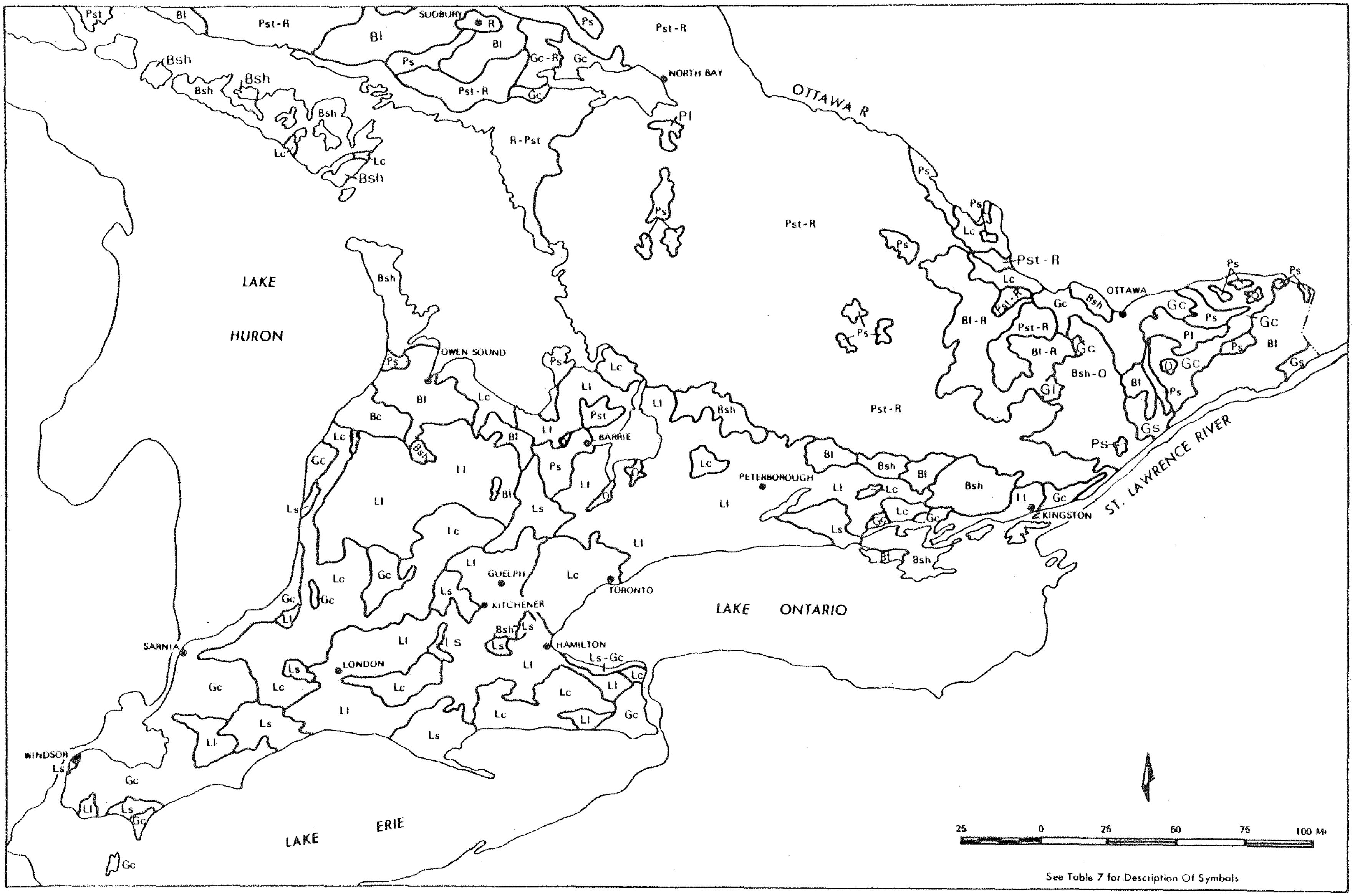


FIG. 18 GENERALIZED SOIL MAP OF SOUTHERN ONTARIO

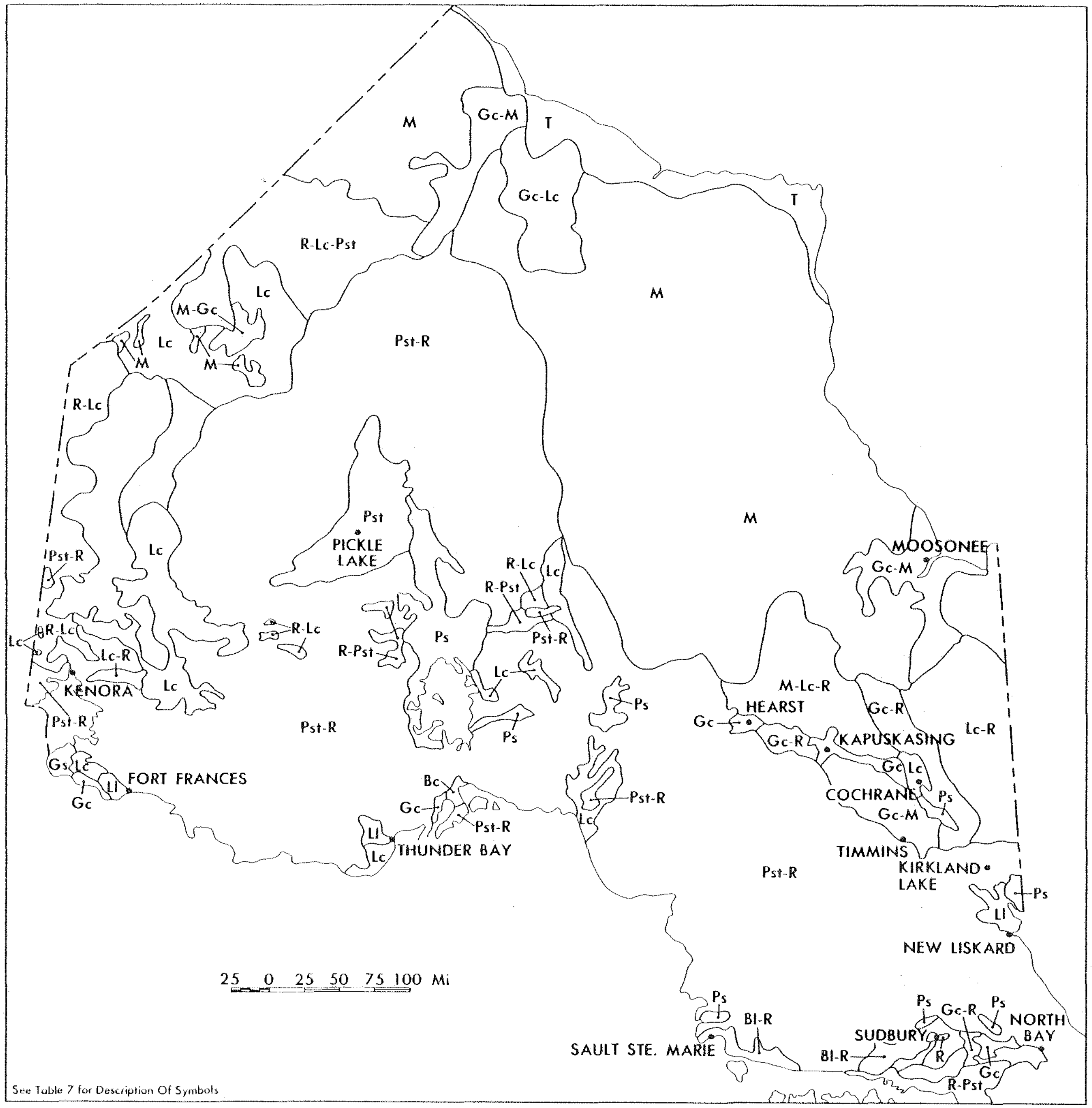


FIG. 19 GENERALIZED SOIL MAP OF NORTHERN ONTARIO

Many of the broad-leaved species common to the Great Lakes - St. Lawrence region can be found such as sugar maple (*Acer saccharum*), beech (*Fagus grandifolia*), white elm (*Ulmus americana*), basswood (*Tilia americana*), and red and white oaks (*Quercus rubra* and *Q. alba*). There are also a number of other species that are more common in warmer areas to the south, but reach their northern limit in this area. Among these are tulip tree (*Liriodendron tulipifera*), pawpaw (*Asimina triloba*), red mulberry (*Morus rubra*), black gum (*Nyssa sylvatica*), sassafras (*Sassafras albidum*), and pignut hickories (*Caryatomentosa* and *C. glabra*). Black walnut (*Juglans nigra*), sycamore (*Platanus occidentalis*), and swamp white oak (*Quercus bicolor*) are also found in this region.

In wood lots, parks, and in most remnant stands where adequate protection and maintenance are provided the forest growth is generally vigorous and productive.

SOILS

The generalized soil maps shown in Figures 18 and 19 illustrate the broad distribution of soils which occur in the province of Ontario. An explanation of the map symbols can be obtained from Table 7.

Soils classified within the Luvisolic Order in the Canadian Taxonomic system occur over a wide range in soil and climatic conditions (Agriculture Canada, 1976). In the southern portion of Ontario under deciduous or mixed-forest vegetation, and Mesic subhumid to humid climates, soils of the Gray Brown Luvisol great group occur (Figure 17). They have dark-coloured "forest mull" types of A horizons, in contrast to the Gray Luvisols with thin or absent Ah or Ahe horizons. The latter have developed under Boreal forest vegetation, ranging from cool, humid Boreal to humid and perhumid Cryoboreal climate in northern Ontario.

In Ontario, the Luvisols have developed mainly on glacial till, glaciofluvial or glaciolacustrine deposits which are weakly to moderately calcareous and have a high base stratus. Clayey textures dominate in this province (Table 7), but significant areas of loamy and sandy loam textured Luvisols occur.

The occurrence of soils of the Podzolic Order in Ontario is closely related to parent material, as they occur almost exclusively on coarse textured stony glacial till, outwash, or sandy glaciofluvial deposits that are acidic in reaction.

The great groups of Podzolic soils which occur most commonly in Ontario include the Humo-Ferric and Ferro-Humic Podzols. Humic Podzols are not particularly common.

The Humo-Ferric Podzol great group (Figure 16) has the most widespread occurrence in the province. They occupy well-drained sites under Boreal and Cryoboreal humid to perhumid climatic regimes, usually on coarse-textured, iron rich, noncalcareous materials. Soils of the Ferro-Humic Podzol great group have darker coloured B horizons of higher organic matter content than that of the Humo-Ferric Podzols. The sites on which they are developed are generally more moist than those of Humo-Ferric Podzols, but less moist than Humic Podzols.

The greatest occurrence of Podzolic soils in Ontario is in northern and eastern portion of the Canadian Shield region. This is substantiated by the acreage estimates given in Table 1 for the stony Podzolic-Rock complex map unit. They also occur in central Ontario in the vicinity of Lake Simcoe and Georgian Bay, as well as in eastern Ontario in parts of the Central St. Lawrence Lowland.

In Ontario, those soils classified within the Brunisolic Order of the Canadian taxonomic system include a broad grouping of soils occurring under a wide range of climatic conditions ranging from Mesic to Cryoboreal in temperatures and from subhumid to perhumid in moisture regimes. The occurrence of great groups of Brunisolic soils is largely dependent on the basic or acidic characteristics of the local bedrock or other source materials. The Melanic, Eutric and Dystric Brunisol great groups are known to occur in Ontario.

The Melanic Brunisols (Figure 20) developed on high-base status and calcareous parent materials, are found mainly in the mild Mesic subhumid to humid climate of the St. Lawrence Lowland. This includes the Bruce Peninsula, Manitoulin Island, areas flanking the Canadian Shield and parts of Eastern Ontario. In many cases these are areas in which limestone bedrock is in close proximity to the soil surface.

Eutric Brunisols also are developed on basic or calcareous parent materials under forest vegetation, but lack the thick, dark coloured Ah horizon of the Melanic Brunisols. In Ontario they occur mainly under Boreal climates in rather small areas throughout northern regions where they are associated with Luvisols, Gleysols, Podzols and Rockland.

Dystric Brunisols are of lower base saturation than the Melanic and Eutric groups, as they are formed on acidic parent materials. In Ontario they have developed under forest vegetation and Boreal climatic conditions with humid to perhumid moisture regimes. They are most extensive in the Canadian Shield region where they commonly are associated with Podzolic soils and Rockland.

Soils classified within the Gleysolic order in the Canadian taxonomic system are poorly drained mineral soils occurring in Subaquic to Peraquic moisture regimes, and within all temperature classes from Subarctic to Mesic in Ontario.

Soils of this order are separated into three great groups, Humic Gleysols, Gleysols and Eluviated Gleysols. They occur throughout all regions of Ontario, in some cases as the dominant soils of the landscape, frequently as associates of other better drained soils, or as minor inclusions occupying undrained depressions in complex soil landscapes. Where they are the dominant soils they are usually found on nearly level to gently undulating topography on alluvial, glacial lacustrine, resorted glacial till or marine sediments. As subdominant associates with other soils, or as mapping inclusions, they commonly occur on undulating to rolling, complex topography on glacial till deposits.

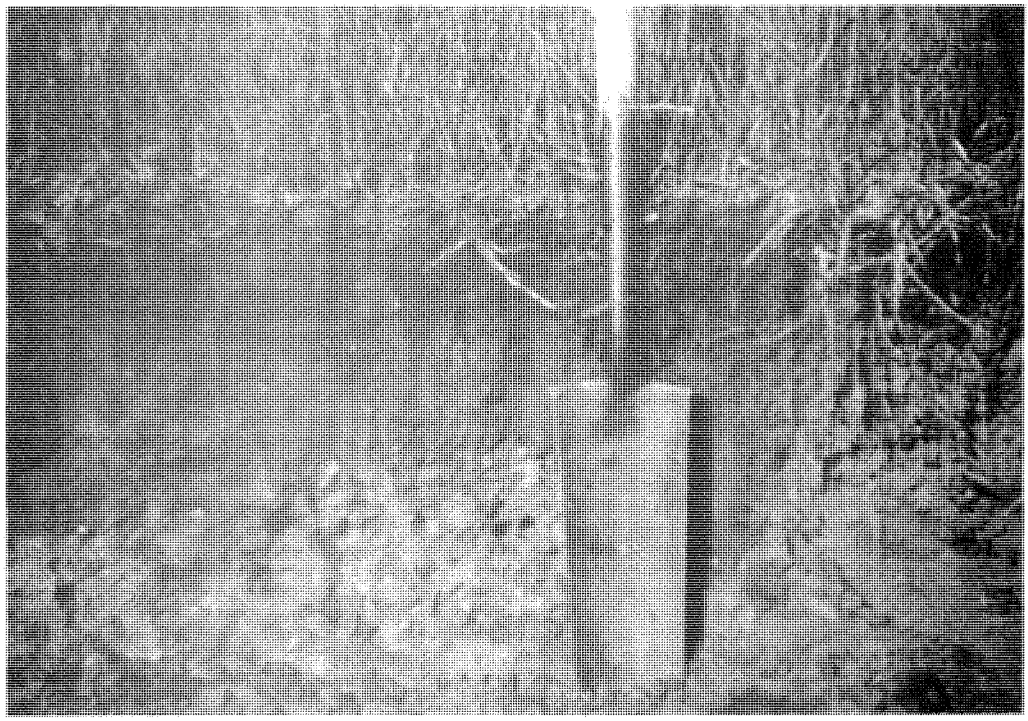


FIG. 20 A MELANIC BRUNISOL SOIL

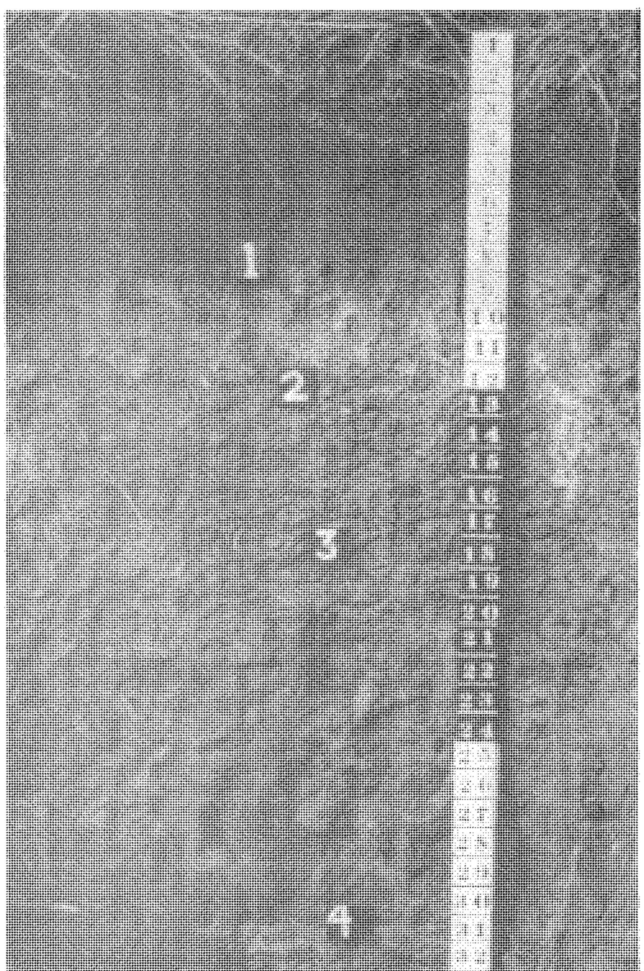


FIG. 21 A HUMIC GLEYSOL SOIL

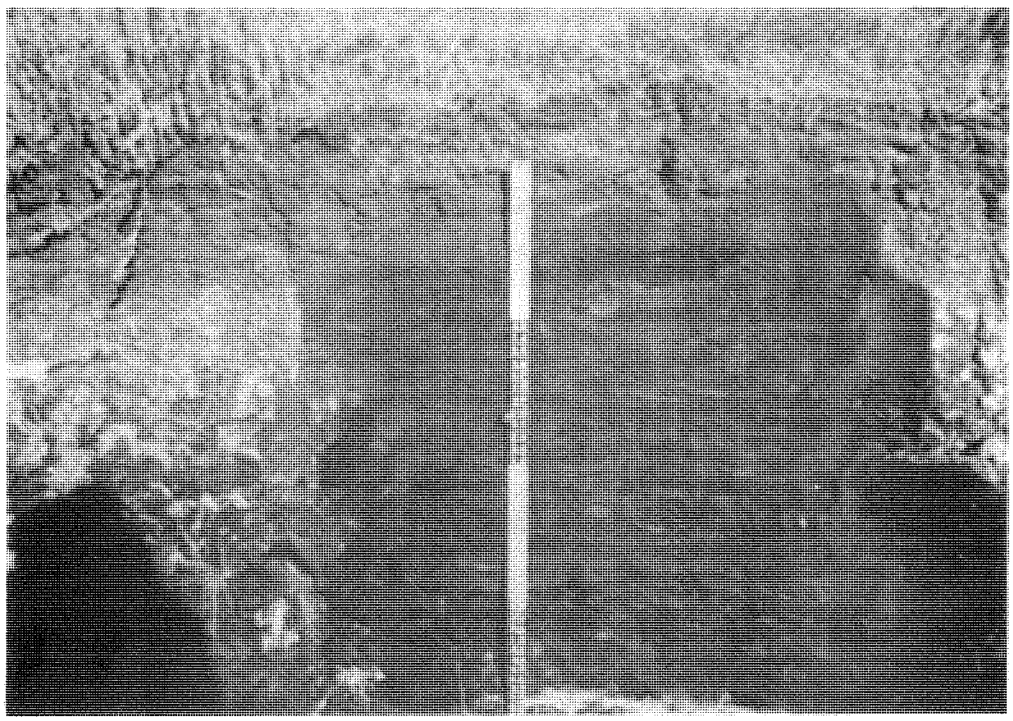


FIG. 22 A HUMISOL SOIL

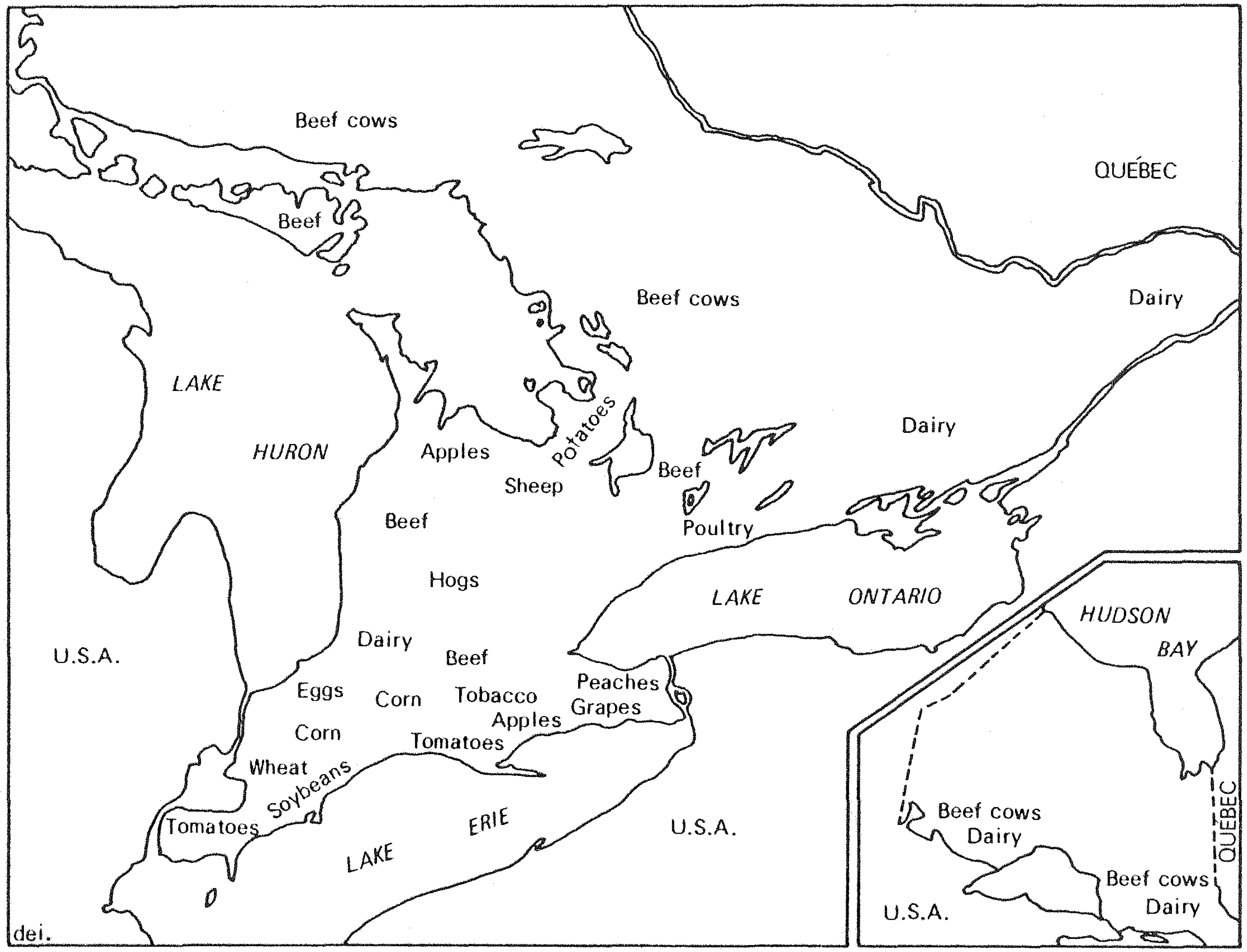


FIG. 23 FARM PRODUCTS OF ONTARIO
(Taken from Trends in Ontario Agriculture, Ontario Ministry of Agriculture and Food, Economics Branch, 1974)

Of most widespread occurrence in Ontario are the Humic Gleysols (Figure 21) which occur in clay plains of the extreme southwest, the Niagara Peninsula, in the Ottawa area of eastern Ontario and the Clay Belt of northern Ontario. These tend to develop in areas where there is a higher component of meadow grass and sedge vegetation, which has imparted a thick dark coloured Ah horizon.

Major areas of soils of the Gleysol great group occur in Cryoboreal climatic regions of northern Ontario. They also occur in small areas scattered through Boreal climatic regions, as subdominant associates with Gray Luvisol soils.

Eluviated Gleysols are of limited occurrence in southern Ontario, usually occurring in potholes or enclosed depressional basins in association with better drained soils. They may support a hydrophytic forest vegetation, but in many cases are cleared of vegetation and cultivated as a consequence of the areas becoming relatively dry during the growing season.

Soils of the Organic Order have developed primarily from the decomposition of hydrophytic or mesohydrophytic vegetation in all temperature regions of Ontario ranging from Mesic to Subarctic.

In southern Ontario they are generally confined to small areas such as shallow lakes, ponds or undrained depressions. In the north they occupy an extensive acreage, occurring both as small, scattered deposits, as well as vast areas of land loosely referred to as "muskeg" terrain.

The great groups of organic soils which are known to occur in Ontario include the Humisols, Mesisols and Fibrisols. In the southern areas of the province throughout much of the West and Central St. Lawrence Lowlands, Humisols (Figure 22) are the dominant organic soils, with lesser occurrence of Mesisols. They are formed on deposits comprised of sedges, grasses, leaves and woody material from tree vegetation. In northern regions throughout the Canadian Shield and Hudson Bay Lowlands they are predominantly Fibrisols formed on organic material largely derived from shrubs, woody material from coniferous trees and mosses, particularly of the sphagnum type.

Organic soils are commonly associated with Gleysolic, Brunisolic, Luvisolic and Podzolic soils, and to a lesser extent with soils of the Regosol Order. Their extensive occurrence with Rockland and Gleysolic soils is substantiated by the acreage figures in Table 7 for the muskeg landtypes.

Soils of the Regosol Order occur as a consequence of their topographic position, or the nature of their parent materials. They are found on landscapes where relatively unaltered soil material is being deposited or exposed, such as eroded slopes and knolls, dunes or alluvial floodplains. Their occurrence in Ontario is generally restricted to subdominant associates, or as minor inclusions with soils of other orders. They tend to occur in all climatic regimes of the province.

Rockland land type is prevalent throughout vast regions of Ontario, as can be seen from Table 7. It comprises much of the area in the Canadian Shield region as well as the region of younger Paleozoic rocks flanking the

Shield. These areas are associated with most of the soil orders which occur in Ontario, but most commonly with Podzols, Organics and Luvisols.

LAND USE

The broad pattern of land use in Ontario has been determined primarily by soil climatic conditions and secondly, by local characteristics of topography and parent material, tempered by economic considerations and geographic location.

Agricultural development has occurred in Ontario primarily in the Mesic and milder Boreal climatic regions. It encompasses a wide variety of activities including production of field crops vegetables and fruits, dairying, beef, hog, sheep and poultry farming. The general distribution of farm products of Ontario is illustrated in Figure 23.

Throughout much of the Mesic climatic region intensive agricultural enterprises, based on cash-cropping, are carried on. The region includes Gray Brown Luvisol, Melanic Brunisol, Gleysolic and Organic soils. A variety of crops are grown on the Luvisols and Brunisols, including grain corn, winter wheat, spring grains, forages, soybeans and tobacco. Mesic warm sections along lakes Ontario and Erie are suitable for the production of tender fruit crops. The Gleysols and Organic soils comprise some of the most productive soils in southern Ontario for "specialty" crops such as canning crops, burley tobacco, and particularly in the latter case, for vegetable production.

Of major concern is the realization that the limited areas of land in Ontario that are suitable for the growing of these valuable cash crops are under a continuing threat from urban encroachment.

Throughout the fringes of the Mesic climatic region, mixed farming is more commonplace, based on both cash-cropping and livestock or poultry operations. Crops such as spring grains, corn silage, pasture and hay predominate on Gray Brown Luvisols, and Melanic Brunisols. Unimproved pasture is the extent of the agricultural uses on shallow Brunisolic soils overlying bedrock or on stony, steep land.

Agricultural land use in regions of Boreal and Cryoboreal climates in Ontario is concentrated mainly on Gray Luvisol soils. The increasing severity of climate limits production to fewer crop species, so that there is greater emphasis on livestock based farm enterprises, including the production of coarse grains, forage and pasture where topography and physical conditions are favourable to crop production.

The prime land use in large areas of Gray Luvisol and Podzolic soils is commercial forestry, including lumbering and pulpwood enterprises, as they are capable of sustained growth of productive forest in Boreal climates. Related activities such as hunting, trapping and recreational uses of land also are important in the same region.

Unproductive forest land occupies a vast area in the province. It includes Rockland land types in which there is barren rock outcrop, or insufficient soil overlying bedrock to support productive forest vegetation. Under Subarctic climates, forest growth on Luvisolic, Brunisolic and Podzolic soils also is limited as a consequence of the very limited growing season. Forest development on Organic soil areas also is poor, being restricted by poor drainage or cool and frozen subsoil conditions.

Much of the unproductive forest land is useful mainly for wildlife habitat, the growth of shrubs, herbs and mosses generally being sufficient to provide a limited grazing capacity in these areas.

SOIL CAPABILITY

Agriculture. The agricultural capability of soils in Ontario has been classified in the Canada Land Inventory (CLI), a system that relied on soil survey information to develop interpretive classifications of land for various uses. The bases of the classes and subclasses in the CLI system are presented in other publication (Environment Canada, 1976).

The area of land occurring in each of the capability classes in Ontario is given in Table 8. The extent of agricultural soils with specified limitations are shown in Table 9.

The largest area of prime agricultural land in the province is located in southwestern Ontario, within the West St. Lawrence Lowland physiographic region. Gray Brown Luvisol soils have the highest agricultural capability, being well suited to a wide range of field crops. They are generally associated with medium textured deposits occurring on nearly level to gently sloping and undulating glacial till plains or glacial lacustrine landforms. Gleysolic soils on clay plains within this region generally are high quality soils as well, rated as capability class 2 with moderate wetness (W) or structural (D) limitations. More steeply sloping, or rolling land occurs in moraines, drumlinized till plains or dissected lacustrine landforms within the region and are rated lower to class 3 or 4 as a consequence of topographic (T) limitations. Often excessive stoniness (P) and undrained depressions (W) are associated with the rolling morainic landforms of complex topography making these areas marginal in terms of agricultural capability.

Coarse-textured Luvisolic soils in subhumid moisture regimes of southwestern Ontario, such as occur in the Norfolk sand plain, have moisture deficiency (M) and fertility (F) limitations which lowers their capability for common field crops to class 4. However, they are considered to have a higher capability rating for specialty crops such as tobacco, where supplemental irrigation is provided.

Soils of the Central St. Lawrence Lowland in general are lower in agricultural capability than those of the Western St. Lawrence Lowland region. As a result of the humid soil moisture regime, the Gleysolic clay soils are rated to class 3 with wetness (W) limitations. There is considerable acreage of coarse textured, eolian modified glacio-fluvial and deltaic deposits in the region on which the Podzolic soils have fertility (F) and moisture deficiency (M) limitation of class 4 severity. The soils developed on glacial till materials generally have moderately severe limitations due to stoniness (P) and topography (T) which lowers their capability at least to class 3 or 4. The shallow soils overlying Paleozoic bedrock, flanking the Canadian Shield region, occupy quite extensive areas in Eastern Ontario, and present serious limitations

Table 8: Area of soils in agricultural capability classes in Ontario

Class	Hectares 000's	Area %
1	2 158	7.8
2	2 219	8.1
3	2 912	10.6
4	2 628	9.5
5	1 917	7.0
6	1 141	4.1
7	11 229	40.8
Organic	2 565	9.3
Unclassified Land in CLI Area	782	2.8
Total	27 551	

(Unpublished data, Environment Canada, Lands Directorate)

Table 9: Extent of Agricultural Soils[1] with Specified Limitations, Ontario

Limiting Factors	Area affected[2] (thousands hectares)	% of agricultural soils
1. Excessive soil moisture	3 057	28
2. Low natural fertility	1 920	18
3. Deficient soil moisture	1 585	15
4. Undesirable soil structure or low permeability or both	1 280	12
5. Adverse climate (cold temperatures)	1 148	11
6. Steep topography	714	7
7. Excessive stoniness	200	2
8. Bedrock near to the surface	109	1
9. Combination of 2, 3, and 4	54	0.5
10. Cumulative minor limitations	10	0.1
11. No limitations	2 249	21
Total area of agricultural soils	10 789	

[1]Soils in classes 1, 2, 3, and 4.

[2]The areas in the table cannot be summed; the areas shown on the C.L.I. maps to be significantly affected by two limiting factors, totalling 1.6 Mhc. are entered twice, once under each factor.

Data taken from Nowland, J.L. 1975. The Agricultural Productivity of the Soils of Ontario and Quebec. Agric. Canada Monograph No. 13.

for agricultural uses as a consequence of stoniness (P) and the proximity of the bedrock to the soil surface (R).

Almost all of the soils within the Precambrian Shield physiographic region belong to class 7 because of stoniness (P), rockiness (R), relief (T) or wetness (W) limitations. Organic soils (O) occur in many of the depressional areas of the Shield landscape which are not occupied by lakes.

The agricultural capability of soils throughout northern regions of Ontario is affected by factors of climate (C) as well as the physical limitations of the soil itself. In the moderately cool Boreal region of northwestern Ontario, a deficiency in the length of the growing season prevents soils from attaining a capability higher than class 2, which is the rating given to Gray Luvisol soils on moderately fine textured glacial till and lacustrine sediments. Gleysolic soils in this region are rated as class 3 due to limitations of wetness (W). The Podzolic soils scattered throughout the Canadian Shield region on noncalcareous coarse textured fluvial or eolian deposits have a capability rating of class 4 or 5 with fertility (F) or moisture (M) limitations.

In areas of cool Boreal temperatures and humid to perhumid moisture regime, such as in the Great Clay Belt of northeastern Ontario, the climatic limitation is more severe in its effect on agricultural capability. The Gray Luvisol soils on glaciolacustrine and glacial till deposits are rated class 3 at best because of the shortness of the growing season. Gleysolic soils are lowered to class 4 and 5 in this region because of the problem of excessive wetness in the humid to perhumid moisture regime.

Forestry. The land capability classification for forestry of the Canada Land Inventory (CLI) provides a means of classifying land on its ability to grow commercial timber. The bases of the classification system are outlined in other publications (Canada Land Inventory, 1967).

Both soil and climatic factors affect the productive capacity of land for timber. Southwestern Ontario, with its mild Mesic climate and dominance of Gray Brown Luvisol soils, has the highest capability for the growth of commercial forest in the province. The land capability for forestry throughout most of this region is in the class 1 to 3 range, with the limitations being due to soil moisture excess (W), and physical restriction to rooting imposed by dense subsoil conditions (D).

The limitations of the land for forest production become somewhat more severe in eastern Ontario. In the Central St. Lawrence Lowland the land capability for forestry is largely class 3 or 4, due to factors associated with excess moisture (W) in Gleysolic soils, fertility (F), and moisture deficiencies (M) in the Podzolic soils, and physical limitations associated with restricted rooting zone (R) in shallow Brunisolic soils overlying bedrock.

In spite of the high capability for forestry throughout the St. Lawrence Lowland, the practice of forestry is limited by the need for land for other uses. Forest management is carried out on lands which are too steep or irregularly sloping, too stony, wet or infertile for agricultural uses. The objective is for timber production on some lands, conservation measures on others, or also for the enhancement of land values for recreation, farming, etc.

In the Boreal climatic region, including much of northern Ontario, the forest capability of Gray Luvisol, Gleysolic and Podzolic soils generally falls in the class 3 to 6 range. The best lands in the moderately cool Boreal region are limited to capability class 3 because of climatic severity (C). The increased severity of this factor in the cold Boreal region limits the best lands in these areas to capability class 4. In either case, factors such as excessive wetness (W), restrictions in rooting zone (D), low fertility (F) and moisture deficiency (M) further lower the ratings.

The Canadian Shield region is largely capability class 4 to 7 for forestry. Podzolic soils are rated highest in this region with fertility (F) and soil moisture deficiencies (M). Shallow soils overlying Precambrian bedrock are reduced to capability class 6 or 7 as a consequence of restrictions in the rooting zone imposed by the bedrock (R), and soil moisture deficiencies (M). Organic terrain in most northern regions is rated class 7 for forestry uses as a consequence of its excessive wetness (W).

Throughout the Boreal climatic region extensive natural stands of productive forest occur. In addition, plantation forestry is becoming increasingly common in those areas which have greatest potential for increased timber production under silvicultural practices.

- -

DAILY ITINERARY

TOUR 1 DAY 1: CHARLOTTETOWN, assembly point
TOUR 10 DAY 7: QUEBEC TO CHARLOTTETOWN by air

TOUR 1 DAY 2: CHARLOTTETOWN TO SACKVILLE
TOUR 10 DAY 8: CHARLOTTETOWN TO SACKVILLE

0 (0)* AGRICULTURE CANADA RESEARCH STATION. A large percentage of land surface in Prince Edward Island is devoted to agriculture. However, land improved for this use has been steadily declining from a maximum of 300 000 hectares in 1911 to less than 200 000 hectares in 1975. Cultural and economic factors have contributed to the decline but the physical attributes of the land have played a significant part. Abandoned grassland and forests have expanded on steeper slopes and in areas with soil moisture or other problems.

Generally speaking, the agricultural economy is a mixture of livestock and cash crop farming. Livestock products provide the chief source of farm

* Numbers in brackets refer to distance in kilometers.

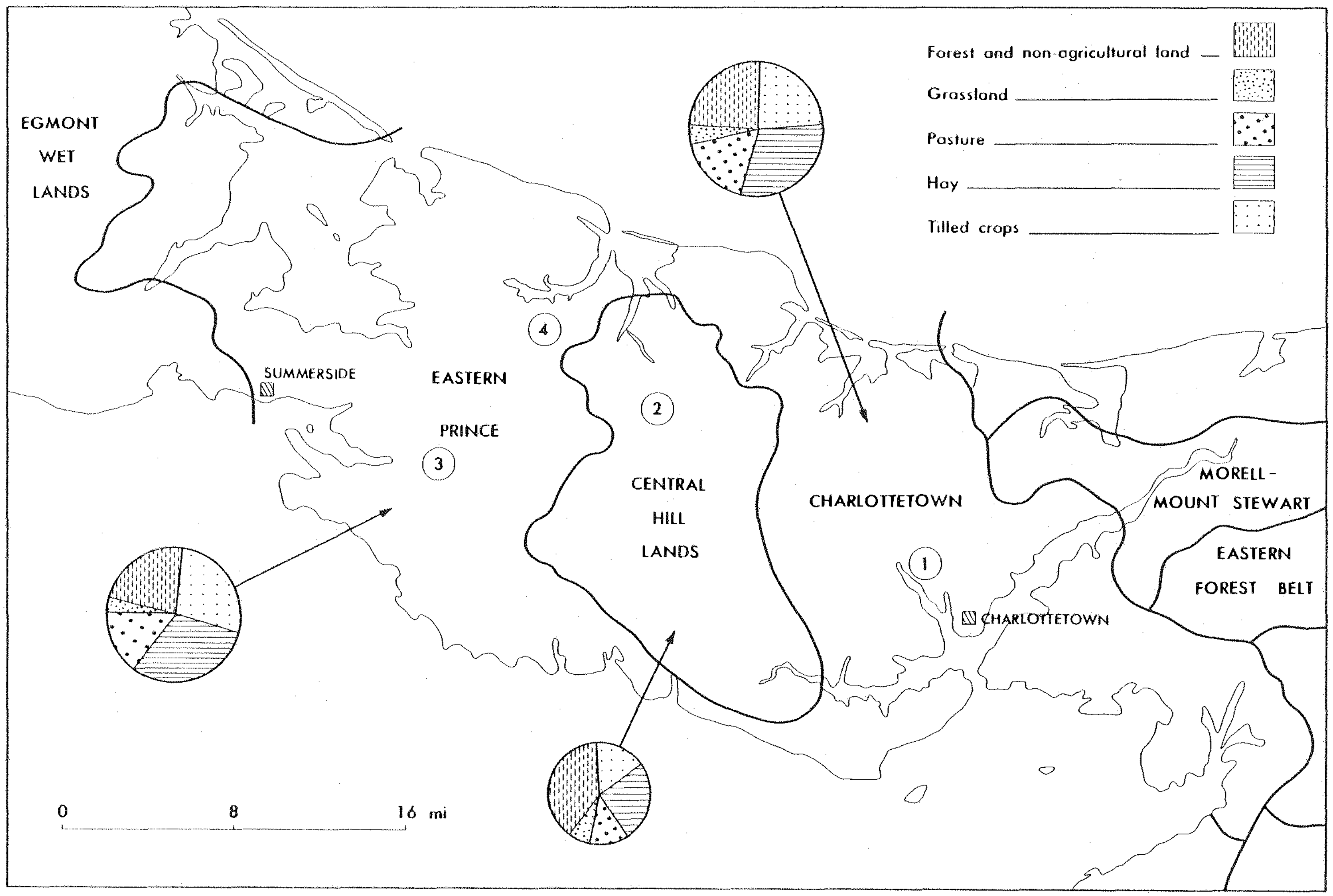


FIG. 24 LAND USE

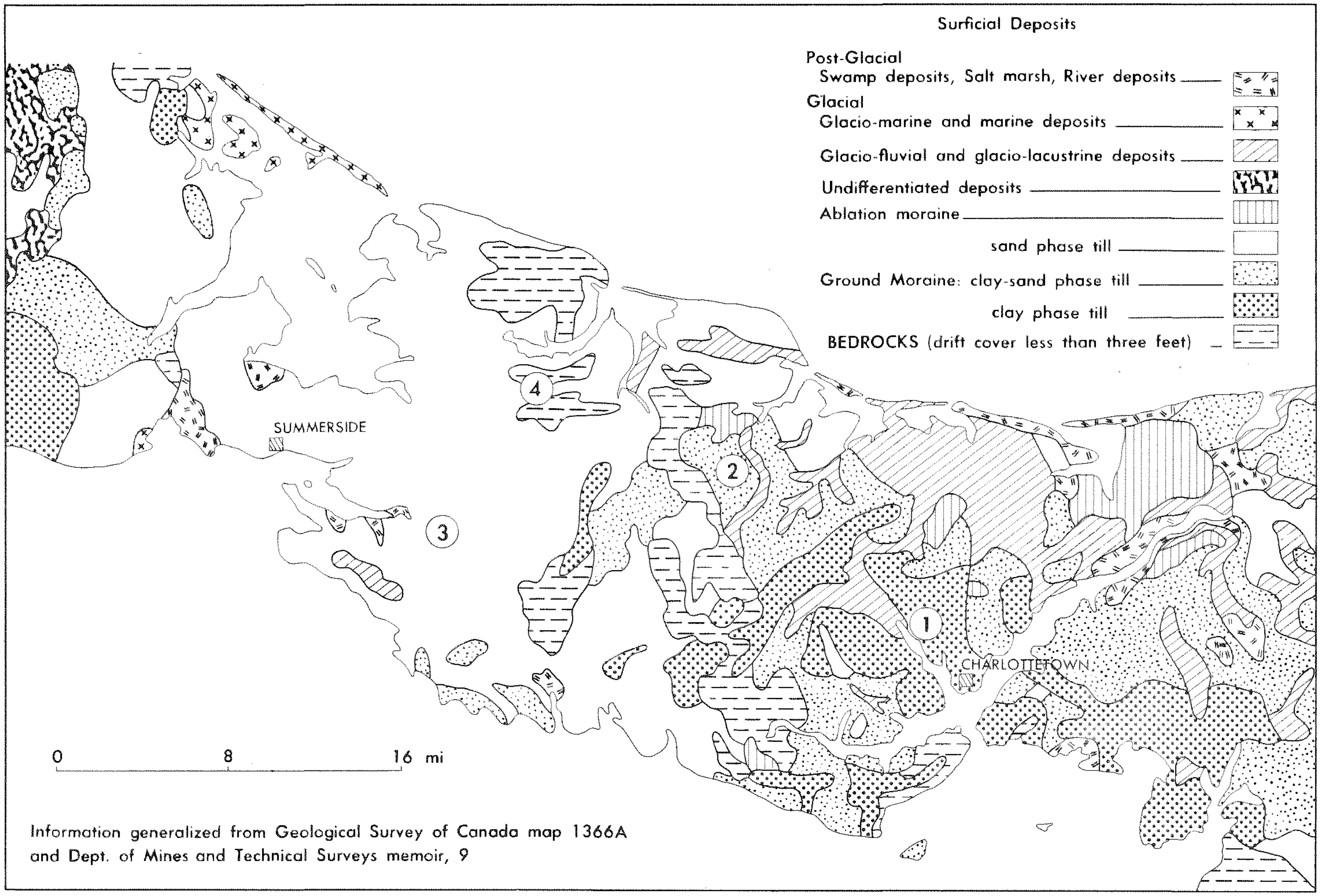


FIG. 25 SURFICIAL GEOLOGY

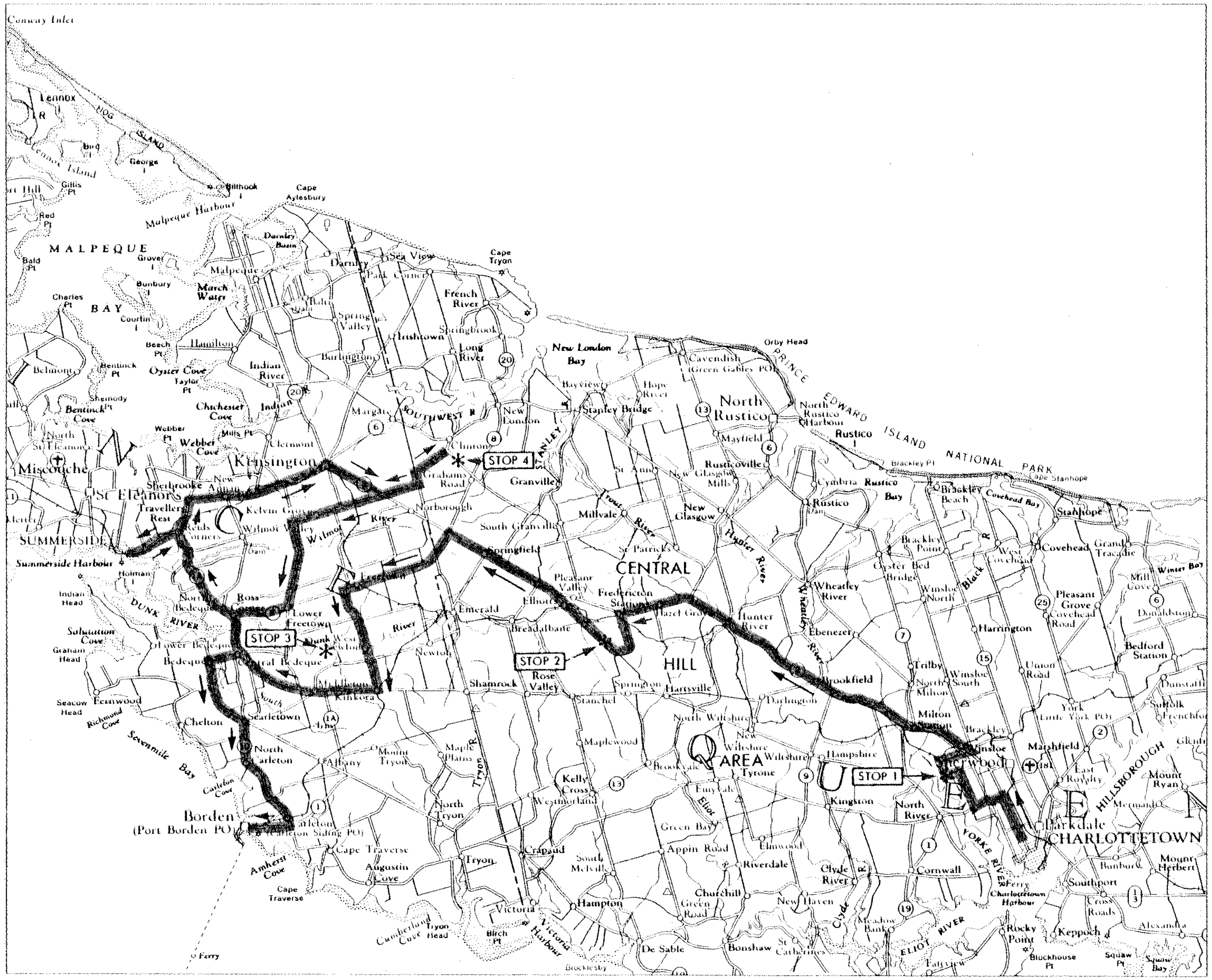


FIG. 26 ISSS TOUR—CHARLOTTETOWN TO PORT BORDEN

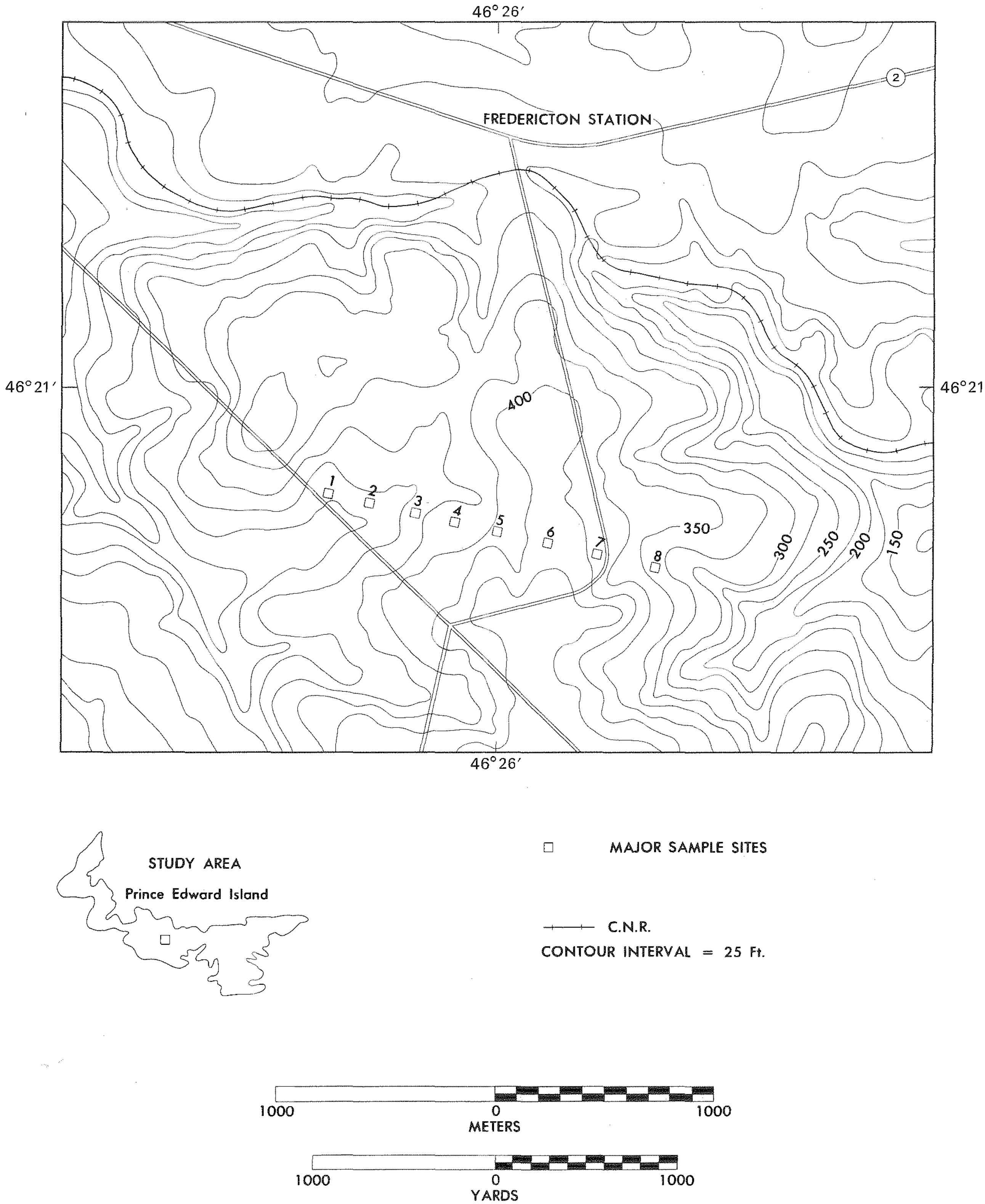


FIG. 27 AREA OF STUDY, (STOP 4, SITE 2)

income but few farmers specialize in one particular product. Increased mechanization, somewhat delayed in reaching the Island, has brought changing trends towards some specialization in farm types and crops. It has also aggravated some old problems and brought new ones to the agricultural scene.

Low fertility, poor soil structure and soil erosion are major management problems. The addition of lime and nutrients is a continuing necessity for acceptable levels of productivity. In many soils a dense, compact fabric occurs within 40 to 60cm of the soil surface and affects rooting depth and nutrient and moisture stress to crops. This may also be one reason for severe winter damage to legumes. Mechanization with larger farm and field size has increased the soil erosion problem. Traditional rotations have been shortened; and some fields have been cropped to potatoes three to five years in seven with rather disatrous results. In general, organic matter levels are low and Island farms are particularly vulnerable to loss of topsoil over the short and long term with associated problems in yield and quality.

Original forest on Prince Edward Island were characterized by an intermixture of northern hardwoods and Boreal Forest types. Sugar maple, beech and yellow birch were dominant species of the hardwood forest with hemlock and red spruce on more moist lower slopes and valleys. Poorer drained sites had conifers with spruce, fir, cedar and tamarack, depending on local variations in soil, drainage, slope and species.

Non-management and exploitation over the period of human settlement have led to the spread of undesirable species and a general increase in unproductive woodland types. Forest now covers about one-half of the Island or 280 000 hectares of which dense woodland comprises about 150 000 hectares. Productivity can and should be improved but only recently has much effort been directed towards attempts at saving and managing this resource.

The island landscape is vulnerable to recreational land market pressures and recreational impact. The significant decline in agricultural census farms, owing in part to increased non-resident land ownership, resulted in legislative limitation on such purchases and holdings. The overall need for land use planning is generally appreciated but methods are often strongly resisted. Organized efforts by government agencies, study groups, community groups and others are proceeding slowly.

11 (19) CENTRAL HILL LANDS. 39 000 hectares of rolling morainal blanket and veneer. Relatively flat-lying, reddish-brown sandstone with interbedded siltstone, minor mudstone, some conglomerate pockets. The bedrock may be soft or unconsolidated but hard sandstone bands or remnant caps are common and frequently within 1 m of the surface. Reddish-brown, acid, dominantly fine sandy loam material, but textures are variable horizontally and vertically depending on origin -- either basal till or mixed glacio residual. Dominantly Humo-Ferric Podzols, some with weak Luvisolic characteristics.

STOP 2 SITE 1: PODZOLIC GRAY LUVISOL

Soil examination site at Fredericton Station (Fig. 26). Location of major sample sites and description of topographic profiles are shown in figures 28 and 29. See Appendix B, Site 1, for profile description.

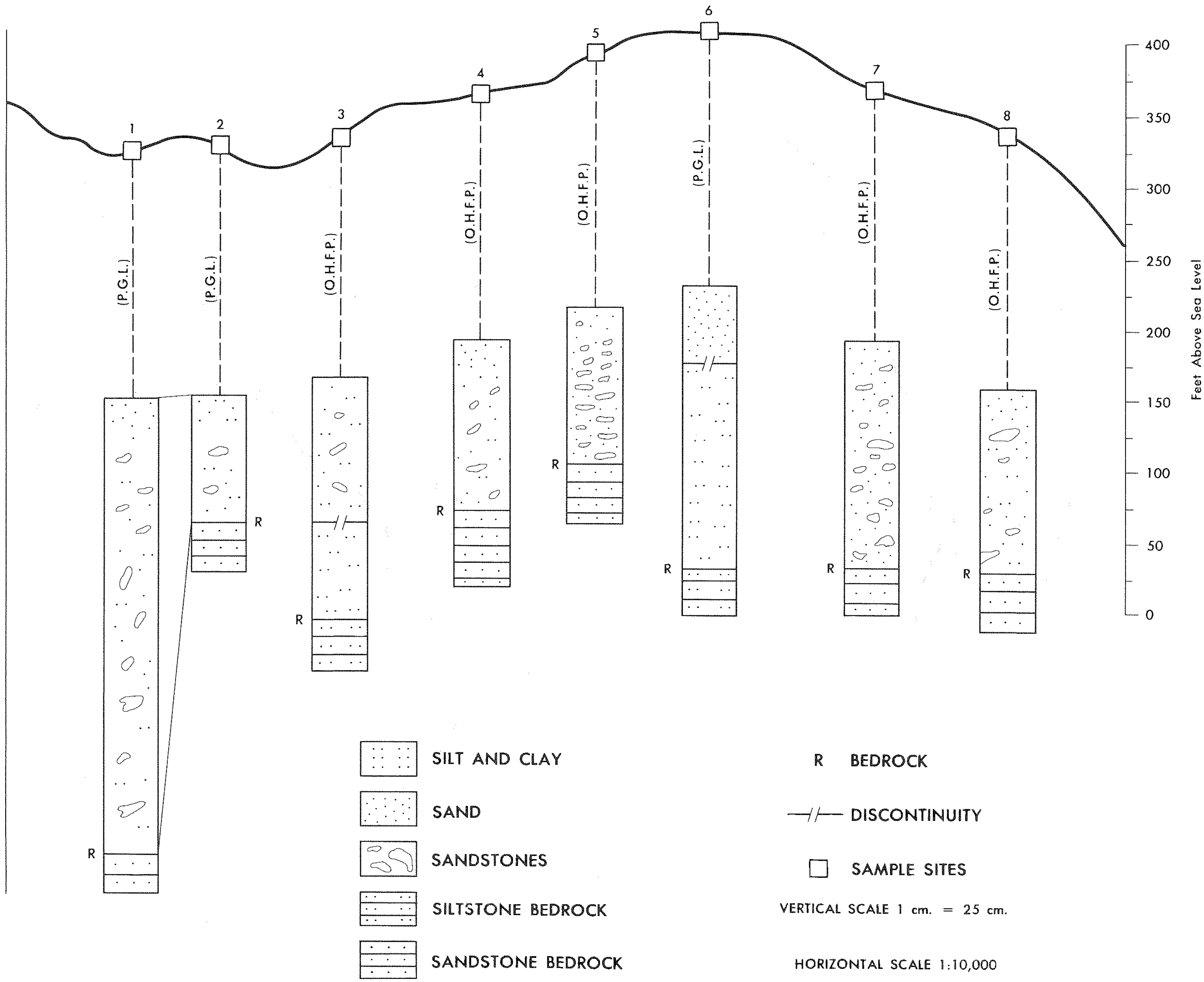


FIG. 28 TOPOGRAPHIC PROFILES
(Note: Profile 1 corresponds to site 1)

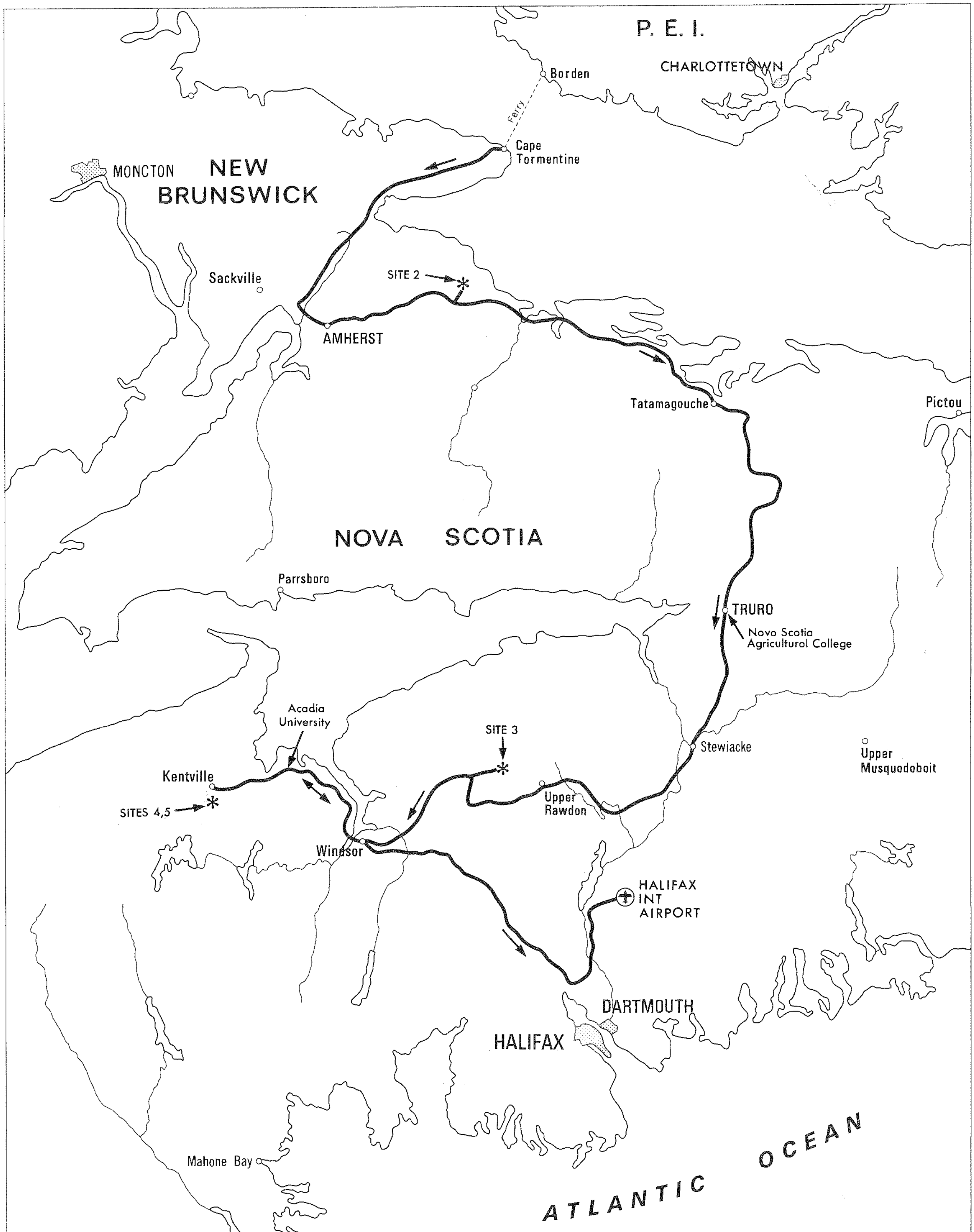


FIG. 29 ISSS TOUR—CAPE TORMENTINE TO HALIFAX

21 (35) EASTERN PRINCE SECTION (fig. 24). Gently undulating to gently rolling morainal blanket. Similar to the bedrock described for the Central Hill Lands but sandstone bands are commonly softer. Similar materials but basal tills are commonly thicker. Humo-Ferric Podzols, Brunisolic and Podzolic Luvisols, gleyed associates.

34 (51) DUNK RIVER WATERSHED. STOP 3 (fig. 26). Erosion studies conducted by the Prince Edward Island Department of Agriculture and Forestry.

80 (133) FERRY, BORDEN TO CAPE TORMENTINE. STOP 4 (fig. 26). Clinton Form. Enter New Brunswick portion of Maritime Plain, sandy loam till, gently rolling, over sedimentary rock. Mixed farming dominant.

103 (170) TANTRAMAR MARSH. Recent marine deposits which appear to have acid-sulphate features. Soils belong chiefly to Gleysols and Organic soils. Mixed farming and cash crops are common on such level soils.

114 (190) TIDAL DAM. Active tidal area noticeable on left at Tantramar River crossing.

117 (195) SACKVILLE (fig. 29). Location of Mount Allison University.

TOUR 1 DAY 3: SACKVILLE TO WOLFVILLE
TOUR 10 DAY 9: SACKVILLE TO WOLFVILLE

0 (0) LEAVE SACKVILLE for the picturesque province of Nova Scotia.

6 (10) FORT BEAUSEJOUR, a historic landmark of early settlement in the region.

9 (15) MARITIME PLAIN. Recent alluvial deposits with level topography which develop mostly gleyed soils.

27 (46) SHINEMECAS. Tormentine soils are one of the more important agricultural soils in Cumberland County. Because of their moderately good drainage, they may be worked earlier in the spring with fewer limitations than most other local types. The dense subsoil, however, does provide some restriction to the vertical movement of water.

Soils in the Tormentine series are adapted to the growing of a wide range of crops, providing pH and fertility are maintained at desirable levels. Heavy liming and fertilization are essential. Spot drainage of depressional areas may be necessary on some fields.

Where the above conditions exist, these soils are suited to the production of cereal grains, corn, peas, beans, grasses and legumes for hay, vegetables and small fruits.

SITE 2: FRAGIC HUMO-FERRIC PODZOL ON SANDY TILL (TORMENTINE)

This site is on a south-facing slope of an undulating to rolling moraine. The soil is moderately well drained. Temperature conditions range from 12°C to 24°C in July.

34 (57) PUGWASH. Natural harbour and location of active salt mine.

44 (73) WALLACE. Oyster beds in bay.

66 (110) COBEQUID HILLS, section of the Nova Scotia Highlands physiographic division. Soils are Ferro-Humic Podzols developed in moderately coarse textured glacial till and having bedrock within 150 cm of the land surface.

81 (136) ANNAPOLIS LOWLAND physiographic division. Topography is gently rolling. Soils are Humo-Ferric Podzols developed in mostly relatively thick, moderately coarse textured glacial till and water-modified till deposits.

89 (149) TRURO (Bible Hill), site of the Nova Scotia Agricultural College (fig. 29).

107 (179) STEWIACKE RIVER VALLEY. Soils are mostly Regosolic and Gleysolic developed in silty to sandy alluvial parent material. Topography varies from level to gently rolling.

129 (215) RAWDON HILLS represents the hilly section of Atlantic Uplands of Nova Scotia. Soils are Humo-Ferric Podzols developed in shallow silty glacial till underlain by metamorphised rocks.

156 (260) STANLEY FOREST. Rolling terrain of the Annapolis Lowland. A management unit of the Nova Scotia Department of Lands and Forests.

SITE 3: GLEYED BRUNISOLIC GRAY LUVISOL ON TILL (QUEENS) (fig. 29)

This site, now occupied by red pine (*Pinus resinosa* Ait), has been rated as forest capability class 2 (91-110 ft^3/ac/yr; 6-8m^3/ha/yr) having fertility (associated with parent rock type, sandstone) and compaction (restriction to rooting depth) as the main factors limiting growth. This forest stand was thinned (15' x 15' spacing) in 1968 when the breast height age was between 50 and 55 years. Subsequent stem analysis has shown that periodic annual diameter growth during the 6 year period following thinning was increased by approximately 250 percent. Also since this stand was nearing maturity when thinned, it is concluded that diameter growth is independent of age and dependent on stocking.

180 (300) START of karst topography with gypsum bedrock outcrops. Open mines and dissected terrain contribute to local features.

185 (309) AVON RIVER VALLEY, area of dikelands and tidal flats.

201 (335) WOLFVILLE, site of Acadia University.

Table 10 Summary of geological materials, showing the most probable origin(s) (STOP 2 SITE 1)

Site	Geological Origin(s)
1	Most probably basal till; possibility of alteration by solifluction or soil creep.
2	Most probably basal till; possibility of alteration by solifluction or soil creep.
3a	Material essentially weathered regoliths altered by solifluction or soil creep.
3b	Frost heaved siltstone.
4	Ablation till over sandstone bedrock.
5	Colluvial debris over sandstone bedrock.
6a	Ablation till or frost heaved sandstone.
6b	Weathered siltstone bedrock.
7a	Ablation till; material altered by solifluction or soil creep.
7b	Frost heaved sandstone.
8	Ablation till.

(see Figs. 27, 28)

Table 11 Plausible Origins of the Sites Studied Based on Field Investigations, Shape Analysis, Orientation and Imbrication, Particle Size, Sorting Characteristics and Micromorphological studies. (STOP 2 SITE 1)

Site	Geological Origins																							
	Basal till						Ablational till						Frost heaved bedrock (sandstone and/or siltstone)						Material altered by solifluction or soil creep					
	F.S	S	O	T	S.o	M	F.S	S	O	T	S.o	M	F.S	S	O	T	S.o	M	F.S	S	O	T	S.o	M
1	*	*	*	*	*	*					*								*	*		*	*	*
2	*	*	-	*	*	-		*	-		*	-			-			-	*	*	-	*	*	*
3a	*	*	*	*	*	-		*			*	-				*		-	*	*	*	*	*	-
3b		-	-	*		-		-	-			-	*	-	-	*	*	-		-	-	*		-
4		*		*	*	-	*	*	*	*	*	-				*	*	-	*	-	*	*	*	-
5			-			-			-			-	*	*	-	*	*	-			-			-
6a		-	-	*	*	*	*	-	-	*	*	*	*	-	-	*	*	*		-	-			
6b		-	-					-	-				*	-	-	*	*	*		-	-			
7a		*	*	*	*	-	*	*	*	*	*	-						-	*	*	*	*	*	-
7b			-			-			-			-	*	*	-	*	*	-			-			-
8		*	*	*	*	-	*	*	*	*	*	-						-	*	*	*	*	*	-

* Possible mode of deposition
\- Study not conducted
0 Orientation and Imbrication
F.S. Field studies
S Shape and roundness
M Micromorphological
S.o Sorting
T Textural analysis

(See Figs. 27, 28)

Table 12 Agricultural land capability - P.E.I.

	Cleared (ha)	Wooded (ha)	Total (ha)
Class 2	163 062	106 351	673 531
Class 3	67 717	72 897	140 615
Class 4	3 388	43 572	46 960
	234 167	222 820	456 987
Classes 5, 6 and 7 cleared and wooded			103 537
			560 524

Table 13 Area in field crops (hectares)

	1971	1972	1973
Wheat	2 676	2 834	3 239
Barley	13 010	10 121	7 287
Oats	20 370	19 838	19 838
Mixed grains	28 910	27 125	32 793
Hay	51 988	51 417	52 227
Potatoes	18 856	15 789	17 004
Vegetables	195	536	577
Tobacco	1 330	1 417	1 457
Corn for fodder	1 093	2 024	2 834

The approximate area of vegetables for processing, mainly peas and carrots was as follows: 1972, 2 430; 1975, 4 049; 1976, 2 834 ha.

Table 14 Census data - P.E.I.

	1961 (ha)	1966 (ha)	1971 (ha)
In farms	392 062.8	370 791.2	309 852.0
Improved land	231 823.2	227 919.6	197 652.4
In crops	156 444.8	159 349.2	140 553.6
In pasture	67 165.2	60 876.4	45 708.4
Other improved land	7 200.4	11 694.0	11 390.4
Unimproved land	152 239.6	142 871.6	112 179.6
Woodland	118 703.6	111 872.4	84 364.4
Natural grass, marsh or wasteland	33 536.0	30 999.2	27 835.2
No. of farms	2 942.0	2 542.8	1 817.2

Table 15 Major uses of managed cropland, P.E.I., 1959

Land use	Hectares	Percent
Hay	114 550	43.3
Grain	66 510	25.1
Potatoes	18 935	7.1
Other roots, blueberries, tree fruits, small fruits and vegetables	4 437	1.7
Improved pasture	149 180	22.8
Total cropland	264 829	

*Calculated from land-use survey field data.

TOUR 1 DAY 4: WOLFVILLE TO QUEBEC
TOUR 10 DAY 10: WOLFVILLE TO HALIFAX

0 (0) LEAVE ACADIA UNIVERSITY to soil sites located at Research Station.

8 (13) CANADA AGRICULTURE RESEARCH STATION.

SITE 4: GLEYED ELUVIATED DYSTRIC BRUNISOL ON TILL (KENTVILLE A)

Also level morainal and north-facing slope but moderately well to imperfectly drained.

SITE 5: GLEYED ELUVIATED DYSTRIC BRUNISOL ON WATER WORKED TILL (KENTVILLE B)

This site, level morainal, is north-facing slope and presents imperfect to poor drainage conditions.

The apple orchard north of these profile sites was planted in 1954 with Gravenstein on M.2 rootstocks and Melba on M.1 rootstocks. Yield of Gravenstein apples has ranged from good to very poor (2460 to 212 kg per tree cumulative by the 21st year) and Gravenstein tree growth has ranged from good to poor (670 to 90 cm^2 trunk cross sectional area at 21 years). Tree performance, along the south side of the orchard, near the east and west profile sites has been intermediate and poor respectively.

Tree performance in this orchard is correlated with soil physical properties that prevent deep rooting. A fluctuating watertable, that is sometimes near the surface during the growing season, may be an additional factor.

40 (67) ATLANTIC UPLANDS of Nova Scotia. Topography rolling to hilly. Some raised bogs in the landscape.

60 (100) SACKVILLE, small town in the vicinity of the most important harbour of the Atlantic provinces Halifax which is open on a year-round basis.

TOUR 1 DAY 5: QUEBEC CITY TO DRUMMONDVILLE
TOUR 10 DAY 6: DRUMMONDVILLE TO QUEBEC CITY

Founded in 1608, historic Quebec City is located on the narrowest extremity of the Quebec escarpment. Bounded on the southeast by the St. Lawrence River and on the east and northwest by the Cap-Rouge-Limoilou depression, which was once part of the Champlain Sea, Quebec City is today a major centre for tourism, government (the seat of the National Assembly and home of 25,000 civil servants) and education. It is also a commercial and distribution centre for the eastern part of the province. Today, metropolitan Quebec City has nearly half a million inhabitants, ninety-two percent of whom are French-speaking.

T1 0 (0)
T10 190 (317) LAVAL UNIVERSITY. Between the university campus and the Montmorency Forest located in Laurentides Park, the road initially follows the depression of the St. Charles River as far as the

burgeoning industrial and commercial districts to the west. The city of Charlesbourg, established on the terraces bordering the depression of the St. Charles River at the foot of the Laurentians and crossed by the autoroute, is a residential community established only recently, in contrast to the older and less affluent residential areas at the mouth of the St. Charles River. The lakes, rivers, valleys, hills and forests on the edge of the Laurentians provide an exceptional holiday playground at the doorstep of greater Quebec City where sports and outdoor activities (cottage living, skiing, hunting, fishing, and so on) are pursued year-round.

T 2 (3)
T 10 190 (317) OLD CHANNEL OF THE ST. LAWRENCE. Leaving the escarpment of Quebec City, the highway crosses a low aluvial zone occupying what was once a channel of the St. Lawrence River. The characteristics of the soil evolving in this area are primarily those of the Regosolic or Gleysolic orders. These lands are largely under urban control and are therefore not available for agriculture or forestry.

We next encounter terraces composed of either layers of calcareous materials (Trenton) and schists from the Quebec City group or the compact granitic and gneissic materials of the Laurentians.

Although relatively clear of trees, the Brunisolic and Podzolic soils bordering on the massif of the Laurentians are cultivated to only a limited extent and this area is often sought out by vacationers and persons wishing to reside on the urban fringe.

T1 42 (70)
T10 148 (247) LAURENTIDES PARK. The Park is a wooded area with a hilly landscape, dotted with lakes and in some places reaching an altitude approaching 1000 m. Because of its abundant rainfall, it is an ideal environment for the podzolization of soils, most of which are the remains of glacial material. In short, Laurentides Park is something of a paradise for wildlife and outdoorsmen.

T1 50 (83)
T10 140 (234) MONTMORENCY FOREST. The Forest is the site of Laval University's forestry research station where the interrelationship of soil, plants and forest management is studied. An examination of the soil of the Laurentians provides a general idea of the scope of this work.

SITE 6: ORTHIC FERRO-HUMIC PODZOL ON THE LAURENTIAN TILL (LAURENTIDES)

This site is located on sandy glacial material in a forested area where the landscape consists of rounded mountains and hills.

The Montmorency Forest is located in Laurentides Provincial Park, approximately eighty km north of Quebec City. It covers a huge massif of the Canadian Shield composed of charnockite rock rich in mangerite and of smaller quantities of granite and gabbro. The rounded hills of this area, which are approximately 700 m high, are covered with ground moraine deposited during the Pleistocene Ice Age. This moraine is composed of stones and boulders, many of which are more than 60 cm in diameter. The texture of this material is a loamy sand predominantly of the textural class 0.5-1.0mm. The glaciofluvial deposits, the texture of which ranges from sandy to gravelly, are normally found in the valleys. There are two types of periglacial deposits: material filling cracks in old polygonal soil formations and material carried along by runoff flowing over the frozen soil. The mean annual temperature is 0.2 C; the mean temperatures during the coldest month, January, and the warmest month, July, are -14.9 and 14.7 C respectively. The mean annual precipitation is approximately 140 cm, 34% of which is in the form of snow. The growing season adds to approximately 1650 degree days, according to data compiled over a four year period. The northern coniferous forest, characterized by the climax of balsam fir and white birch, is the dominant form of vegetation in the Montmorency Forest. The soils of this region, most of which are developing on the basal till, often form drainage catenas. The climate, vegetation and soil together constitute a system of dynamic forces which encourage the development of Ferro-Humic Podzol soil in well-drained areas and Orthic Gleysol in areas where drainage is poor.

The Montmorency Forest was given to the Faculty of Forestry and Geodesy of Laval University by the provincial government in order to promote forestry education and research. Approximately 40 years ago, the forest was the object of intensive cutting by Anglo-Canadian Pulp and Paper. The deforestation attributable to man, fire, hurricanes and tornadoes has rejuvenated the stands of timber in the forest. A 1962 inventory revealed that at that time 90% of the volume consisted of stands less than 50 years old.

In order to facilitate the various types of work done in the Montmorency Forest, the area has been divided into 37 zones on the basis of the distribution of drainage basins. Cutting operations are conducted in several of these zones in accordance with annual yield potential. There is clear-cutting of mature stands of timber, whereas young stands are thinned for marketing, making it possible to recover 30-40% of the standing volume.

At rotation age, for the overall area, stands averaging 168 m^3/ha undergo an average annual growth of 2.2 m^3/ha.

A number of zones are devoted exclusively to research in ecology and silviculture. Here, the work consists primarily of thinning and fertilizating trees and conducting studies of the biomass.

Three zones are reserved for hydrological research. In addition to benchmark stations, a lysimeter and a series of stations for measuring the groundwater level have been established. A small, 150 ha drainage basin is strictly reserved for domestic water needs.

Two zones are reserved for recreational use and for conducting forestry studies in general. They are open to the public for trout fishing in summer and cross-country skiing in winter.

Approximately three-quarters of the stands of balsam fir in the Montmorency Forest are between 20 and 30 years old. They date from the clear-cutting carried out by Anglo Canadian Pulp and Paper during the Second World War. These young stands have yet to be thinned and are generally overcrowded, with 12 000 to 30 000 stems/ha. As a result, a number of trees are not growing. Five years ago, an experimental precommercial thinning program was established in order to

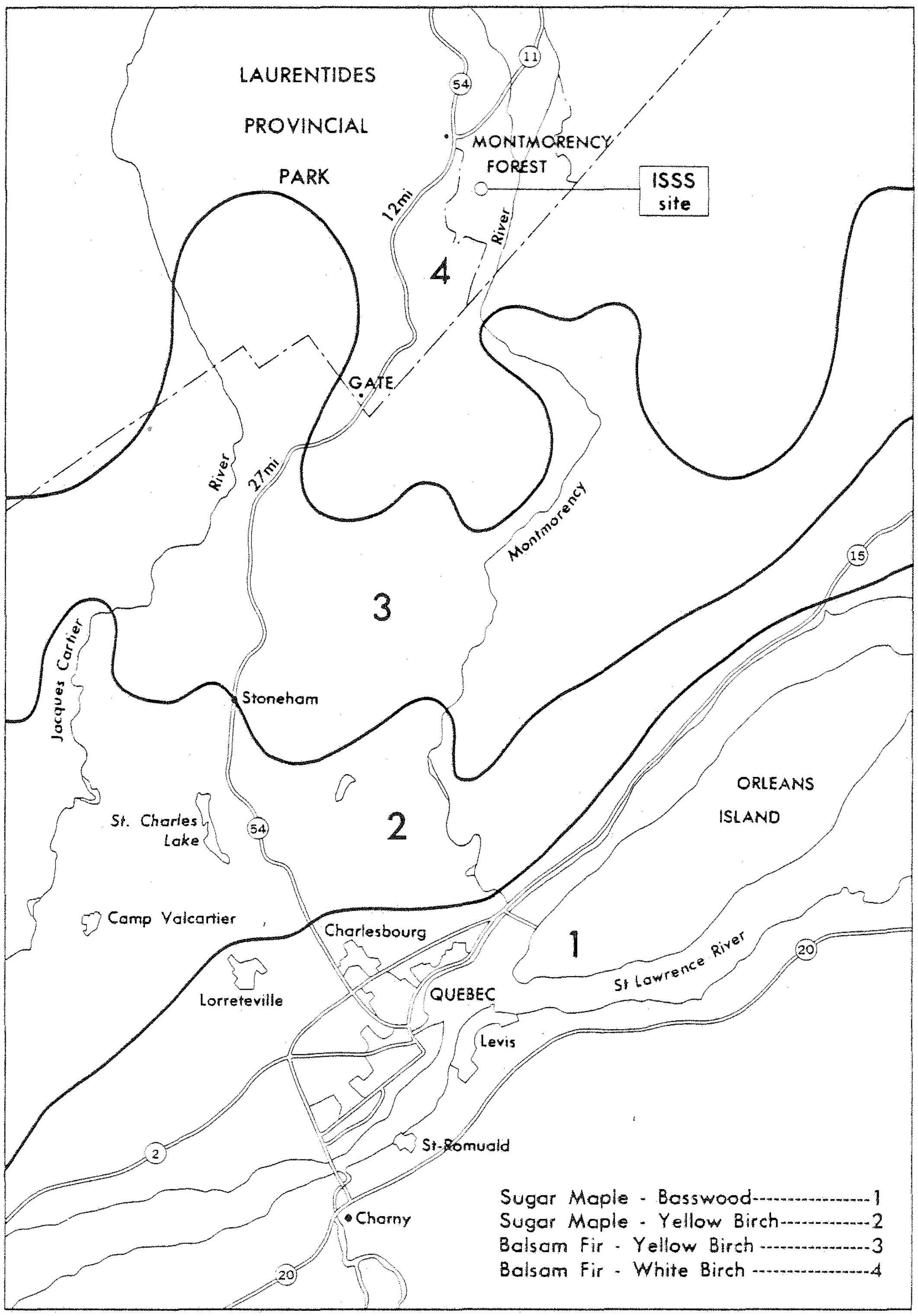


FIG. 30 APPROXIMATE BOUNDARIES OF VEGETATION CLIMAX DOMAINS
Re: Fourth North American Forest Soils Conference
"A Visit to Montmorency Forest," August 1973

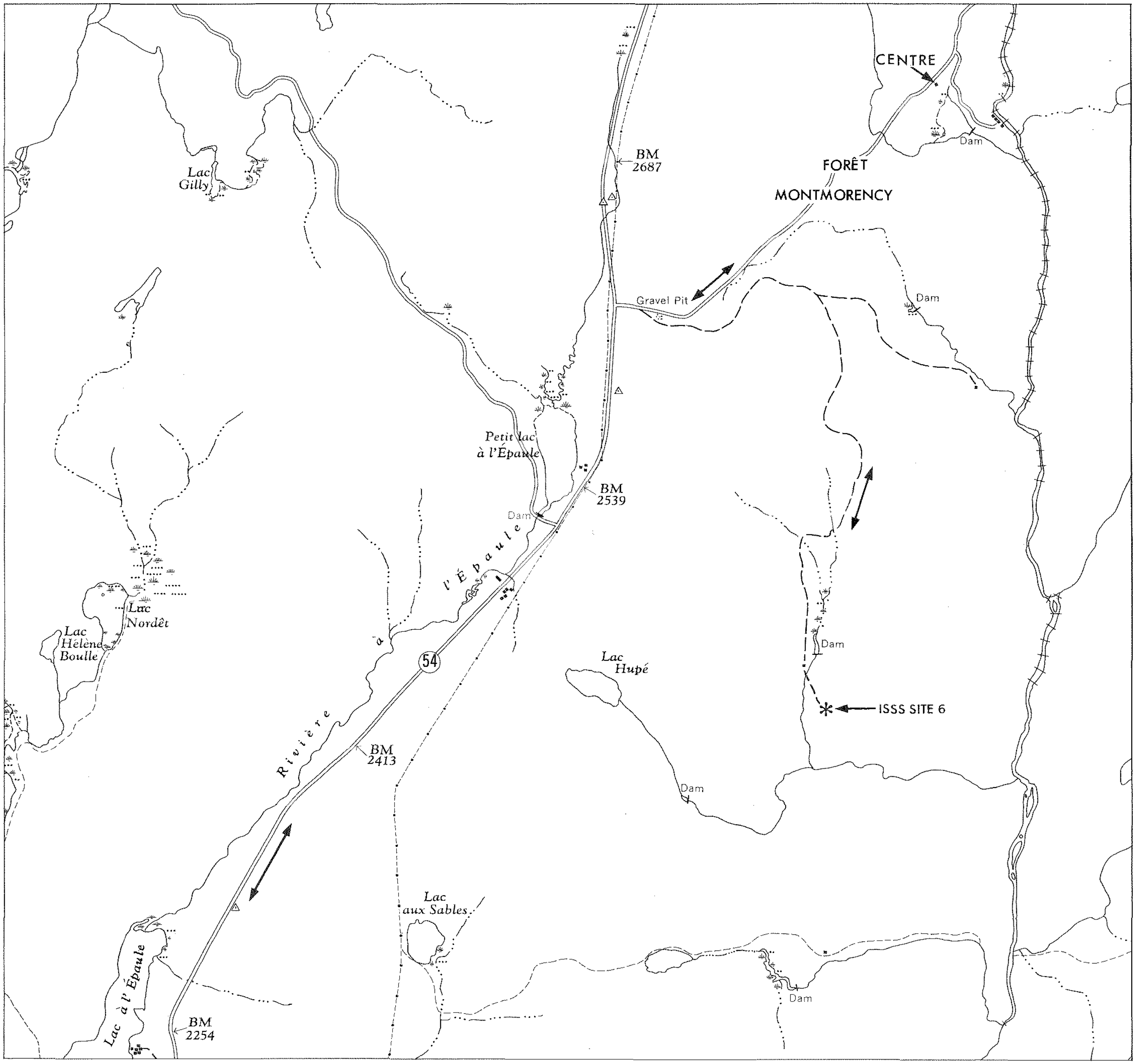
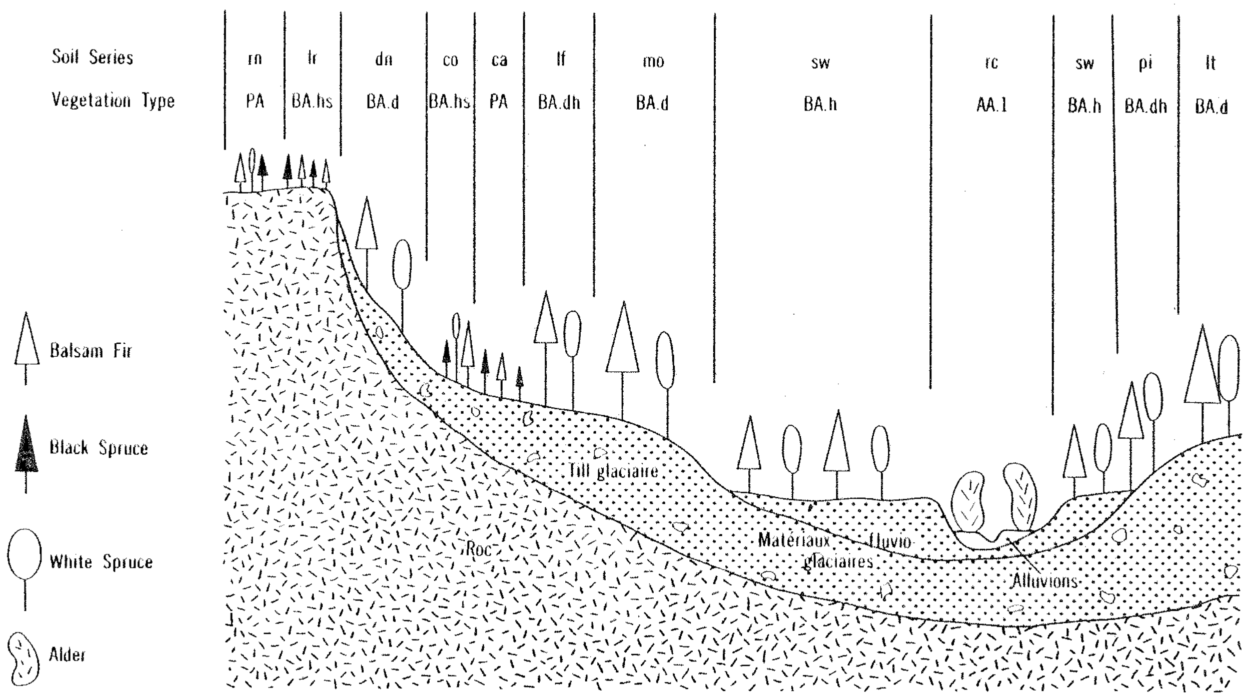


FIG. 31 LOCATION OF ISSS SITE 6



Abbreviations for Soil Series

ca: Cauchon
co: Colligan
dn: Des Neiges
lf: La Foi
lr: Lac Rossignol
lt: Laurentides
mo: Montmorency
pi: Piché
rn: Ruisseau du Nord
rc: Rivière Cachée
sw: Swain

Legend for Vegetation Types

Swamp alder
AA.1: alder-balsam fir

Forests of balsam fir-white birch
BA.d: balsam fir-white birch-Dryoptesis
BA.ch: balsam fir-white birch-Dryoptesis-Hylocomium
BA.n: balsam fir-white birch-Hylocomium
BA.hs: balsam fir-white birch-Hylocomium-Sphagnum

Forests of balsam fir-black spruce
PA: balsam fir-black spruce

FIG. 32 RELATIONSHIP OF SOILS, TOPOGRAPHY AND VEGETATION IN MONTMORENCY FOREST

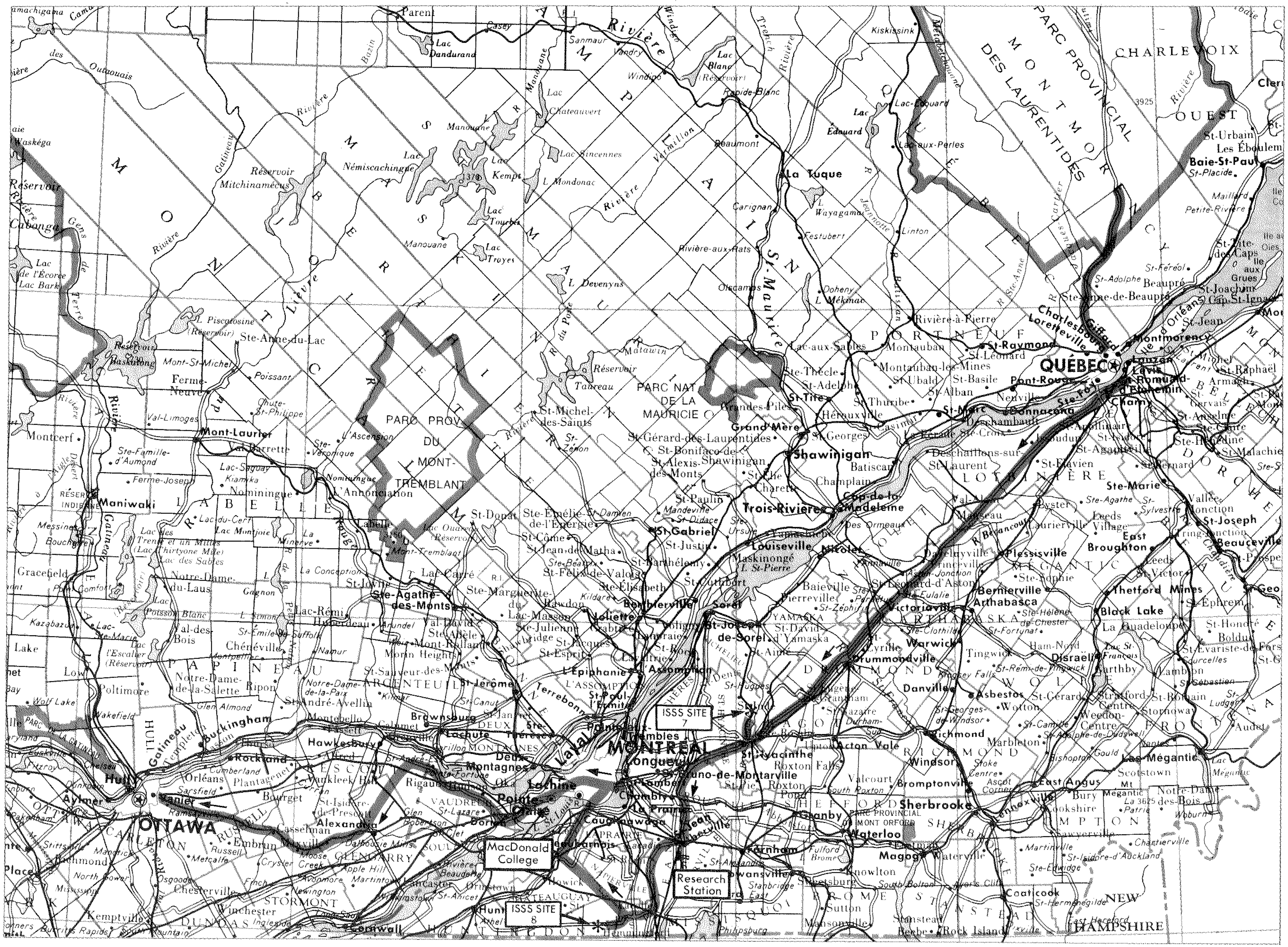


FIG. 33a LOCATION OF ISSS SITES 7 AND 8 ISSS TOUR—QUEBEC CITY TO OTTAWA

study the growth of a small number of trees having optimum growing space. Excess trees were removed by chemical and mechanical names. In the first case, cacodylic acid or phenoxy silvicides were used; in the second, trees were spaced either manually or by means of a tractor. The results achieved after 5 years are encouraging, the thinned trees having recorded a much healthier growth.

Fertilization projects are in progress mainly on fir stands. Their purpose is to compare the effects of P, K, Mg and N (urea) fertilizers. Comparative studies on the effect of nitrate fertilizers from various sources have been conducted. Moreover, an experiment is being conducted in order to determine the impact of fertilization on the ecosystem of the natural forest. For example, changes have been observed in the composition of leaf tissue following application of measured amounts of fertilizers. For this reason, the researchers responsible for these projects believe that fertilization of the forest may have an effect on animals which feed on trees, such as the moose.

T1 100 (167)
T10 90 (150) THE ST. LAWRENCE. Crossing the St. Lawrence River, one is afforded a brief glance at the steep cliffs and the majestic expanse of the seaway, not to mention the panorama of metropolitan Quebec City.

T1 103 (170)
T10 87 (147) SOUTH SHORE. The part of the St. Lawrence lowlands situated between Quebec City and Drummondville is a rural area with a subdued landscape varying in altitude from 70 to 140 m. The area supports mixed farming oriented primarily toward dairy production. Generally speaking, the basic components of the soils are sandy deposits, poorly drained in some areas and of only average agricultural value (classes 3 and 4). The forests in the process of regeneration, succession stands and "mixed woods" where coniferous and deciduous trees grow side by side are of limited commercial value because the marketable species are relatively dispersed. In inland villages and along the autoroute there are a number of small industries related to farming and forestry operations, as well as service industries associated with the transportation of people and goods; the latter complete the picture of the major economic activities of this region.

T1 190 (317)
T10 0 (0) DRUMMONDVILLE is located in the region known as the Bois-Francs, where the furniture and textile industries are the major sources of employment for the urban population. Agriculture continues to thrive in a variety of forms in this part of the province and is practised on unconsolidated marine, fluviatile and glacial deposits. The landscape ranges from flat to slightly undulating. The moisture regime of the soils varies from slightly inadequate to good, and weather conditions are suitable for growing corn. In the region of the Eastern Townships and in a number of other areas where the sugar maple grows, the maple syrup industry is a supplementary springtime activity.

TOUR 1 DAY 6: DRUMMONDVILLE TO MONTREAL
TOUR 10 DAY 6: MONTREAL TO DRUMMONDVILLE

T1 0 (0)
T10 126 (210) TRAVELLING TOWARD SAINT-HYACINTHE. The landscape is characterized by a gently undulating plain where deposits which are the remains of the Champlain Sea scarcely conceal the glacial forms and in turn give way to clayey marine sediments which in some places are covered with

sandy fluviatile materials. Generally speaking, the soils belong to the Humo-Ferric Podzol, Eluviated Dystric Brunisol and Orthic Humic Gleysol subgroups.

T1 26 (44) T10 106 (176) SAINT-HYACINTHE, an urban community located in the centre of a major agricultural zone. The presence of an Institute of Agricultural Technology reflects the importance of agriculture for a large number of local residents.

T1 38 (67) T10 94 (153) SAINT-THOMAS D'AQUIN. One of Quebec's prime agricultural areas, particularly with respect to the dairy industry and rowcrops which require a relatively high temperature threshold.

SITE 7: ORTHIC HUMIC GLEYSOL ON MARINE CLAYS (SAINTE-ROSALIE)

Examination of a Saint-Rosalie soil profile in an agricultural zone where a humid and unsaturated regime and mild weather conditions prevail. The topography is generally flat and the drainage conditions less than ideal.

A large percentage of the soils of the St. Lawrence plain have been cleared of trees and have since been used for agricultural purposes, although a different trend has developed near urban centres or along major waterways, where agricultural land is rapidly being taken out of production as a result of land speculation and property transfers. In view of the favourable climatic conditions and the superior quality of the soils in this region, a considerable number of crops are grown for use in the dairy industry or in the raising of beef cattle. For example, the region has lush pastures and produces good hay. In addition, grain corn, barley, wheat, soybeans and sugar beets are major crops well suited to the soils of this region. The use of fertilizers has produced encouraging results in view of the moderately high nutrient potential of the agricultural lands. Clayey soils related to the Sainte-Rosalie series, as well as the soils of members associated geographically with this series, have limitations attributable to physical properties which are often undesirable: compactibility, slow drainage and insufficient aeration. In the Montreal and Lac Saint-Pierre regions, moreover, clayey soils of the same type occupy a total area in excess of one million acres (400 000 ha).

A number of soil-related agricultural problems, such as the poor drainage conditions of clayey soils, have gradually been eliminated, whereas other problems are arising elsewhere, particularly since the introduction on an increasingly massive scale of heavy farm machinery which leads to greater compression of the soil and destroys its weak structure.

T1 60 (100) T10 66 (110) SAINT-JEAN. This agricultural and commercial centre boasts an Agriculture Research Station and a military college.

Located in the St. Lawrence lowlands, this pedologic subregion of Montreal is one of Quebec's prosperous agricultural areas. Moreover, in the counties south of Montreal (Châteauguay, St-Jean, Napierville, Laprairie and Huntingdon), there are some 20 000 ha of organic soils, approximately 2500 ha of which are used for the production of horticultural crops. The organic deposits spread throughout this part of the region are the remains of lakes formed when the Champlain Sea retreated. The deposits are of varying depths, in some places exceeding five metres. Generally speaking, these organic soils are in a moderate state of decomposition too far advanced for the soils to be used industrially, and given the climatic conditions of the area and the proximity of markets, are better suited to high yield market-garden crops such as carrots, onions, celery, lettuce, radishes, and so on.

T1 81 (135) SHERRINGTON. A considerable number of the residents of this part
T10 45 (75) of the province, located south of Montreal, are involved in the cultivation of organic soils.

SITE 8: TYPIC MESISOL ON ORGANIC MATERIAL (LANSON)

Examination of an organic soil and special visit to a tract of muck soil currently under cultivation. Mention should be made of the varying thickness of the organic deposit and of the extent to which the organic material has been depleted as a result of cultivation. The bog is a landform common to the lowlands. Moreover, this particular bog borders on an area relatively rich in nutrients in which grasses and mosses are the dominant species. There are a number of deciduous trees and shrubs on the surface in the natural state. In some places, the deposit may extend to a depth of five metres.

The profile exhibited at site 8 reveals a very dark-coloured and moderately decomposed peat, consisting largely of sedges and rushes, with the presence of wood in the intermediate horizon. The peat has an acid reaction. Mention should be made of the major drainage work being carried out in order to bring the organic soils under production.

T1 101 (169) SAINTE-CLOTHILDE. Here, an agricultural research station is located
T10 25 (41) amidst organic lands cultivated by a group of market gardeners specializing in vegetable production.

T1 110 (183) SAINTE-MARTINE. This community is representative of the region's
T10 16 (27) flourishing agricultural activity, and is the site of a plant for processing vegetables produced on mineral soils. Of special interest is the microrelief which is characteristic of the St. Lawrence River floodplain.

T1 123 (205) CAUGHNAWAGA, an Indian reserve located on the urban fringe, where
T10 3 the encroachment of the urban on the rural is noteworthy. The open areas are taken out of production and are under speculation.

T1 126 (210) The MERCIER BRIDGE spans the St. Lawrence River and provides access
T10 0 to greater Montreal.

Founded in 1642, Montreal was soon dubbed Canada's metropolis because of its superior geographical setting and its accessibility by water. Today, with a population of 3 000 000, metropolitan Montreal is both a thriving international meeting place and a major commercial, industrial, cultural and tourist centre. Well served by its elaborate network of air, land, and sea communications, Montreal continues to attract diversified interests and, to some extent, to set the pace for the country's economy. Secondary and tertiary economic activity, often more diversified and intensive than in other parts of the province, is prevalent in a substantial part of the suburban Montreal. However, the establishment of industrial and residential complexes, along with the phenomenon of land speculation and the purchase of land by non-residents, is resulting in an irreversible encroachment on agricultural land and is contributing to some extent to the abandonment of agriculture as a profession.

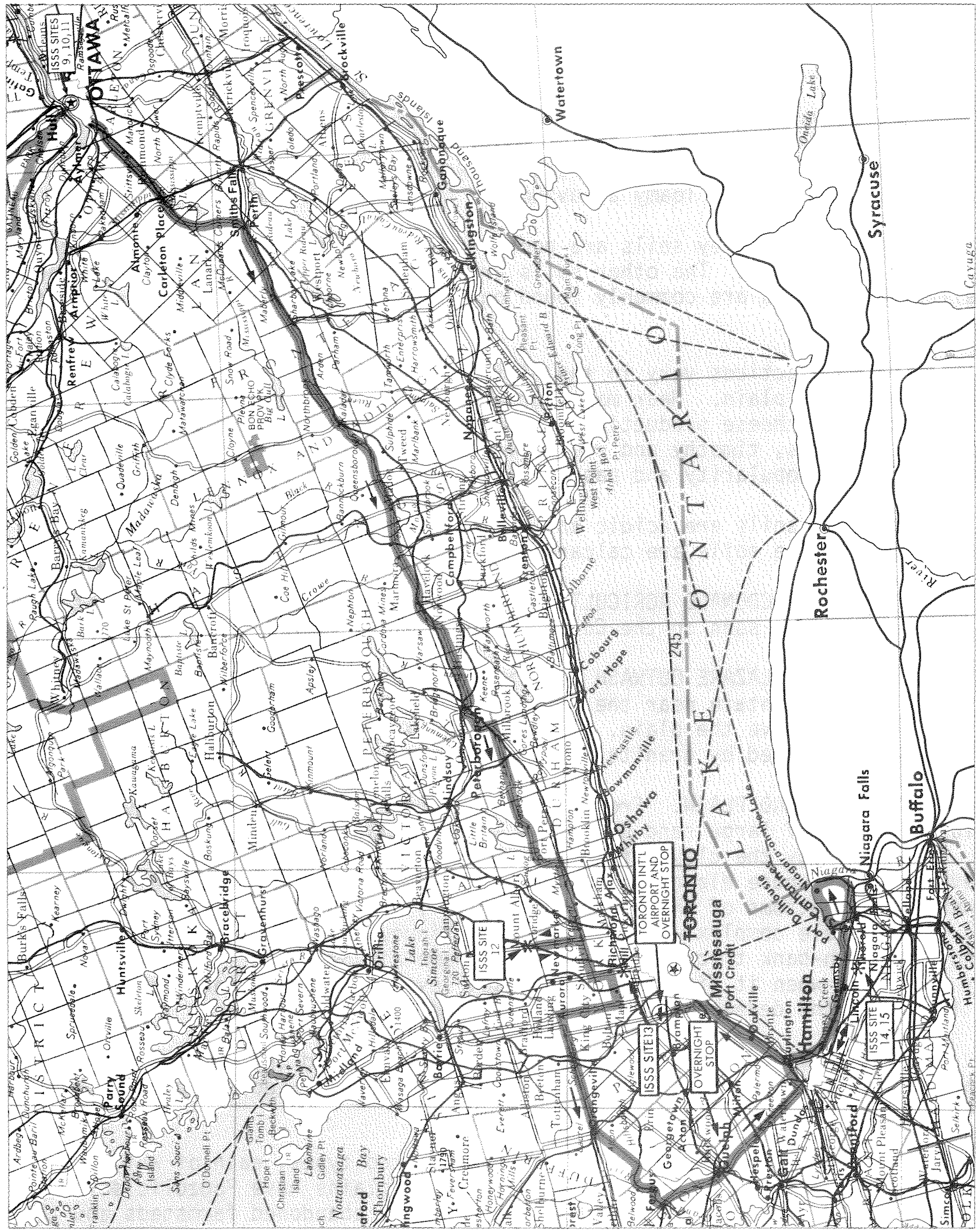


FIG. 33b LOCATION OF ISSS SITES—ISSS TOUR—OTTAWA TO GUELPH, TORONTO

TOUR 1 DAY 7: MONTREAL TO OTTAWA
TOUR 10 DAY 4: OTTAWA TO MONTREAL

T1 0 (0)
T10 117 (195) LOWER TERRACE OF THE ST. LAWRENCE LOWLANDS. The first portion of the route between Montreal and Hudson traverses the central lower terrace of the St. Lawrence Lowland. Along the Ottawa River the elevation is between 100 and 200 feet (30-60m). The lowlands are underlain by flat lying Paleozoic formations consisting of sandstone, dolomite, limestone and shale. The lowlands are covered by glacial till, which for the most part is capped by loamy alluvium, or by clayey marine sediments.

Most of the clayey soils are poorly drained; organic deposits are occasionally associated. The other soils are imperfectly or poorly drained, and well-drained soils are commonly found only on low ridges and along low escarpments.

Farming practices vary in the different parts of the St. Lawrence Lowland and Ottawa clay plain. Near major urban centers production of fluid milk is widespread and cheese production is common. In other areas the choice of crops is limited: oats, timothy and red clover are the mainstays, silage corn is increasing in popularity and pasture is abundant. Alfalfa is seldom grown.

The sandy soils are acidic and of low fertility, whereas the till soils and clayey marine soils are calcareous to weakly acidic.

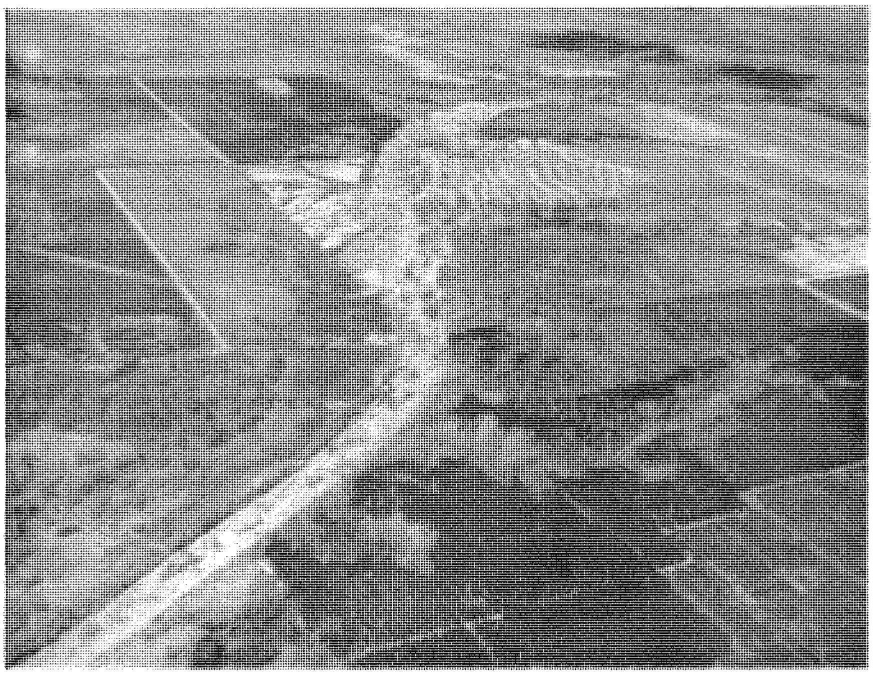
T1 15 (25)
T10 102 (170) MACDONALD AGRICULTURAL COLLEGE. A well protected arboretum may be seen on the College farm.

T1 25 (41)
T10 92 (154) ST-LAZARE OUTWASH deposits can be seen along the river. Rigaud Mountain near the town of Rigaud, rises some 400 ft. (120 in) above the plain. The mountain is composed of Precambrian quartzite and gneiss intruded by granite and syenite.

T1 35 (59)
T10 82 (136) SAND PLAIN. From Rigaud to Ottawa the route traverses a group of large sand plains in Russell and Prescott counties, separated by the clays of the lower Ottawa valley. The sand plains have a level surface whose elevation is approximately 250 ft (75 m) above sea level, whereas the bottoms of the intervening clay-floored valleys lie below 200 ft (60 m). This whole complex was at first a continuous delta built by the Ottawa River and its north-bank tributaries into the Champlain Sea, and later was cut to pieces by the river when it first rose above sea level. Massive landslides also were a factor in the development of the landscape.

The texture of the sand ranges from coarse toward the north and fine toward the south. Everywhere the sands are underlain by Leda clay, which is sensitive and subject to sliding.

The sand plains thus can be divided into two types, each of which has a distinctive pattern of land use. The dry sand plains have Podzolic soils that are acidic and of low fertility. There are many abandoned farmsteds and the land is being reforested. By 1964 more than 20 000 acres (8000 ha) had been replanted to trees.



Courtesy of National Research Council of Canada

FIG. 34 OBLIQUE AERIAL VIEW OF THE LANDSLIDE NEAR CASSELMAN, ONTARIO

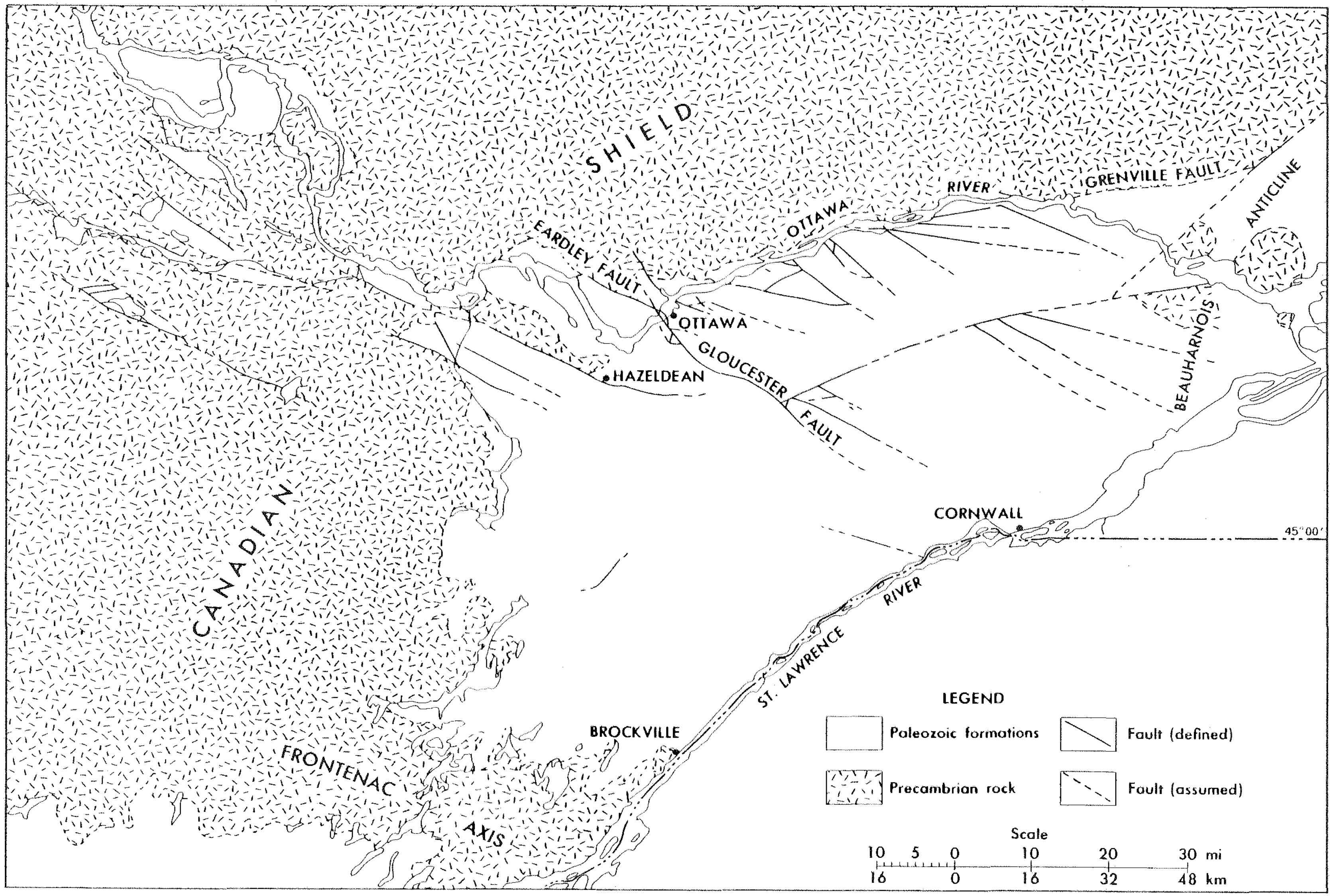


FIG. 35 MAP SHOWING CANADIAN SHIELD, OTTAWA-ST. LAWRENCE LOWLANDS AND FAULTS IN THE OTTAWA AREA (After Wilson, 1964)

In the fine sand areas the soil drainage is mostly poor but artificial drainage is profitable. These areas have become prosperous dairy farming, potato, and grain corn areas but good fertilizer and management programs are essential.

T1 83 (138) NATION RIVER. Large earthflows or landslides are an important
T10 34 (57) geomorphological feature of the landscape of the former Champlain Sea sediments. Landslide scars occupy many square miles of terrain of the Ottawa-St. Lawrence valleys including what is now productive agriculture land.

The example to be visited is the South Nation River Landslide which occurred May 16, 1971. It is located about 30 miles (48km) east of Ottawa near the village of Casselman, Ontario. The landslide began in an 80 ft (24m) high clay slope of the river and rapidly retrogressed until nearly 70 acres (28 ha) of land were involved. The crater left by the landslide extends 2100 ft (640m) along the river and 1600 ft (490m) back from the bank. Debris from the landslide was carried both upstream and downstream filling nearly 8000 ft (2450m) of river bed to a depth of more than 30 ft (10m). The accompanying photograph (Figure 34) is an oblique aerial view of the landslide. To the left of the figure a scar of an older landslide is visible. This landslide took place in 1910 and indicates that this area is prone to earthflows.

Earthflows occur in the clay sediments deposited in the Champlain Sea; an arm of the sea which occupied the Ottawa-St. Lawrence Valleys in post glacial time. These clays have an open structure, which when broken down by disturbance causes the clays to suffer a dramatic loss in strength and in some cases turn to a viscous fluid. At many landslides, such as the South Nation, liquification of the clay is a prominent feature and is the basic cause of their ability to retrogress or enlarge themselves.

The excursion to the South National River Landslide will be by bus from Ottawa and will be about four hours duration. A walk through the fields of about one mile will be required, so that walking shoes are necessary. Descriptive material on this landslide and the more general earthflow problem will be provided.

T1 110 (183) OTTAWA urban and residential area. Designed as National Capital
T10 7 (12) of Canada a century ago, the City has gradually developed with the concept of a powerful and centralized central government.

T1 117 (195) CENTRAL EXPERIMENTAL FARM. The National Capital Region lies in
T10 0 (0) a Paleozoic lowland basin bounded by ancient Precambrian rocks (Fig. 35). This basin is bounded on the west by a southward extension of the Canadian Shield, which includes a southeasterly spur, the Frontenac Axis that forms the Thousand Islands as it crosses the St. Lawrence River and eventually joins the Adirondacks. The eastern margin of the lowland is the less topographically expressed Beauharnois anticline. The lowland is bounded on the north side of the Ottawa River by the Gatineau Hills, part of the Precambrian Shield which rises abruptly to a height of about 1000 ft.(300 m). This sharp break in elevation is due to faulting, the block to the south having dropped down. The overlying sedimentary rocks were then placed in a protected position escaping the full forces of subsequent erosion. The down-dropped

block is bounded on the west and south by faults and tilted towards the west. The western boundary, (Gloucester fault) is seen as a bluff facing the northeast. Precambrian outliers are exposed along the main fault (Hazeldean) west of Ottawa, which passes through Hazeldean and forms the northern flank of the Carp Valley.

The rocks of the present lowland were deposited in Paleozoic times on a sinking continental margin of Precambrian rocks. During the late Cambrian or early Ordovician, sandstones (Nepean formation) buried the erosion surface of the Precambrian platform. A succession of shallow seas flooded the lowland during the Ordovician period, depositing thick beds of limestone, dolomite, shale and thin layers of sandstone. Deposition was followed by consolidation of deposits and the development of numerous faults. The majority of the faults are parallel or at right angles to the Shield.

There were no more recognizable deposits left in the Ottawa Region until the beginning of the Pleistocene. By the end of the Plieocene, a long period of erosion has removed the bulk of the sedimentary rocks which overlapped onto the Shield. Several major modifications to the preglacial landscape were made by the Laurentide Ice Sheet. However, no direct evidence has been found for a glaciation earlier than the Wisconsin.

Glacial tills and morainic deposits are generally sandy and calcareous containing equal proportions of Precambrian granitic rocks and Paleozoic pebbles and boulders. South and southeast of Ottawa the tills are drumlinized and in most cases modified by wave action leaving excessively stony surfaces. Sand and gravel ridges occur south of Ottawa, but their former slopes have been subdued by wave action and marine deposits. The presence of marginal glacial lakes during the retreat of the Ice Sheet has been indicated in places by varved clays, (near Uplands Airport) now buried by marine clays and sands.

The Champlain Sea invaded the Ottawa Valley about 12 000 years ago. The northern boundary of the invasion was defined largely by the zone of faulting along the Paleozoic-Precambrian border. The sea was stopped by a wall of Precambrian rocks rising abruptly above the Paleozoic lowland, along the Eardley fault west of the Gatineau Valley and east of Papineauville where, to the north of the present river an escarpment rises above the highest marine beaches. Between these points the Champlain Sea penetrated farther north over the Precambrian Shield via the emerging valleys of the Gatineau and Lievre rivers. The highest traces of the sea are beach deposits found at 675-700 ft (205-215m) above present sea level.

Deposition of brackish marine sediments continued for a period of 1000-3000 years. The finer sediments (silt and clay) now termed 'Leda clay', were widely spread over the deep water section of the sea, in layers up to 200 feet (66m) thick.

As the Champlain sea withdrew the water ceased to be purely marine and changed first to estuarine and then for a brief time a lake occupied the lowland. The gradual transition from a brackish marine to a lacustrine or ancestral fluvial environment may be the reason for the presence of two clays, a nonfossiliferous, noncalcareous upper layer and a fossiliferous, calcareous, soft lower layer. During this period large quantities of sand were brought into the sea by rivers fed from the melting ice sheet, resulting in the formation of deltas. Only later as the sea began to fall did the sand spread over the lowland to mantle the clays.

The Ottawa river and its tributaries flowing across the sand plains rapidly cut through the sand deposits exposing the buried clay. At one time, the Ottawa River had several channels, which with time became integrated, leaving dry sand plateaux that were ultimately covered with vegetation. East of Ottawa the old channels are 2-6 miles (3.2-9.7km) apart, in places up to 60 feet (17.8m) deep and floored by clay and silt. Some of the channels are still occupied by streams. However in others there is no stream system and peat bogs like the Mer Bleue have developed.

The Ottawa Valley has a humid climate with a mean annual air temperature of 5.4 C and a mean annual precipitation of about 820 mm. The mean annual soil temperature at 50 cm is about 6 C and the mean summer soil temperature about 15 C. The growing season (May to Sept.) precipitation averages about 390 mm and the average annual snowfall is about 230 cm. Degree (C) days above 5 C average 1830.

SITE 9: ORTHIC MELANIC BRUNISOL ON TILL (GRENVILLE)

Grenville series is widely distributed in the region. It is developed on glacial till, that is weakly weathered, moderately to strongly calcareous and slightly stony to bouldery. Its topographic expression ranges from gently undulating to moderately undulating. The soil profile is well drained, moderately pervious and has moderate surface runoff on the gentler topographic positions. There has been slight to moderate erosion depending on the cultivation history.

Under the original native vegetation (red maple, birch, beech and poplar) the soil has a moderately thick mull surface horizon denoting the action of earthworms. The brown subsoil is rich in bases inherited from the calcareous parent material.

The Grenville soil material on gentle slopes has moderate to severe limitations for granular material, few limitations for general fill, moderate limitation for highway and road construction, few limitations for shallow excavations, moderate limitation for septic tank installations.

For agricultural use the best sites are rated Class 1, but excessively stony phases are rated Class 5P.

SITE 10: ORTHIC SOMBRIC BRUNISOL ON SAND VENEER OVER MARINE CLAY (MANOTICK)

Manotick series is widely distributed in the region. It is developed on sand over clay marine deposit that is weakly weathered, and slightly to moderately acidic in the upper sequence. Its topography ranges from very gently to moderately undulating. The soil profile is excessively to well drained, rapidly pervious with low surface runoff on all topographic positions.

Under the original native vegetation these soils had a thin leaf litter and moder layer over a thin eluviated Ae horizon. The brown subsoil shows weak accumulation of sesquioxides.

The Manotick soils are poor sources of sand for general construction and for road fill because the sand is thin over clay. They have moderate limitations for local roads and streets primarily because of the underlying clay, moderate limitation for shallow excavations because of the sandy surface materials, and moderate limitation for septic tank absorption fields because of seasonal depth to water table.

For agricultural use the Manotick soils are rated Class 3FM because of the sandy soil surface.

A series of research projects are being conducted on this Manotick soil and on the adjacent Bainsville soil site (shallow loam over clay). The objectives are:

1. to study the movement of nitrogen under field conditions;
2. to test methods for measuring soil water content.

The nitrogen transport study utilized the monitoring of small plots and also tracer techniques to follow nitrogen movement. The results to date indicate that late fall and early spring leaching account for the major losses. The importance of soil structure is being considered with respect to its influence on the mode of nitrogen transport, but the results to date are highly tentative.

The utility of the air-entry permeameter method for measuring saturated conductivity coupled with water desportion curve data for modelling water transport is being examined on these plots. A method of utilizing the soil dielectric constant is being tested for indirect measurement of the soil water content.

SITE 11: ORTHIC HUMIC GLEYSOL ON LOAM VENEER OVER MARINE CLAY (BAINSVILLE)

Bainsville series is rather widely distributed in the region. It is developed on loam over clay marine deposit that is weakly weathered, and slightly to moderately acidic in the upper loamy layer. Its topography ranges from level to very gently sloping. The soil profile is poorly drained except where artificial drainage has been installed. When artificially drained the numbers of earthworms increase markedly with a consequent increase in the porosity and transmissibility to water. The soil water table is usually close to the soil surface during the period of late fall to late spring.

Under the original native vegetation these soils had a moderately thick leaf litter and mor layer over a moderately thick Ah horizon. The cultivated surface soils have Ahp horizons moderately high in organic matter. The subsoils show the mottling and dull colors typical of Gleysolic soils.

TOUR 1 DAY 8: OTTAWA TO GUELPH
TOUR 10 DAY 3: TORONTO TO OTTAWA

T1 0 (0)
T10 330 (550) OTTAWA DOWNTOWN. From Ottawa, the buses proceed westward on the Queensway. The route follows Highway 7 and 15 westward at the end of the Queensway.

Ottawa is situated within the Ottawa Valley Clay Plain physiographic region, a subdivision of the Central St. Lawrence Lowland. The plain is comprised of deep clay or silty clay deposits associated with the Champlain Sea, interrupted by bedrock exposures, glacial till or beach ridges of fragmental and coarse textured materials. The land surface of large tracts within the plain is level, but erosion has created a dissected landform and gullies are numerous adjacent to the major rivers and streams.

The combination of low relief, fine texture and impermeability of the sediment over much of the plain have contributed to a dominance of poorly drained soils in the region.

T1 30 (50) T10 300 (500) CARLETON PLACE. An abandoned shoreline of the Champlain Sea occurs in this vicinity, manifested by marine beach deposits of flaggy limestone, and sand and shorecliffs incised in the glacial till uplands.

The town of Carleton Place itself is situated in the Smiths Falls limestone plain which is the largest and most continuous tract of shallow soil over limestone in Southern Ontario. Where irregularities in relief occur, in some cases due to faulting, clay has accumulated in low lying areas. However, organic soils are most common in the depressions of the plain supporting a dense swamp forest cover.

T1 52 (87) T10 278 (463) PERTH. Founded in 1915, originally a military settlement first peopled by soldiers of a Scottish regiment and later settled by families from Ireland and England.

T1 59 (98) T10 271 (452) CANADIAN SHIELD. The Canadian Shield physiographic region spans a distance of approximately 65 miles along the tour route; from Wemyss to Madoc.

The very ancient and resistant crystalline rocks of the shield account for almost two-thirds of Ontario's land surface (Fahey, 1974). The shield rocks outcrop extensively or may lie partially obscured beneath a thin coarse textured veneer (less than one foot) of glacial debris. They include large masses of granite, granite gneiss, syenite, diorite, etc. and lesser amounts of crystalline limestone. Irregular slopes with high relief and organic deposits occupying the depressions, dominate the landscape. Small lakes also are common.

In the Canadian taxonomic system, soils of the Podzolic, Brunisolic and Organic Orders occur in this region. Humo-Ferric Podzols predominate where the parent materials have a large granitic component, whereas soils of the Melanic and Eutric Brunisol Great Groups are associated with parent materials high in crystalline limestone. Most of the organic soils consist of Humisols or Mesisols derived from swamp forest vegetation.

Agricultural use within the shield region is confined to occasional small and scattered pasture fields with the major limitations being due to topography, shallow soil, stoniness or rockiness. In general, the region is classified as 7PR for agricultural use. Forests, however, dominate the region. The capability for forestry ranges from moderately high (4R, 4y) to extremely low (6y, 7R) with the limitations which affect agriculture also applying to forestry use, although to a slightly lesser extent. The capability of the area for recreation is somewhat improved, particularly adjacent to many of the small lakes which have a moderately high capability (3BNY) for swimming, boating, fishing and camping.

T1 123 (205) T10 207 (345) DUMMER MORAINES. An area of rough, stony land bordering the Canadian Shield on the west is encountered intermittently along the route from Madoc to a few miles west of Norwood. It is referred to as the Dummer moraines. The moraines are characterized by a mixture of sedimentary limestone and Precambrian rocks giving rise to excessively stony and bouldery landscapes. Loam to sandy loam textures and moderately high permeability contributes to the dominance of well drained soils in this region. They are predominantly Eutric Brunisols with a very shallow solum (20-30cm) and often have carbonates in the surface horizons.

A surprizingly large proportion of this land was put to agricultural use in the days of early settlement, but severe limitations imposed by stoniness and topography resulted in abandonment of many farms since the turn of the century. Agriculture capability for much of the region is $6_P^7\ 3_P^3$.

Extensive areas of forest do not occur throughout the region, and it is often restricted to farm woodlots. Some of the cleared land, however, is being returned to forest, as its capability is moderately high for this use. The forest capability classification generally ranges from 2_L^D, 3m, 4R, 5w. A low capability for recreation generally is characteristic of this region, except in the vicinity of a few lakes and the Trent Canal system offering swimming, camping and boating opportunities.

T1 150 (250) T10 180 (300) PETERBOROUGH DRUMLIN. The rolling glacial till plain comprising the Peterborough drumlin field occurs along the route approximately from Norwood on the east to Point Perry on the west. It achieves its name from the city which occupies the geographic centre of the drumlin field. The plain contains approximately 3,000 good drumlins, in addition to other drumlinoid-hills and surface flutings on the glacial drift. The general orientation of the drumlin axes is from northwest to southeast indicating the direction of ice advance from the Lake Ontario basin. The drumlins throughout are composed of highly calcareous glacial till containing great quantities of angular limestone and Precambrian materials. Typical drumlins are less than 800m in length, 200m or less in width and 25m in height. Many are closely spaced, averaging four or five to the square mile and rest on a gently sloping moraine base. In other instances the drumlins are more widely separated and glacial spillway channels, sand or clay plains occupy the intervening space.

Soils on the drumlinized landforms are largely well drained loams and sandy loams. They exhibit profile characteristics of the Gray Brown Luvisol Great Group for the most part, however, they are transitional to the Eutric Brunisol Great Group where development of the illuvial Bt horizon is less strongly expressed.

The agricultural utilization of soils in the drumlin field is adversely affected by the steep slopes, stoniness and the swampy lowlands. Thus, the capability classification of the mineral soils can range from Class 1, 4t, 5w and 5p. Organic soils which are common in the glacial spillways may be class 4 or 5 (Hoffman, D.W. and C.J. Acton, 1974).

Most of the drumlin field has only slight to moderate limitations for forestry use. However, forests usually are restricted to soils of low agricultural capability, hence are most common on the steep slopes or in wet landscapes. Forest land classification on these sites may be 3^{m}_{l} or 5w due to either a deficiency or excess of soil moisture (m or w), and nutritional problems associated with the high carbonate content (L) of the soil.

The drumlinized landscape has a low capability for outdoor recreation, however, the area in general has some of the best recreational capabilities in Ontario and offers a variety of activities. A number of fairly large lakes, as well as the Trent-Severn waterway occur in the area which afford a moderately high capability for water based recreation. Fishing in the area is good with freshwater species such as bass, pike, walleye, trout and muskellunge present in many of the waters. Skiing and snow cruising are popular throughout the lakes region and winter carnivals attract large numbers of visitors. The region is geared to a recreation economy and is widely known as one of the best year-round resort areas in Ontario.

T1 230 (383) OAK RIDGES MORAINE. The Oak Ridges moraine physiographic region
T10 100 (167) is encountered at several locations along the tour route, from the town of Manchester to Ballantrae, north of Richmond Hill, and again east of Orangeville. It is one of the most distinctive physiographic units of southern Ontario, forming the height of land north of Lake Ontario. The moraine has a typical interlobate character, much of it being composed of glacial till, but is extensively covered with sand and gravel in hills and terraces. Beds of stratified fine sand, silt and clay are also quite common indicating that large portions of the moraine were submerged during the latter stages of its deposition.

The first soil pit stop is located within this region, approximately 2 miles north of Ballantrae, off Highway 48, in the York Regional Forest.

SITE 12: GRAY BROWN LUVISOL AND EUTRIC BRUNISOL SOILS ON GLACIOFLUVIAL SANDS

The general area of the site is characterized by a hummocky glaciofluvial landform with strong slopes. The soil pit is situated in the upper slope position in the landscape with very gentle slopes in its immediate vicinity. The soil parent material is calcareous, uniformly sorted fine sand. There are few undrained depressions, streams or lakes in this landscape which is evidence for the permeable nature of the soil materials. The site occurs in the mild Mesic temperature region, humid to subhumid moisture regime. In terms of regional climate it is part of the Simcoe and Kawartha Lakes climatic region (Brown, et al., 1968). Some climatic characteristics of the region are given in Table 16.

In general, the winters in this region are cold and the summers warm. The growing season is long enough to permit the growth of most farm crops. The highest monthly precipitation occurs in July, and there is a very slight water deficit during the growing season (approximately 2.5cm).

The soil variability encountered over the landscape is apparent to a degree in the excavation at the site to be examined. Pedogenic development has given rise to pedons which exhibit properties of both Brunisolic Gray Brown Luvisol and Orthic Eutric Brunisol subgroups in close proximity to each other. Little change occurs in soil morphology as a function of slope. Parent material variability can be fairly significant across the landscape including fine sand, silt, gravel and even stony glacial till protruding through the fluvial material on some of the higher ridges.

Table 16. Climatic Characteristics of the Simcoe and Kawartha Lakes, South Slopes and Niagara Regions.

	Simcoe and Kawartha Lakes	South Slope	Niagara Fruit Belt
Mean Annual Precipitation (mm)	762-813	762-813	762-813
Mean Annual Temperature (C)	6.5	7.5	9
Mean Ann. Length of Growing Season (days)	195	205	210
Mean Ann. Frost-Free Period (days)	135	145	160
Mean Daily Max. Temp. for July (C)	26	27.5	26.7
Mean Daily Min. Temp. for Jan. (C)	-13	-10.5	-6.5

Soils: The dominant soil of the area has properties of the Brunisolic Gray Brown Luvisol subgroup of the Canadian taxonomic system, with lesser amounts of Orthic Eutric Brunisol subgroups. At this site they are referred to as Pedon 1 and Pedon 2, respectively. In the Soil Survey of York County, these soils were classified as the Pontypool soil series. They are well-drained to excessively drained sandy loam soils formed on calcareous, glaciofluvial sand parent materials, on irregular steeply sloping topography. The map unit bears the name of the dominant soil series and is symbolized Ps.

The characteristic feature of the site is the development of a soil profile of highly variable depth due to the tongued nature of the B horizon. The upper sola has been fairly uniformly weathered with the development of soil colors of high chroma attributed to the weathering of iron bearing minerals. The major difference in soil morphology within the site is the intermittent occurrence of the textural B horizon (Bt). It is most prominent in and adjacent to pedon 1, but is absent in, and surrounding, pedon 2. There is a significant increase in both silicate clay, and iron in the Bt horizon of pedon 1, but in contrast, the increase in iron content in pedon 2 occurs only in the upper B horizon (Bm1 and Bm2). There is no significant increase in clay in the B horizon of pedon 2. An explanation for the discontinuous nature of the textural B horizon at this site is not clearly evident. The parent material is reasonably uniform at the two pedons. Possibly a significantly higher silt content throughout the solum of pedon 1 compared to that in pedon 2 could contribute to greater differences in moisture tension, and possibly affect the precipitation and accumulation of clay in the B horizon. In contrast the internal drainage in pedon 2 could be more rapid causing a more uniformly dry moisture condition, and lesser illuviation of the mobile constituents in the B horizon.

Land Use: The Pontypool sandy loam soils are used for agricultural purposes in areas where the slopes are not excessively steep. The uses include general farming, dairying and some cash cropping. Crop production is limited by low fertility, low moisture holding capacity and susceptibility to wind erosion. Its agricultural capability rating is Class 4S for crops such as cereal grains, hay and pasture. Cash crops such as potatoes, peas, tomatoes and corn do well when the soil is heavily fertilized, however, intensive development of row crops must be discouraged because of the danger of erosion. In areas of irregular, steeply sloping topography which are common in this region, the agricultural capability is lowered to class 6T, being suitable only for permanent pasture use. In these areas, and where the soil is predominantly of sand texture and highly susceptible to wind erosion, reforestation of agricultural lands has been a common practice.

The original vegetation of the region was a mixed forest of pine and hardwoods. The valuable white pine have largely been depleted, and few trees of any size are left in the present woodlots. Among the hardwoods, sugar maple, beech and lesser amounts of basswood, white ash and red oak are most important.

The land capability classification for forestry of the area is $3M^{4}_{L}$ $4M^{4}_{L}$ $2M^{2}_{L}$ the limiting factors being soil moisture deficiency and nutritional problems associated with high levels of carbonates. Red pine and sugar maple are the indicator species adapted to the region and land.

Plantations of Red Pine such as in the York Regional Forest at Vivian are evidence of the effectiveness of reforestation practices on the Pontypool soils. Site productivity data for this plantation at an age of 50 years is given in Table 18. Tree height was measured at 22m. According to these measurements, the area is site class 1 (Ontario Department of Lands and Forests, 1960).

As a consequence of the virtual lack of lakes or rivers in the Oak Ridges Moraine, the area has a low capability for recreation, class $5P^{Q}_{O}$ and 6^{P}_{O}. However, the variety in topography of the moraine enhances opportunities for general outdoor recreation such as hiking and nature study or for aesthetic appreciation of the area.

T1 250 (417) RINGWOOD. The South Slopes physiographic region forms the
T10 80 (133) southern slope of the Oak Ridges moraine, and occurs along the tour route intermittently between Ballantrae, Richmond Hill and Maple. The region is a glacial till plain, ranging from areas of ground moraine with limited relief to drumlinized or fluted landforms with gently rolling topography. The plain is generally dissected with steep-sided valleys and

Table 17. Hardwood Woodlot Site Data in 1/20 Hectare Plot, York County Forest, Vivian

Number of Trees/ha

Diameter (DBH cm)	*Fangus grandifolia*	*Acer saccharum*	*Prunus serotina*	*Fraxinus americana*	*Quercus borealis*	*Tsuga canadensis*	Total
0-5	-	-	-	-	-	-	-
6-10	-	-	-	-	-	-	-
11-15	-	20	-	-	-	20	40
16-20	100	40	-	20	-	20	180
21-25	20	80	20	-	-	-	120
26-30	80	-	20	-	-	-	100
31-35	20	20	20	20	-	-	80
36-40	-	-	-	20	20	-	40
41-45	-	-	-	-	-	-	-
46-50	-	-	-	-	40	-	40
Total	220	160	60	60	60	40	600

Table 18. Red Pine Plantation Site Data in 1/20 Hectare Plot, York County Forest, Vivian (*Pinus resinosa*)

Diameter Class (DBH cm)	No. Trees/ha
0-5	-
6-10	-
11-15	100
16-20	20
21-25	200
26-30	260
31-35	140
Total	720

gullies carrying drainage to the south. The gullies are continually developing as a consequence of present day soil erosion, which is a critical problem in the region. The glacial till is medium to moderately fine in texture, calcareous and dominantly of shale and limestone composition. The soils are predominantly well and imperfectly drained with characteristics of the Gray Brown Luvisol Great Group.

T1 261 (435) RICHMOND HILL. Glacial lacustrine ponding of sediment between
T10 69 (115) the higher land of the interlobate moraine and the ice lobe in the Lake Ontario basin has given rise to a tract of fine textured soils referred to as the Peel Plain physiographic region. Along the tour route, it is encountered only briefly, southeast of Richmond Hill, and again west of Maple before reaching Highway 400.

The second soil pit stop is located within this region south of Richmond Hill on the property of the David Dunlap Observatory of the University of Toronto.

SITE 13: GRAY BROWN LUVISOL SOILS ON FINE TEXTURED LACUSTRINE VENEER OVERLYING GLACIAL TILL (CASHEL)

The Peel plain region is characterized as a fine-textured lacustrine veneer overlying glacial till, similar to that found in the South Slopes region. In the vicinity of the soil pit the fine-textured glacial till is most evident with possibly a thin smear of lacustrine material on the surface. In general, the deposit is calcareous. silty clay in texture, and contains significant quantities of red and gray Paleozoic shale. The landform is an undulating (veneered) glacial till plain with very gentle slopes. Streams have cut deep valleys in the plain with drainage being to the south to Lake Ontario.

The site occurs in the mild Mesic temperature region, humid to subhumid moisture regime. In terms of regional climate it is part of the South Slopes climatic region (Brown _et al_., 1968). Some climatic characteristics of the region are given in Table 18.

As a consequence of the dissected landform, surface drainage is fairly well established, and there is a dominance of well and moderately well drained soils in the landscape. However, due to the fine texture of the deposit, imperfectly drained soils are common in the inter-stream areas, and poorly drained soils in the channel bottoms. The soils belong to the Cashel catena and are classified as Orthic Gray Brown Luvisols, Gleyed Gray Brown Luvisols and Orthic Humic Gleysols, respectively, in the Canadian taxonomic system.

Soils: The predominant soil exposed in the pit site has properties of the Orthic Gray Brown Luvisol subgroup of the Canadian taxonomic system. In the Soil Survey of York County, this soil is classified as the Cashel series, and bears the map unit symbol CaC. It is moderately well drained and has developed on calcareous lacustrine clay underlain by glacial till (Hoffman and Richards, 1955). Soil erosion also may be a contributing cause, although there is little evidence of this occurring during recent times. The Bt horizons has a large increase in clay compared to that of the AB horizon, and its distribution in voids, channels and along ped faces is suggestive of an illuvial origin. There is not a corresponding increase, however, in illuvial iron and aluminum in the

Bt horizons which normally would be expected. There is some evidence to support the hypothesis that the glacial till parent material has been modified with a shallow lacustrine veneer, as is generally the case in this physiographic region. Little gravel-sized material occurs in the upper solum, but it gradually increases in content with depth. Also, the color and structural difference between the upper and lower Bt horizons may represent a lithological change.

It is considered that the slow internal drainage and textural uniformity of the deposit, and the general regularity of the land surface all have contributed to the uniformity in pedological development exhibited at this site.

Land Use: Cashel soils are used for dairying and general farming. They are well suited to the production of corn, cereal grains, legumes, hay and pasture. Where the topography is level to very gently sloping they have no significant limitations to crop production, and are rated as capability Class 1 for agriculture. On steeper slopes, topographic limitations and susceptibility to erosion tend to lower this capability rating.

Unfortunately these high quality agricultural soils are under effects of the "urban shadow", situated as they are close to the city of Toronto. Thus large acreages have been removed from active agricultural use in recent years for hobby farms, rural estates, urban and industrial uses. This trend is likely to continue.

Although these soils now are almost completely deforested they supported a hardwood forest of high quality. On the better drained soils sugar maple, beech, white oak, hickory, basswood and some white pine were common, while the depressional areas carried elm, white ash, and white cedar. The capability classification for forestry of the area in which the site is situated is

$1^{4}\overset{3}{\underset{W}{2D}}\;2^{2}_{D}$ with red pine and hard maple as the indicator species for the drier

sites, and white spruce and soft maple on moist sites. The class 2 soils have slight limitations due to permeability or physical limitations to rooting depth, as well as excess soil moisture. Because of competition for land in this region, forestry uses are likely to be confined to relatively small regions that are unsuitable for other uses, or to regions where forest cover enhances farm, estate or recreational values.

Recreational uses of land in this area are minimal because of the lack of continuous streams, lakes, or a variety in topography.

Much of the area lacks a suitable habitat for wildlife. The land capability for ungulates (deer) is high because of the capacity of the soil to provide food and cover, however, deer populations are low as a consequence of the intensive agricultural land use and urbanization. In contrast, both the land capability and population of waterfowl are low because of the flatness of the topography limiting development of wetlands.

After leaving the soil pit site at the David Dunlap Observatory, the tour proceeds through the town of Richmond Hill on Highway 11, and then westward on Major Mackenzie Drive towards Maple.

T1 265 (442) MAPLE. Extensive coarse aggregate deposits in the Oak Ridges
T10 65 (108) moraine are evident along the route on the eastern outskirts of Maple where mining operations are taking place.

West of Maple, the typical level to very gently sloping landscapes of the Peel plain is encountered briefly before passing once more over the South Slopes and Oak Ridges Moraine regions as the tour proceeds north on Highway 400.

T1 277 (462) Along the northern slopes of the Oak Ridges moraine, deep deposits
T10 53 (88) of stratified clay and silt have been laid down in basins in the Schomberg clay plain physiographic region. In general, the rolling relief of the underlying till plain has not been completely eliminated thus undulating to gently sloping landscapes are common, and even some rough topography exists where dissection has occurred.

T1 282 (470) HOLLAND MARSH. As the route leaves Highway 400 and travels
T10 48 (90) westward on Highway 9 it crosses through the Lake Simcoe basin, a broad valley extending southward from Lake Simcoe (Chapman and Putnam, 1973). At one time the valley was a shallow extension of the lake which has developed into a marsh of approximately 20 000 acres through which the Holland River meanders to Lake Simcoe. The vegetation in the central portion of the marsh consisted of sedges and reeds, whereas a swamp forest largely of white cedar developed along the margins. Most of the marsh has now been cleared of vegetation, drainage established and developed for market garden agriculture. Crops of onions, lettuce, celery, carrots, spinach, potatoes and other vegetables have transformed the marsh into a prosperous farming and trading center, and the location of numerous vegetable storage and packaging plants.

The soils of the marsh are mainly classified in the Organic Order of the Canadian taxonomic system, as Humisol and Mesisol Great Groups. Although Typic, Humic and Mesic subgroups do occur, the majority are relatively shallow and constitute Terric subgroups. Subsidence and loss of organic material through wind erosion have contributed to a shrinkage rate slightly in excess of 2.5 cm/year, which continuously increases the area of shallow soils in the marsh. The soil capability classification of the organic soils range from class 1 to 7 with major limitations being shallowness of the organic soil and the high pH of the mineral substratum (Hoffman and Acton, 1974).

T1 288 (480) MONO MILLS. A section of the Oak Ridges interlobate moraine is
T10 42 (70) encountered again along Highway 9 westward to Mono Mills. At Mono Mills the route crosses the Niagara escarpment. In this vicinity the typical rock exposures of the escarpment are almost completely obscured by hummocky, bouldery ridges, and deposits of sand and gravel of the interlobate moraine.

T1 302 (503) HORSESHOE MORAINE. Flanking the highest part of the Niagara
T10 28 (47) Escarpment on the west is a horseshoe shaped region (Horseshoe moraines) consisting of irregular, complex landscapes of glacial till and kame deposits, as well as old spillway channels with broad sand and gravel terraces and swampy valley floors. At Orangeville the latter physiographic features are well expressed. The spillway channel developed during the recession of the Wisconsin glacier at the time of the first split in the ice lobes which occurred in this vicinity. In a number of areas, post-glacial dissection has

deepened the channels leaving abandoned alluvial terraces often as much as 30m above the valley bottoms. This drainage network forms the headwaters of the Nottawasaga and Credit Rivers which rise in the Orangeville area.

T1 325 (542) ORANGEVILLE. Along the tour route between Orangeville and
T10 5 (8) Bellwood the Hillsburgh Sand Hills physiographic region is briefly encountered. This was the first land to appear as the glacier melted in Ontario. The region is characterized by the rough topography of a kame moraine, fine sandy materials and swampy valleys. The sandy deposit overlies coarse stony glacial till, but in most cases the overburden is of sufficient depth that the till has little or no effect on soil development.

T1 330 (550) FERGUS. Smoother and more regularly sloping land of the Guelph
T10 0 (0) drumlin field occurs in the vicinity of Fergus and southward to Guelph. Within this area are approximately 300 drumlins of all sizes, in general being smaller and less steep than those of the Peterborough drumlin field. They have originated as a result of an ice thrust from the western end of the Lake Ontario Basin. During retreat of the glacial ice, drainage of the ice front developed in valleys approximately at right angles to the trend of the drumlins themselves. Therefore, the landscape consists of alluvial sand or gravel terraces fringing the drumlins, separated by inter-connecting cross-valleys presently with swampy vegetation. The glacial till comprising the drumlins is loamy in texture and calcareous, derived mainly from dolomitic bedrock exposed along the Niagara escarpment and fragments of red shale, which outcrop at the escarpment base.

The soils developed on both glacial till and glaciofluvial outwash materials have characteristics of the Gray Brown Luvisol Great Group. They are good soils for general agricultural crops, as evidenced by their capability rating of 1 and 2S.

Enroute from Fergus to Guelph, the tour route departs from Highway 6 to pass through the Elora Research Station of the Ontario Ministry of Agriculture and Food, managed under contract by the University of Guelph for field research studies. The station contains 970 acres (388 ha) of land largely for experimental use including research relating to field crops, soils and agrometeorology, beef and dairy cattle.

The tour concludes for the day at Guelph, "the Royal City", situated in the heart of Ontario's industrial, commercial and agricultural zone.

TOUR 1 DAY 9: GUELPH TO NIAGARA TO TORONTO
TOUR 10 DAY 2: TORONTO TO NIAGARA TO TORONTO

T1 0 (0) GUELPH. The city of Guelph spreads over the rolling countryside
T10 176 (280) of the Guelph drumlin field. Surrounding the drumlinoid hills are extensive gravel terraces deposited in two large glacial spillways, the forerunners of the Speed and Eramosa rivers, which have their confluence near the heart of the city. These landforms can be observed as the tour proceeds southward from the city on Highway 6.

T1 3 (5) PARIS AND GALT MORAINES. A few miles south of Guelph, the ir-
T10 173 (275) regular, hummocky, stony landscape of the Paris and Galt moraines are encountered. These moraines form a parallel set of hummocky

ridges, and comprise the eastern flank of the Horseshoe moraines. They are of the recessional type, containing kettles and kames, formed by the retreating Lake Ontario ice-lobe.

The soil material comprising the moraine is a calcareous, stony loam glacial till, which develops characteristics of the Gray Brown Luvisol great group. Agricultural use in the region is definitely limited as a consequence of topographic (T) and stoniness (P) factors, as well as associated soil factors (S) related to soil moisture and fertility deficiencies. The generalized capability rating for agriculture is $3^{5}_{S}\ 5T^{5}_{P}$.

T1 13 (21) FREELTON. Immediately south of the village of Freelton the
T10 163 (259) Flamborough plain physiographic region is encountered. Generally it is a region of thinly covered bedrock with many limestone outcroppings. What little overburden there is, apart from a few drumlins, is either bouldery glacial till or outwash sands and gravels. Swamps are plentiful, primarily carrying a good stand of cedar vegetation.

Soils in the region consist predominantly of Gray Brown Luvisols in the better drained landscapes, and Humic Gleysols or Organics in the depressions or swampy sites. Their agricultural capability ranges from class 2 to 4, with soil moisture (M), fertility (F), slope (T), shallowness to bedrock (R) and wetness (W) limitations.

The Flamborough plain grades into the Norfolk sand plain region on its southern extremity (Chapman and Putnam, 1973), where deltaic sands and silts of glacial Lake Warren become deeper over the Paleozoic bedrock. These soils too have characteristics of the Gray Brown Luvisol great group. Their agricultural capability is Class 4, primarily due to topographic (T) and moisture (M) limitations as a consequence of their moderate slopes and coarse textures. However, these soils are being increasingly utilized for more specialized crops like sweet corn, tomatoes, strawberries, and even tree fruits. Sprinkler irrigation is being used in some localities to overcome the soil moisture limitation experienced in these soils.

T1 20 (33) CLAPPISON'S CORNERS. Lying immediately above the Niagara escarp-
T10 156 (247) ment in vicinity of Clappison's Corners along the tour route is a narrow belt of fine textured soils in the Haldimand Clay Plain. It is encountered again where the tour travels along the escarpment edge from Stoney Creek to Grimsby.

The material is a shaly till derived largely from the red and grey shale beds below the escarpment. Although the landform tends to be morainic, the ridges have a subdued relief due to having been built under water. Intervening troughs in the landscape are commonly floored with lacustrine silt or clay.

The outstanding characteristic of this region are the soils of heavy texture and variable drainage. Where the landform is undulating or sloping and surface drainage established, soils of the Gray Brown Luvisol great group occur. Otherwise, where the topography is more uniformly level, Humic Gleysols are the dominant soils. The agricultural capability throughout the region includes

Class 2 soils with moderate structural (D) limitations, and Class 3 soils where topography (T), structure (D) and excessive wetness (W) present problems in agricultural use.

T1 22 (37)
T10 154 (243) NIAGARA ESCARPMENT. The tour route crosses the Niagara escarpment at this point. The escarpment stands out boldly in this region, separating the two levels of the Niagara Peninsula. In general, the base follows the 350 ft (115 m) contour, while the top of the cliff reaches the 625 ft (205 m) level. Vertical cliffs along the brow expose the Silurian dolomite formations underlain by sandstone of the Medina-Cataract group. The lower slopes are carved in Ordovician red shale of the Queenston formation.

Agricultural use along the escarpment has been largely inhibited due to the steep slopes and shallow, rocky soil. Nonetheless, during the pioneer stages of settlement some lands were cleared and cropped. The clay soils were easily eroded and badly gullied land is the consequence. In contrast, the escarpment has some gentle slopes and terraces, which are successfully used for vineyards in this region.

Some sections of the escarpment have been largely urbanized due to the highly attractive building sites it affords. Also, throughout the history of settlement the rocks of the escarpment have served as a source of building material including cut stone, lime, shale for the making of brick, and more recently for enormous quantities of crushed limestone. In spite of the obvious exploitation of the valuable resources of the escarpment which has occurred in some areas, attention has been given to resource conservation and the provision of recreational facilities throughout the region. Both public and private parks provide facilities for picnics, swimming, camping, hiking and skiing. A fairly recent development, the Bruce Trail, provides a continuous foot path along the brow of the escarpment from the Niagara River to Tobermory at the northern tip of the Bruce peninsula, a distance of 430 miles (692km).

The recreational attributes of the escarpment are enhanced by the almost continuous and varied forest cover which occurs throughout this physiographic region. Because of its limited agricultural potential much of the natural hardwood forest remains. Other areas have been reforested principally on abandoned farm land. The soil capability for forestry throughout much of the escarpment in this area is $1^{5}2^{4}{}_{D_{W}}5^{1}{}_{R}$ with limitations being due to physical restrictions to rooting by dense subsoil (D), excessive wetness (W) and restriction of rooting zone by bedrock (R).

T1 23 (40)
T10 153 (240) IROQUOIS PLAIN. At the base of the escarpment lies the Iroquois plain physiographic region (Chapman and Putnam, 1973). It is the lowland extending around the western part of Lake Ontario, and is first encountered on the tour approximately where Highway 6 and 403 intersect, north of the city of Hamilton. The Queen Elizabeth Way traverses through the heart of this region, which the tour will follow enroute to Niagara Falls.

The deposits of the Iroquois plain are associated with glacial Lake Iroquois which existed during late Pleistocene times when the St. Lawrence river was ice-blocked, and the escarpment formed the lake shoreline. The underlying deposits largely consist of weathered red Queenston shale which is overlain by lenses of clay till and lacustrine sand. Although the beds of sand overlying the clay are never very deep, the soils have proven to be well suited to the production of tender fruit crops. It is this combination of soils and favourable climate which has enabled the Niagara fruit belt to attain a place of unique importance with regards to Ontario's food producing capability.

The tour route departs from the Queen Elizabeth Way at Stoney Creek and ascends the escarpment enroute to the first stop, which provides an opportunity to view the general pattern of land use throughout the lowlands region.

T1 41 (70)
T10 135 (210) NIAGARA FRUITLANDS AREA. The Regional Municipality of Niagara is a very historic area. It became one of the first Regional municipalities in the province when established in 1970. More than twenty cities, towns, villages and townships of the counties of Lincoln and Welland are merged into twelve local municipalities. One of the twelve, Niagara-on-the-Lake, fittingly enough was in 1872 the site of the first parliament for Upper Cánada.

With such a lengthy history, Niagara was settled rather early. Many early settlers were of British origin connected with the Militia. Others, of British, German and Dutch extraction settled here in the 1770's as a result of the American War of Independence. The original farming was very general in nature with field crops, livestock, fruits and vegetables. Because of the ideal climate afforded by the proximity to Lake Ontario it was possible to grow "tender" fruits. Mennonite families moving from the Pennsylvania Dutch settlements spurred on the development of the fruit industry. By the turn of the Twentieth Century a commercial fruit industry was developing. Fruit was shipped by rail and water to the urban centres of Toronto and Montreal. Following the first world war many people from eastern Europe migrated to Canada working first in the Northern forests and mines. Gathering some savings they moved to Niagara to undertake fruit growing. More Mennonites moved into the Vineland and Virgil areas having suffered poorly in the dirty thirties in Western Canada.

Some of the original families were good farmers and retained their holdings, others were tempted by the opportunity to live from the sale of part of their land. There was little control on the severing of hundred acre (40 ha) farms into several parcels with 20 to 25 acres (8 to 10 ha) becoming a typical fruit farm. It was a size the beginner could afford and the vendor still had land to farm as well as money in the bank.

As the small holdings became more numerous, industrial wages in St. Catharines and Hamilton became more attractive and the automobile became affordable by all, the part time farmer became a major part of the Niagara scene. The willing worker is able to operate a small scale fruit or grain farm and work in a plant. Once the mortgage is lifted a pension and farm income provide a pleasant life.

With the post-war boom the cities of Hamilton and St. Catharines spread out onto the fruitlands for industrial, commercial and residential development. The smaller towns, not be outdone, allowed subdivisions and strip residential areas to spring up along the roadways. Needless to say problems arose requiring sewer and water systems which soon became overtaxed. Residential lots became so costly that increased demand for small country holdings continues to the present day.

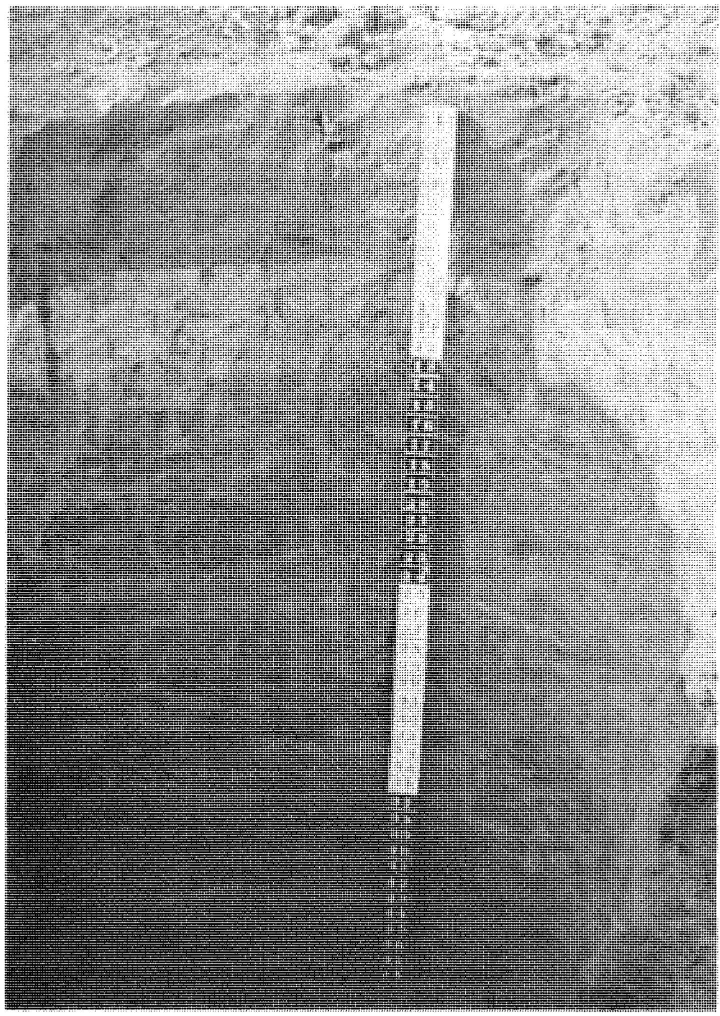


FIG. 36 THE VINELAND SOIL, AN ORTHIC LUVIC GLEYSOL

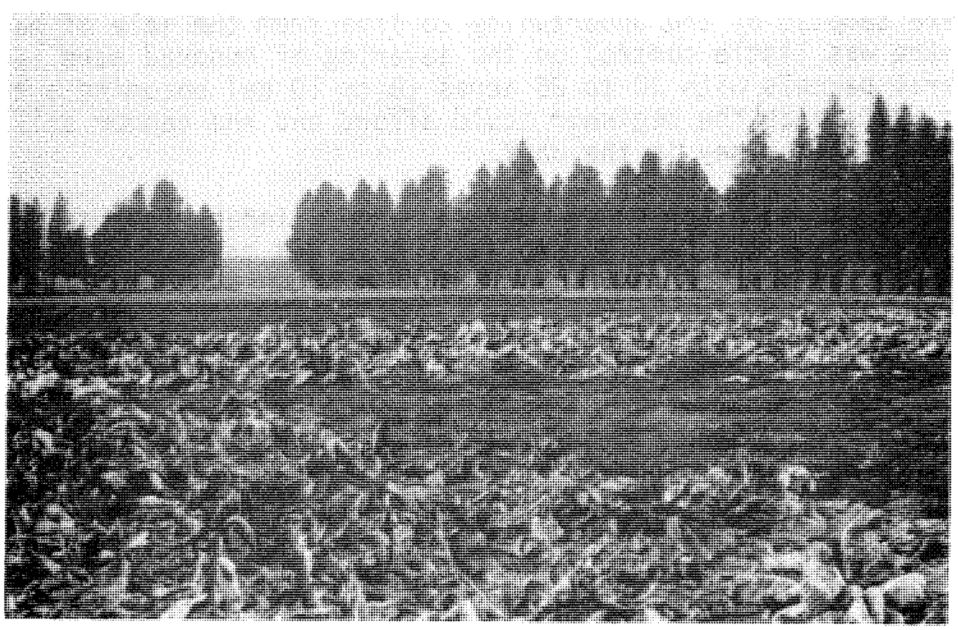


FIG. 37 THE LEVEL LANDSCAPE OF VINELAND SOIL

Agricultural Land Use: Because of the generally small size of the farms, those who continued to farm on a full-time basis have developed very intensive operations. Fruit growers use close spacings of trees and vines, vegetable growers double crop and a sizeable greenhouse industry (flowers and vegetables) has developed. Others have specialized in broiler chickens, turkeys, laying hens or hog production. Most of these small holdings depend on purchased inputs. Dairying remains the backbone of farming south of the escarpment, as the clay plain is not well suited to long term cash grain production on a commercial basis.

The approximate figures given in Table 19 give an indication of the varied and productive agriculture in the Niagara region.

Land Use Conflicts: Naturally enough, small holdings do not allow substantial setback distances from roadways, lot lines or neighbouring residences. Livestock barns and greenhouses have been a source of aggravation between the operator and the neighbouring rural resident. Most of the conflicts have been between farmers and non-farm residents, but a few fruit growers and livestock or greenhouse operators have exchanged words. Recently, by-laws have been changed in many municipalities to require set-back distances as calculated by Ontario's "Agricultural Code of Practice".

The figures shown in Table 20 indicate the shrinking base of the tender fruit land in the Niagara region. There has been some exchange in land used for tree fruits and grapes, but a major portion of the new grape acreage formerly grew field crops. When the loss of most of the tender fruit land from the adjoining Hamilton-Wentworth municipality was added, the change in fruit land acreage is quite dramatic. This concern has been the subject of considerable debate between the fruit land preservationists and development oriented spokesmen. Many fruit growers are caught in the middle of the debate. They wish to maintain the valuable fruitland resource, but only if a viable fruit industry can be maintained. With the decreasing land base and imported canned fruits readily available, the tender fruit industry has tended to divide. The fresh fruit portion has continued to do well, but the processing of fruit in general has declined. However, the processing of grapes, which is the largest processing sector, has expanded. Efforts have been made through provincial programs to encourage the planting of processing peaches and French Hybrid grapes. Hopefully incentives for the industry and growers alike will provide the viability to make preservation of the fruit land an attractive goal for all growers. With good planning and adequate markets it is felt that a significant agricultural industry in the Niagara region can be maintained for years to come.

After leaving the Niagara region look-out stop, the tour continues eastward along Regional Road 25 to Grimsby where it again rejoins the Queen Elizabeth Way enroute to Vineland, the headquarters of the Horticultural Research Institute of Ontario.

T1 61 (101) VINELAND. The research institute, first established in 1906, is
T10 115 (179) presently operated by the Ontario Ministry of Agriculture and Food for research with fruit crops, vegetables and ornamental plants. Also a part of the Vineland Station is the Horticultural Products Laboratory, which has made significant contributions in the area of food processing, wine making and new product development.

Table 19. Agricultural Production in the Niagara Region

Commodity	Approximate Value ($ Million)
Grapes	15
Tender Fruits	15
Vegetables	3
Greenhouse Flowers	32
Poultry meats	33
Eggs	5½
Milk	14
Beef	3
Hogs	7
Sod Production	1
Cash Grains	2½

Table 20. Changing areas in the Niagara Region between 1951-71 (hectares)

	Total	Tree Fruit	Grapes
1951	17 600	10 800	6 800
1971	16 480	8 480	8 000
Change	-1 120	-2 320	+1 200

During the stop, tour leaders will discuss the scope of the research been conducted at the research station. Also, an opportunity will be given to examine two soils common to the Niagara region. A noon-hour lunch also will be provided during the course of this stop.

SITE 14: GLEYED GRAY BROWN LUVISOL ON DELTAIC SANDS (VINELAND)

The site is situated in the Iroquois plain physiographic region on a nearly level to very gently sloping lacustrine plain. The soil parent material consists of calcareous, stratified loamy very fine sand and very fine sandy loam, underlain by occasional lenses of silty clay. Lacustrine clay is to be expected at depths greater than the excavation at this site, which is again underlain by reddish clay glacial till.

There is some variation in the depth of the sandy overburden, as a consequence of erosion as well as dissection of the landscape. In general, the depth of sand varies from 2 to 8 ft (0.5 to 2.5 m), the variability being greatest where the sand merges with the clay plain. The deep gullies and stream channels that traverse this area are cut into the clay sediments below the sand. The characteristics of the soil profile are fairly uniform from place to place within the entire plains area.

The dominant soils are represented at this site with some moderately well and moderately poorly drained catenary members also occurring in the landscape.

From a climatic standpoint, this is one of the most favoured regions in Ontario. It is in the mild to moderately warm Mesic temperature region, humid to subhumid soil moisture regime. In terms of regional climate it is part of the Niagara Fruit Belt climatic region (Brown et al., 1968). Some climatic characteristics of the region are given in Table 16.

The climate of the Niagara Peninsula is uniquely mild for an area so far north; the temperature being moderated by the Great Lakes, particularly Lake Ontario. The lowest temperature recorded in 60 years of records at Vineland was -27 C (-16 F) in 1918. In only 5 of those years has the temperature dropped below -23 C (-10 F). A winter low of -18 C (0 C) is common at Vineland. These minimums are higher than anywhere else in Ontario and even higher than places further south which are away from the moderating influence of the Great Lakes.

Soils: The dominant soils are classified in the Orthic Luvic Gleysol and Gleyed Gray Brown Luvisol subgroups of the Canadian taxonomic system. In the soil survey of Lincoln county, imperfectly drained soils developed on medium and fine sand parent materials are classified as the Vineland soil series (Wicklund and Matthews, 1963), and symbolized on the soil map as Vfsl.

In the United States system of soil classification corresponding subgroups are Typic Hapludalfs. Gleyic Luvisols are the nearest equivalents in the FAO system of soil classification.

A striking feature of the soil exposed at this site is its reddish color, which is unique when compared with sands that occur elsewhere in the province. The sands are believed to have originated from the red sandstones of the Grimsby formation primarily from erosion of bedrock exposed along the escarpment, and deposition in the deltaic environment of Lake Iroquois. The sand grains appear to be coated with hematite and are thoroughly sorted into a grade of very fine sand.

The reddish hue of the soil parent material tends to mask horizon development to a fairly large extent, particularly throughout the subsoil horizons. However, a significant clay increase occurs in the Btg horizon and is accompanied by a slightly stronger grade of structural development than the underlying horizons. There is a corresponding slight increase in free iron (oxalate extractable) in the Btg horizon in comparison to the horizons above and below.

A prominent characteristic of the soil is its mottling, a condition that is present throughout the entire soil profile. The intensity of mottling is most noticeable in the upper horizons where the hue of the soil is less red than it is at greater depths. It is indicative of a high but fluctuating water-table. Undoubtedly the fine-textured layers in the IICkg horizon and the till sediments which underlie the sands in this region contribute to this imperfect drainage condition, as a consequence of their compactness and impermeability acting as a barrier to water movement.

Land Use: In general the best orchards in the Niagara Fruit Belt are found where the depth of sandy soil exceeds 75 cm. The Vineland soils are by far the most important soils for peach and cherry production, provided they are tile drained, as these tree fruits cannot withstand poor drainage conditions. As the sand in the A horizon is very fine, it behaves more like a silt loam in terms of its water holding capacity. The available water held in the top 75 cm is approximately 18 cm. In most years irrigation is not needed for peach or cherry production on these soils.

The climatic characteristics of this region also are favourable for the growth of these tender fruit crops.

The lowest temperature that fruit buds can withstand depends on a number of factors including conditions before being subjected to low temperatures, the rate of temperature change, species, variety, etc. In general peaches are more sensitive than other tender fruit crops.

A minimum temperature of -25 C (-13 F) or lower, at the time of maximum hardiness will result in peach fruit bud damage and with many varieties complete loss of crop. Even more important than loss of crop is loss of trees from winter injury. Loss occurs not only from cold injury but also from peach canker, a disease which will move into dead and injured tissue.

A critical period in fruit crop production is bloom period. Bloom normally does not occur with most tree fruits in the Niagara Peninsula until mid May. Air close to the lake is slow to warm because of the large body of cold water which warms much slower in spring than the land. Cool breezes from the lake in spring retard fruit bud development. The chance of frost at bloom time is greater in most other parts of North America even as far south as Georgia because bloom occurs earlier than in the Niagara Peninsula and temperature extremes at bloom time are greater.

The area below the escarpment slopes gently to Lake Ontario. This slope frequently is sufficient to provide good air drainage and prevent frost damage.

From a climatic standpoint the Niagara Peninsula is better adapted to fruit production than any other in Ontario and this is the main reason the industry is here.

After leaving the soil pit stop on the Victoria farm, the tour proceeds southward along Niagara Region Road 24 to Claus Rd., west to Cherry Ave. to the Rittenhouse farm, the location of the second soil pit.

SITE 15: HUMIC LUVIC GLEYSOL ON TILL (TRAFALGAR)

The most distinctive and extensive surficial deposit in the Iroquois plain region is the reddish-coloured silty clay loam to silty clay glacial till. This material is similar in color and consistency to the underlying Queenston shale from which it is derived. The deposits may have been initially deposited as lake-laid sediments, but subsequent glacial advances from the Lake Ontario basin have incorporated rock fragments with the clay, as well as leaving behind a very gently sloping to gently undulating till plain landform. The parent materials contain, in certain areas, high quantities of silt, and in other locations less silt and higher quantities of clay. The soil texture ranges therefore from silty clay loam to heavy clay.

The soils at this site are largely imperfectly drained. On these materials the internal drainage is slow and the external drainage or runoff is slight. Tile drains have been installed in most of these soils to provide adequate drainage for the growth of horticultural crops.

Moderately poorly and poorly drained soils also occur in these landscapes, in slightly depressional sites that have more surface water accumulation. They differ little in their morphological characteristics from the better drained catenary members, exhibiting pronounced reddish colors and little profile development. Their surface texture, however, does tend to be somewhat finer, more commonly being a clay.

Often in the upper portion of the landscape a shallow layer of sand will occur overlying the reddish silty clay till.

Soils: The dominant soil at this site is classified as a Humic Luvic Gleysol in the Canadian taxonomic system. The closest equivalent in the United States soil taxonomy is the Argiaquic Argialboll subgroup. In the FAO system, the Gleyic Phaeozem is the closest counterpart at the great group category.

In the Soil Survey of Lincoln County (Wicklund and Matthews, 1963) these soils are referred to as the Trafalgar soil series, bearing the soil map symbol TSICL.

Land Use: These soils have many limitations in their use for agricultural crops. Their most serious limitation are attributed to the drainage condition and undesirable structure. After a tile system has been installed and organic matter added to ameliorate soil structure they have been subject to intensive agricultural use. Historically, they have been devoted to the production of

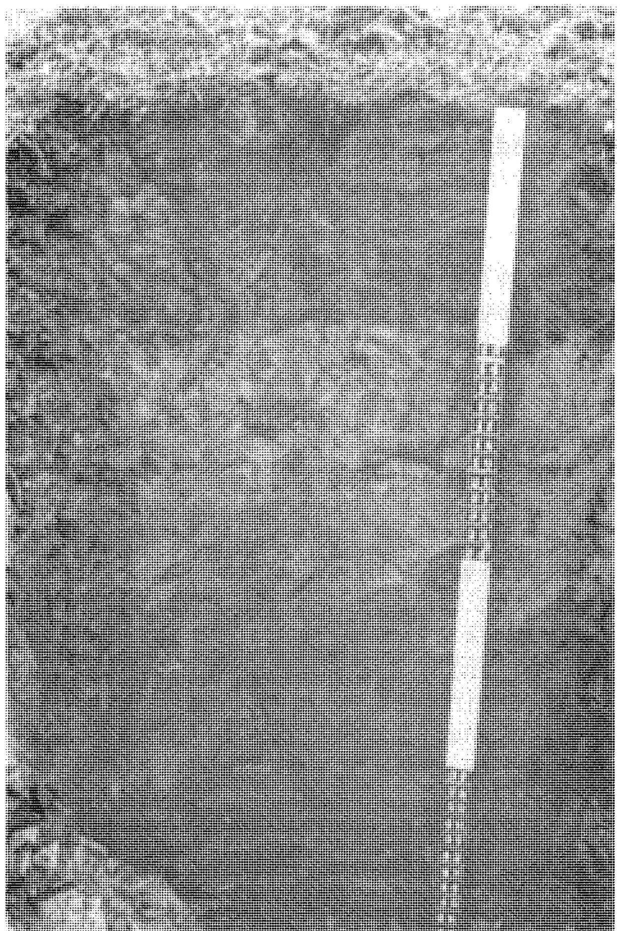


FIG. 38 THE TRAFALGAR SOIL, A HUMIC LUVIC GLEYSOL

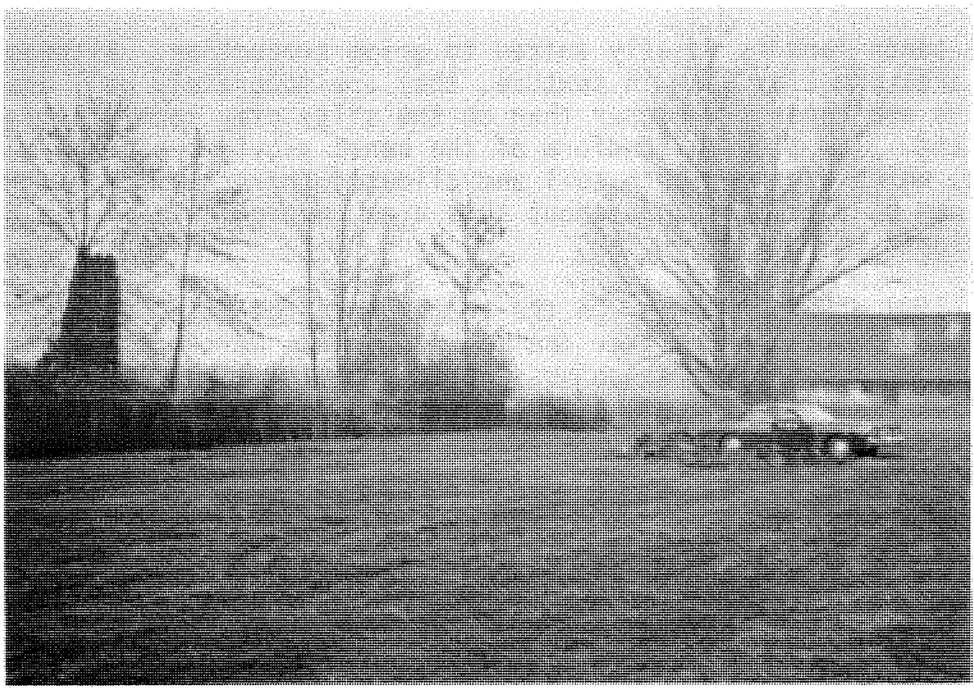


FIG. 39 THE LEVEL LANDSCAPE OF TRAFALGAR SOIL

grapes, pears and plums because these crops will withstand these soil conditions although growth and yields are frequently low.

There are numerous examples of abandoned vineyards and orchards on these soils where crop management has declined and production fallen to uneconomic levels. Many of these have become the target of urban expansion in the region, particularly if they occur adjacent to existing centers of development.

The tour route continues eastward on the Queen Elizabeth Way after leaving the Horticultural Research Institute at Vineland. At the Jordan exit the route proceeds southward to Niagara Regional Road 81.

T1 66 (110) At this point the route ascends onto the first bench of the
T10 110 (170) Niagara Escarpment and travels east towards St. Catharines.

The bench land is ideally suited to grape production. Although the soil in this area are clay loam in texture, they are moderately well drained, and the yields are generally higher than on the silty clay loam and clay soils in the lowland. The sloping landform of the bench provides air and surface water drainage, which enhances both soil and climatic characteristics. However, soil erosion can be a problem throughout this area particularly on the moderate to strong slopes.

T1 80 (133) WELLAND CANAL. On the eastern edge of St. Catharines the tour
T10 96 (147) route passes over the Welland Canal, part of the inland waterway which allow ocean vessels to proceed approximately 2340 miles (3767 km) inland from the Atlantic Ocean to the Canadian and U.S. Lakehead. This vast waterway, including its locks, bridges, gates and channels is operated and maintained in Canada by the St. Lawrence Seaway Authority.

The present Welland Canal was completed in 1932. It consists of eight locks in a distance of 26 miles (42 km) which lift vessels some 326 ft. (99 m) to the level of Lake Erie, thus overcoming the obstacle of the Niagara escarpment. The average transit time of vessels through the Canal is twelve hours.

T1 88 (147) ST. CATHERINES. A stop will be made at Brights Wines for a tour
T10 88 (133) of their vineyards, and to hear a discussion of soil and climatic conditions relating to grape production. The tour here will be concluded with an opportunity to taste some of Brights Fine Canadian Wines.

T1 104 (173) NIAGARA FALLS. The tour route will pass through Niagara-on-the-
T10 72 (107) Lake and along the River Road to Niagara Falls, one of the most majestic wonders of the world. The tour will stop here for a sight-seeing opportunity. Tour guides will join the buses to provide details about the Niagara River and its famous Falls, as well as the historical background of the region.

After the sight-seeing tour, the buses will travel non-stop to Toronto where overnight accommodation has been arranged. The tour officially ends here.

T1 176 (280) TORONTO. Toronto, the capital of Ontario, is Canada's second
T10 0 (0) largest city with a population in excess of 2.2 million. It is

a major Canadian commercial, manufacturing and financial center, and the busiest Canadian port of the Great Lakes.

About 60 percent of Toronto residents are of British origin, with the balance made up of small nationality groups mostly of European descent. It is truly a cosmopolitan city with a strong blending of peoples of various ethnic groups.

In terms of its early history, the Seneca, a tribe of Iroquois lived in a village on the site during the 1600's. Its present name was derived from this period, meaning "place of meeting" attributed to two important Indian trails crossing at this site about 300 years ago. The French established a mission, trading post and fort here in the 1700's, which was subsequently abandoned. Later in the century, in 1793 settlement took place as the site was chosen as the capital of Upper Canada (present-day Ontario), and was named York. It was renamed Toronto in 1834, when it received its city charter.

TOUR 1 DAY 10: TORONTO TO EDMONTON
TOUR 10 DAY 1: EDMONTON TO TORONTO

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APPENDIX A THE CANADIAN SYSTEM OF SOIL CLASSIFICATION

Soils are classified in Canada according to a hierarchical system developed by the Canada Soil Survey Committee. Classes in all of the five categories: order, great group, subgroup, family and series, are based upon observable or measurable soil properties. Diagnostic properties at high categorical levels reflect soil genesis and hence the environmental factors that influence soil genesis. The 9 soil orders, arranged alphabetically, are defined in brief, general terms and the great groups are listed.

Brunisolic order - Soils having genetic horizons but lacking the horizons diagnostic of other orders. They occur dominantly in subhumid to humid forested regions and they usually have brown B horizons. Great groups are: Melanic Brunisol - has a mineral-organic surface horizon (Ah) and is not strongly acid; Eutric Brunisol - lacks a well defined Ah and is not strongly acid; Sombric Brunisol - has an Ah and is strongly acid; Dystric Brunisol - lacks a well-developed Ah and is strongly acid.

Chernozemic order - Soils of the grasslands; they have a well-developed base-rich, mineral-organic surface horizon (Ah). The four great groups are based upon color of the surface horizon which reflects soil climate: Brown, Dark Brown, Black and Dark Gray.

Cryosolic order - Soils of the permafrost zone that includes about 1/3 of Canada; they may be composed of either mineral or organic material having permafrost near the surface (1 to 2m). There are three great groups: Turbic Cryosol - strongly cryoturbated mineral soils as indicated by microrelief or by mixed horizons; Static Cryosol - mineral soils that are not strongly cryoturbated; organic material having permafrost within 1 m.

Gleysolic order - Soils having drab colors, prominent mottling or other features resulting from periodic or permanent high water table and reduction. They occur commonly in depressions and level areas that either receive runoff water or are groundwater discharge areas. There are three great groups: Humic Gleysol - well-developed mineral-organic surface horizon (Ah); Gleysol - lacks a well-developed Ah; Luvic Gleysol - has a B horizon (Btg) of significant clay accumulation.

Luvisolic order - Soils usually in forested regions, in which leaching has resulted in significant translocation of clay from the A to the B horizon (Bt). Usually they have a light gray eluvial horizon (Ae). The great groups are: Gray Brown Luvisol - mild soil climate and forest mull Ah; Gray Luvisol - cold to cool soil climate with usually less than 5 cm Ah.

Organic order - Soils composed dominantly of organic materials (more than 17% organic carbon) of the required thickness (usually 60 cm for fibric materials and 40 cm for others). Great groups are: Fibrisol - mainly fibres that are not decomposed; Mesisol - more decomposed than Fibrisol; Humisol - highly decomposed, few fibres; Folisol - composed mainly of thick leaf litter over rock.

Podzolic order - Acid soils developed under forest and heath; they have a B horizon enriched in humified organic matter and Al and Fe weathering products, usually underlying a light gray, weathered Ae horizon. Great groups are: Humic

Podzol - B depleted of Fe; Ferro-Humic Podzol - B rich in organic matter combined with Al and Fe; Humo-Ferric Podzol - B contains less organic matter than Ferro-Humic Podzol.

Regosolic order - Development of genetic horizons is absent or very weakly expressed. Great groups are: Humic Regosol - has a dark, mineral-organic surface horizon (Ah); Regosol - either lacks or has a thin Ah.

Solonetzic order - Soils associated with saline materials and having prismatic or columnar structured, Na-rich, B horizons that are hard when dry and nearly impermeable when wet. They occur mainly in the grasslands associated with Chernozemic soils. Great groups are: Solonetz - lacks a well-developed eluvial Ae; Solodized-Solonetz - has a well-developed Ae; Solod - has an Ae and an AB in which the structure of the former B has disintegrated.

Subgroups are formed by subdivisions of great groups according to kind and arrangement of horizons indicating conformity to the central concept of the great group, intergrading to other orders, or additional special horizons. Families are differentiated from subgroups on the basis of parent material characteristics, soil climate factors and soil reaction. Series are differentiated from families on the basis of detailed soil features.

CLASSIFICATION CORRELATION

Canadian	US	FAO
Brunisolic	Inceptisol	Cambisol
Chernozemic	Mollisol	Kastanozem, Chernozem, Rendzina
Cryosolic	Pergelic subgroups	Gelic subgroups
Gleysolic	Aqu suborders	Gleysol, Planosol
Luvisolic	Alfisol	Luvisol
Podzolic	Spodosol	Podzol
Organic	Histosol	Histosol
Solonetzic	Natric great groups	Solonetz

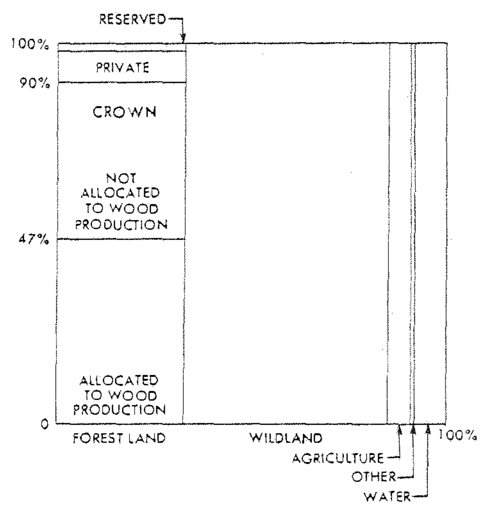


FIG. 40 AREA CLASSIFICATION OF CANADA 1968

Area Classification by Provinces, 1968

	NEWFOUNDLAND LABRADOR	NEWFOUNDLAND ISLAND	PRINCE EDWARD ISLAND	NOVA SCOTIA	NEW BRUNSWICK	QUEBEC	ONTARIO	MANITOBA	SASKATCHEWAN	ALBERTA	BRITISH COLUMBIA	NORTHWEST TERRITORIES	YUKON	CANADA
	thousands of acres													
FOREST LAND														
Suitable for Regular Harvest	13 362	8 628	617	9 615	15 501	121 845	115 471	37 854	21 627	60 127	134 838	21 745	27 063	588 293
Not Suitable for Regular Harvest	8 203	-	-	-	108	49 920	105	54	2 825	2 100	-	102 799	24 905	191 019
Reserved	74	182	7	340	48	62	4 958	561	1 468	6 096	3 238	-	-	17 034
TOTAL FOREST LAND	21 639	8 810	624	9 955	15 657	171 827	120 534	38 469	25 920	68 323	138 076	124 544	51 968	796 346
WILD LAND	43 565	17 222	33	1 562	627	140 186	80 571	79 026	48 823	42 400	85 164	677 656	79 454	1 296 289
AGRICULTURE	-	126	738	1 053	1 138	9 109	17 481	17 871	64 062	47 124	3 771	-	-	162 473
OTHER, urban, etc.	-	95	8	486	278	2 035	1 633	170	2 111	1 385	737	-	-	8 938
TOTAL LAND	65 204	26 253	1 403	13 056	17 700	323 157	220 219	135 536	140 916	159 232	227 748	802 200	131 422	2 264 046
WATER	7 005	1 497	5	655	447	57 553	43 833	25 104	20 172	4 150	6 380	32 938	1 107	200 846
TOTAL LAND AND	72 209	27 750	1 408	13 711	18 147	380 710	264 052	160 640	161 088	163 382	234 128	835 138	132 529	2 464 892

APPENDIX B: SITE AND PROFILE DESCRIPTIONS, ANALYTICAL DATA AND MICROMORPHOLOGY

SITE 1: PODZOLIC GRAY LUVISOL ON ACID TILL (CHARLOTTETOWN)

Soil Name:	Charlottetown fine sandy loam.
Location:	Central Hill Lands, Prince Edward Island. 46° 20' 46" N. Lat, 63° 26' 12" W. Long.
Elevation:	100 m. M.S.L.
Landform:	Rolling morainal
Slope:	Lower portion of a 3% south-facing slope. Moderate microrelief.
Drainage:	Well drained; rapid surface removal. Moderate to slow internal drainage.
Vegetation:	Magaguadavic-Hillsborough ecoregion; characterized by sugar maple (*Acer saccharum* Marsh.) with beech (*Fagus* sp.) and scattered yellow birch (*Betula alleghaniensis* Britton) abundant on upland sites; red spruce (*Picea rubens*), balsam fir (*Abies balsamea* (L.) Mill), hemlock (*Tsuga canadensis* (L.) Carr.) on valley tills.
Climate:	Station: Charlottetown, C.D.A. 46° 15' N. Lat, 63° 08' W. Long. Elevation: 22 m. M.S.L. Precipitation: Mean annual precipitation 107 cm. of which 80 occurs in the form of rainfall. Precipitation is equally distributed over the year. Temperature: mean annual temperature is 5°C. The mean daily maximum and minimum temperatures for the month of July are, respectively, 24°C and 14°C and those for January are -3°C and -10°C.
Parent Material:	Strongly acid, reddish-brown fine sandy loam basal till. Figures 12, 13, Table 2, 3 -- Surficial deposits in the area are quite variable. Exposures reveal the bedrock to be frequently within 3 ft. of the surface. Figures 12 and 13 and Table 2 from a thesis by Mr. Bruce MacLean give an interpretation of materials from a series of 8 profiles studied in the immediate area. Profile no. 1 is the location of the present sample site.
Soil Classification:	Canada: Podzolic Gray Luvisol, coarse loamy, mixed, acid, cool humid family U.S.A.: Typic Cryoboralf, coarse loamy, mixed, acid, frigid family F.A.O.: Albic Luvisol

Horizon	Depth	Description
L-H	5-0	Partly decomposed leaf litter over thin mull-like moder;
Ae	0-10	Light reddish-brown (5YR 6/4m-6/2 d) fine sandy loam; structureless; very friable; few roots; abrupt, irregular and broken boundary with tongues to 20 cm;

Bf	10-30	Reddish-brown (2.5YR 4/6m) (5YR 5/6d) fine sandy loam; moderate, fine and medium granular; non-sticky; very friable; abundant medium and fine roots; clear wavy boundary;
Bm1	30-45	Reddish-brown (2.5YR 4/6m) (5YR 5/6d) fine sandy loam; friable; weak medium subangular blocky; slightly sticky; nonplastic; coarse fragment about 15% by volume estimate mainly sandstone gravel-cobble; gradual, wavy boundary;
Bm2	45-60	Dark reddish-brown (2.5YR 3/6m-5/6d) fine sandy loam; weak, medium platy breaking to fine and medium subangular blocky; firm in situ, friable; a few, fine roots concentrated along fracture faces; possibly incipient fragipan; gradual, wavy boundary;
Bt1	60-90	Dark reddish-brown (2.5YR 3/6m-5/6d) fine sandy loam; weak coarse platy, breaking to weak subangular blocky; few medium and fine roots; few fine pores; common thin cutans in voids and on some peds; compact, dense; sticky; slightly plastic; silt caps on pebbles, gradual, smooth boundary;
Bt2	90-185	Dark reddish-brown (2.5YR 3/6m-5/6d) fine sandy loam; similar to horizon above but less compact in place; dense; massive to weak coarse platy; common, thin cutans; coarse fragment estimate 20% by volume.
R	185-198	Shattered sandstone bedrock.
R	198	Sandstone bedrock.

Discussion: Since 1950, changes in the soil classification system used in Canada included a division of the Podzolic Order into a Luvisolic Order (clay translocation) and a new Podzolic Order (organo-sesquioxide accumulation). While zonal development is Podzol, locally and regionally many profiles exhibit weak Luvisolic characteristics and some have weak to relatively strong fragipan characteristics. The Bt horizon in this profile is weakly expressed but meets 1973 Canadian criteria.

Micromorphology: Four thin sections were studied by B. MacLean and these are presented using terminology of Brewer.

Depth	Description
23-28	A skel-silasepic frabric containing a few ferro-argillans. The plasma appeared to be rather uniformily distributed except for some grain coatings and a few sesquixodic manganiferous nodules.
55-59	A silisepic fabric plasma separated by channels often coated with ferro-organic nodules and ferro-argillans.

94-99	A skel-insepic porphyroskelic fabric pattern with moderately thick ferro-argillans on voids and channel faces. Oriented clay determined as 2.5%.
109-114	Skel-insepic porphyroskelic fabric with moderately thick ferro-argillans. Determined oriented clay values estimated at 1.3%.

Mineralogy: The mineralogy of this particular profile was not examined but similar associated profiles were examined by Dr. McKeague in 1973. The data presented are for Tignish soil, a Podzolic Gray Luvisol on loam till material.

About 80% of the heavy mineral grains in the 50 to 100 u fraction were either opaque or so severely weathered that they could not be identified readily. The soils examined contained identifiable amphibole, zircon, tourmaline, and apatite. Apatite and chlorite were markedly depleted from horizons near the surface.

The mineralogy of the clay fraction indicated mica as the dominant mineral in most horizons. Kaolinite occurs in all horizons, chlorite and expansible minerals in most horizons. The general weathering trend seems to be alteration of mica to expansible minerals.

Minerals in the clay fraction <2μ of selected horizons of Tignish soil (reported as fractions (to 0.1) of total pyllosilicates.

Horizon	Chlorite	Kaolinite	Mica	Expansible	Montmorillonite
Ae1	.1	.3	.4	.0	.2
Ae2	.3	.1	.3	.1	.2
Bf	.2	.2	.3	.3	.0
Bt1	.3	.1	.5	.1	.0
Bt2	.2	.1	.5	.2	.0
Bc	.2	.1	.4	.3	.0

Physical and Chemical: Bulk density values and water retention data were done on cores and indicate the dense nature of the lower sola and the fineness of porosity. Saturated hydraulic conductivity values, also done on cores, indicate slow permeabilities in the lower B horizon.

Particle size data indicates good textural uniformity of material overlying bedrock. Fine sand is the dominant fraction while very fine sand and silt make up 50% of the fine earth total. Many sites in this Central Hill area have fewer uniform parent materials. Frequently, till deposits are shallow or the soil is developed in weathered bedrock or glacio residual material with rapid textural variation horizontally and vertically.

The profile is strongly acid throughout. Cation exchange capacity is low with values shown by neutral salt extraction and buffered at pH 7.

TABLE 21. ANALYTICAL DATA OF THE PODZOLIC GRAY LUVISOL (CHARLOTTETOWN), SITE 1
DONNÉES ANALYTIQUES DU LUVISOL GRIS PODZOLIQUE (CHARLOTTETOWN) À SITE 1

Horizon	pH $CaCl_2$	Org. matter Loss on ign. / matière organique perte au feu %	Exchangeable Cations / Cations échangeables (meq/100g): Neutral Salt Extra. / sels neutres Ca	Mg	Al	Buffered / Tamponnée Ca	K	C.E.C. / Capacité d'échange cationique (meq/100g): P. Charge / Charge permanente	Buffered / Tamponée	Pyrophosphate Fe %	Al %	Mn %	Oxalate Fe %	Al %	Dithionite Fe %	Al %
Ae1	4.1	0.7	0.3	0.1	0.6	20.0	27.0	1.1	4.9	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Ae2		0.4											0.0	0.1	0.6	0.4
Bf1		4.4											0.1	0.3	0.9	0.3
Bf2	4.1	4.2	0.3	0.1	3.3	5.0	41.0	3.8	13.9				0.3	0.6	1.0	0.3
Bf3		2.8								0.2	0.6	0.0	0.3	0.6	0.9	0.3
Bf4	4.1	1.4							5.8				0.2	0.6	0.8	0.2
Bm1	4.0	1.2	0.1	0.0	3.2			3.4	8.3				0.1	0.4	0.7	0.1
Bm2			0.2	0.1	3.6	5.0	50.0	4.0		0.0	0.3	0.0	0.1	0.2	0.7	0.1
Bt1	4.2		0.2	0.0	3.6	5.0	41.0	4.1		0.0	0.2	0.0				

Horizon	>2mm %	Particle Size Distribution - Analyse granulométrique: Sand / Sable (% <2mm) VCS	CS	MS	FS	VFS	Total	Silt / Limon Total	Clay / Argile Total	Clay / Argile (<0.2u)	Moisture / Humidité (%) Max.	60 cm	1/3 atm.	1 atm.	Saturated Hydraulic Conductivity / Conductivité hydraulique saturée cm/hr	Bulk Density / Densité apparente g/cm^3	Liquid Limit / Limite de liquidité %	Shrink. Limit / Limite de retrait %
Ae1	11	0	1	5	32	20	58	37	5	1	50.9	39.5	34.5	23.6	3.2	1.32		
Ae2	10	0	1	5	28	18	52	38	10	1								
Bf1	22	0	1	4	29	18	53	38	9	1	61.4	44.5	39.0	34.3	11.5	1.05		
Bf2	34	1	2	6	28	17	54	37	9									
Bf3	29	1	1	5	29	19	55	36	9	3								
Bf4	19	2	2	5	29	18	56	35	9									
Bm1	25	1	2	6	27	18	54	37	9									
Bm2	40	1	2	5	27	17	52	37	11	4	47.5	39.9	36.1	34.0	0.7	1.33	21.2	16.2
Bt1	23	1	2	5	27	18	53	34	13	4	35.4	31.5	27.9	25.6	0.4	1.62	20.7	16.7
Bt21	20	1	2	5	25	17	50	36	14									
Bt22	17	1	3	6	27	16	53	34	13							1.86		
Bt23	25	1	2	6	27	15	51	35	14									

SITE 2: FRAGIC HUMO-FERRIC PODZOL ON SANDY TILL (TORMENTINE)

Soil Name:	Tormentine sandy loam.
Location:	Northwestern Nova Scotia near the Northumberland Strait. 45° 53' 09" N. Lat. 63° 53' 25" W. Long.
Elevation:	8 m. M.S.L.
Landform:	Undulating to rolling morainal.
Slope:	Middle portion of a 7% south-facing slope.
Drainage:	Moderately well drained.
Vegetation:	Maritime Lowlands ecoregion; characterized by red spruce (*Picea rubens*), black spruce (*Picea mariana* (Mill.) BSP.), red maple (*Acer rubrum* L.), white birch (*Betula papyrifera* Marsh.), white pine (*Pinus strobus* L.) and balsam fir (*Abies balsamea* (L.) Mill).
Climate:	Station: Nappan, C.D.A. 45° 46' N. Lat, 64° 15' W. Long. Elevation: 8 m M.S.L. Precipitation: mean annual precipitation 104 cm of which 81 occurs in the form of rainfall. The season of maximum precipitation falls between April and November. Temperature: mean annual temperature is 6°C. The mean daily maximum and minimum temperatures for the month of July are, respectively, 24°C and 12°C and those for January are -2°C and -12°C.
Parent Material:	Reddish-brown sandy loam glacial till.
Soil Classification:	Canada: Fragic Humo-Ferric Podzol, coarse loamy, mixed cool humid family U.S.A.: Typic Fragiochrept, coarse loamy, mixed, frigid family F.A.O.: Dystric Cambisol

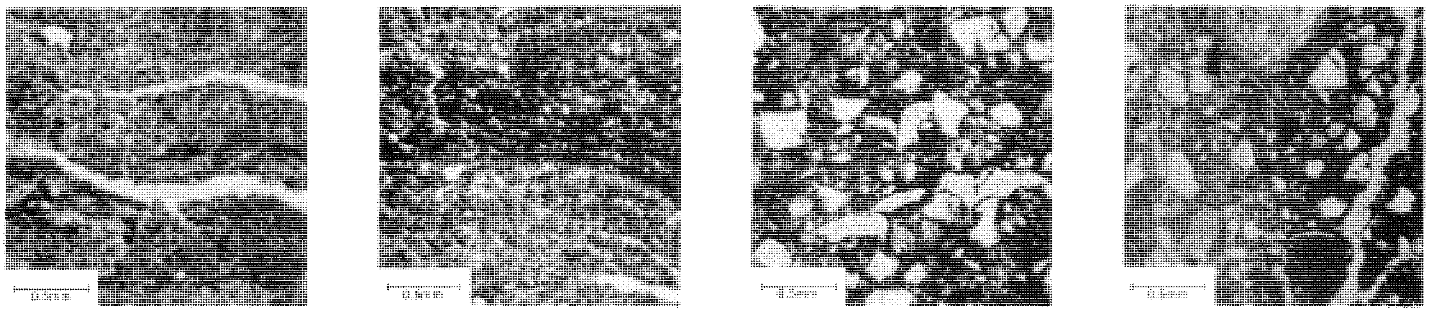
Horizon	Depth	Description
Ap	0-18	Reddish-brown (5YR 4/4m) light reddish-brown (5YR 6/3d) sandy loam; weak, fine granular; very friable; abundant roots; abrupt smooth.
Ae	18-26	Pink (5YR 7/3d) (pinkish-gray 5YR 6/2m) sandy loam; weak, fine granular; very friable, abundant roots; diffuse broken.
Bf	26-43	Red (2.5YR 4/6m) reddish-brown (5YR 5/4d) loam; weak, fine subangular blocky to granular; very friable; abundant roots; clear smooth.
BC	43-59	Reddish-brown (2.5YR 4/4m) light reddish-brown (5YR 6/3.5d) silt loam; moderate, medium platy breaking to fine, subangular blocky; friable to firm; plentiful roots; clear smooth.
Aexj	59-72	Reddish-brown (5YR 5/4m) light reddish-brown (5YR 6/4d) and yellowish-red (5YR 4/6m) sandy loam; weak, medium, platy breaking to fine, subangular blocky; firm; slightly brittle and very few roots; abrupt smooth.
Bx1	72-81	Reddish-brown (2.5YR 4/4m) reddish-brown (5YR 5.5/3d) gravelly sandy loam, strong, medium platy breaking to fine, subangular blocky; firm to very firm; brittle; few thin isolated clay films (along ped surface and occasionally in matrix), many planar voids; diffuse wavy.
Bx2	81-106	Reddish-brown (2.5YR 4/4m) light reddish-brown (5YR 6/3d) gravelly sandy loam; strong, medium platy; brittle; common isolated clay films; many planar voids; diffuse wavy; firm to very firm.
Bx3	106-131	Reddish-brown (2.5YR 4/4m) reddish-brown (5YR 5.5/4d) gravelly sandy loam; strong, medium platy; brittle; common isolated clay films; many planar voids; diffuse wavy; firm to very firm.
Cx	131-180+	Reddish-brown (2.5YR 4/4m) reddish-brown (5YR 5/4d) sandy loam, strong, coarse platy; firm to very firm; brittle; few thin isolated clay films

TABLE 22. ANALYTICAL DATA OF THE FRAGIC HUMO-FERRIC PODZOL (TORMENTINE), SITE 2
DONNEES ANALYTIQUES DU PODZOL HUMO-FERRIQUE FRAGIQUE (TORMENTINE) A SITE 2

Horizon	pH $CaCl_2$	pH H_2O	Org. Matter Loss on ign. / matière organique perte au feu %	Org. C / carbone organique %	Exchangeable Cations / Cations échangeables Buffered - Tamponnée Ca (meq/100g)	Mg	K	Na	C.E.C. / Capacité d'échange cationique meq/100g
Ap	4.9	5.0	5.4	3.2	1.32	.37	.21	.31	13.1
Ae	5.1	5.2	4.4	2.1	.95	.17	.06	.36	11.9
Bf	4.9	5.3	3.8	1.8	.25	.08	.06	.25	8.5
BC	5.1	5.1	0.9	0.1	.13	.05	.05	.49	6.2
Aexj	4.6	5.0	0.7	0.0	.18	.08	.06	.27	4.8
Bx1	4.5	5.2	0.7	0.0	.24	.16	.05	.17	3.3
Bx2	4.8	5.0	0.7	0.0	.19	.08	.06	.22	4.5
Bx3	4.5	5.2	0.7	0.0	.19	.27	.08	.06	4.3
Cx	4.6	4.9	0.8	0.0	.25	.21	.06	.09	4.9

Horizon	Pyrophosphate Fe %	Pyrophosphate Al %	Moisture / Humidité 1/3 atm. %	Bulk Density / Densité apparente g/cm^3	Saturated Hydraulic Conductivity / Conductivité hydraulique saturée cm/hr	>2mm %	Particle Size Distribution - Analyse granulométrique: Sand - Sable VSC (% <2mm)	CS	MS	FS	VFS	Total	Silt / Limon	Clay / Argile
Ap	.20	.19	36.6	1.28	50.6	3.9	1.5	2.5	9.5	26.1	12.9	52.5	39.3	8.2
Ae	.28	.24				6.0								
Bf	.25	.30		1.40	18.7	6.5	0.5	1.7	7.4	23.1	13.9	46.6	46.6	6.9
BC	.05	.13			16.7	2.8	0.2	1.0	5.8	19.6	14.2	40.8	52.9	6.3
Aexj	.02	.10		1.59	18.0	7.9	0.5	2.0	9.6	29.0	14.4	55.5	38.1	6.4
Bx1	.02	.09		1.75	2.49	17.2	0.1	1.2	6.5	26.2	16.2	50.2	44.8	5.0
Bx2	.02	.12	18.2	1.86	0.164	8.2	0.3	1.8	10.8	33.6	14.4	60.9	31.4	7.7
Bx3	.02	.09				15.0								
Cx	.02	.17		1.70	0.95	20.5	0.5	2.4	12.1	36.4	11.4	62.8	29.0	8.2

Figure 41. Micromorphology of the Fragic Humo Ferric Podzol at Site 2.



a. plane light b. plane light c. plane light d. plane light

Ap This horizon is loosely packed brown material consisting mainly of strongly fused dense aggregates (500-5000µm) but with many areas of weakly to moderately fused aggregates (50-500µm). Complete matrans (<125µm) occur on almost all free sand grains. Sesquioxidic nodules (<2000µm) are (R), sharp and equant, most are rounded (<1mm), and some have matrans about 100µm thick. Pale brown to black moderately humified organic material is (C) and rock fragments (manganiferous and ferruginous sandstone) as sand and gravel are (R).
-1- argillasepic porphyroskelic aggregates
-2- matrigranoidic//matrigranoidic porphyroskelic

Bf This horizon is loosely packed material consisting of weakly birefringent orange-brown aggregates (40-500µm) in the intergranular spaces between some large light brown dense aggregates (2-15mm). The smaller aggregates in many cases are fused with other small aggregates and sometimes with the large ones. The orange-brown material probably consists of an Fe-Al-organic complex with fine matrix material and forms complete coatings (100µm) on all sand grains and occasionally forms partial coatings (<250µm with most <100µm) on some of the large aggregates. Sesquioxidic nodules (<2mm) are (VR), mostly diffuse and occasionally contain some manganiferous material. Dark brown moderately humified organic material (<2.5mm) is rare and rock fragments as sand and gravel are (R).
-2- matrigranoidic//ortho-matrigranic

Aexj There are two completely different areas in this horizon. The first is medium grayish brown dense fine grained material with (O-C) vughs (<500µm), (C-F) subhorizontal skew planes, and an overall moderate porosity (Fig. 41a). Sesquioxidic material is (R), occurs occasionally as very diffuse nodules (<1500µm) but mainly as diffuse elongated stringers (nodules 80-500µm thick and <8mm long) that are subhorizontal and often curved (Fig. 41b). Irregular manganiferous nodules (<100µm) are (VR) and vugh sesquans (<80µm) are (VR).
The second area is not quite as abundant and consists of grayish brown sandy material with abundant fine matrix material that fills most intergranular spaces but leaves (C-F) vughs (<2.5mm with most 250-500µm) (Fig. 41c). Argillans are (O) (in Fig. 41c) and consist mainly of thin moderately oriented ferriargillans (100µm with most <40µm) with some weakly oriented silty argillans (<150µm) and both occasionally appear as compound cutans. The cutans are usually complete on the small vughs and partial on the large. There are a few large areas of the first fabric type mixed with the second. Diffuse manganiferous nodules (<1mm) are (VR) and there are occasional rock fragments (manganiferous, ferruginous, and argillaceous sandstones, siltstone, igneous) as gravel.
-1- silasepic porphyroskelic (first area) and vughy argillasepic porphyroskelic (second area)

Bx1 This horizon is moderately packed medium brown material that consists of dense large peds separated by wide subhorizontal planar voids. Vughs (4mm) are (C) within the peds. About 20% of the area is dark to very dark brown due to the (C) sesquioxidic material and (R-O) manganiferous material. The sesquioxidic material occurs mainly as very large diffuse nodules covering large areas (15mm) (Fig. 41d) and occasionally as sesquans and argillasesquans (<100µm) on voids and embedded grains. The manganiferous material occurs mostly as irregular nodules (<2mm) with (R) skew plane mangans (<150µm). Argillans (<125µm) are (C), usually moderately oriented but many are strongly oriented, occur on most skew planes and vughs, commonly on embedded grains, occasionally as vugh fillings (<1mm), and commonly are engulfed. The clay in the s-matrix is highly birefringent and rock fragments as sand and gravel are (R).
-1- skel-latti-mosepic porphyroskelic

C This horizon consists of very dense, highly weathered, manganiferous and ferruginous sandstone in which most of the grains are medium size (250-1000µm). The grains in decreasing order of abundance, are quartz, feldspar, ferruginous grains, biotite, and some opaques.

SITE 3: GLEYED BRUNISOLIC GRAY LUVISOL ON TILL (QUEENS)

Soil Name:	Queens sandy loam.
Location:	Central Nova Scotia east of the Minas Basin portion of the Bay of Fundy. 45° 07' N. Lat, 64° 51' W. Long.
Elevation:	31 m. M.S.L.
Landform:	Slightly mounded morainal.
Slope:	Crest of a 5% northeast slope.
Drainage:	Imperfectly drained.
Vegetation:	Maritime lowlands ecoregion; characterized by red spruce (*Picea rubens*), black spruce (*Picea mariana* Mill, BSP.), hemlock (*Tsuga canadensis* (L.) Carr.), balsam fir (*Abies balsamea* (L.) Mill.) and red maple (*Acer rubrum* L.).
Climate:	Station: Truro. 45° 22' N. Lat., 63° 16' W. Long. Elevation: 40 m M.S.L. Precipitation: mean annual precipitation 110 cm of which 87 occurs in the form of rainfall. The season of maximum precipitation falls between April and November. Temperature: mean annual temperature is 5°C. The mean daily maximum and minimum temperature for the month of July are, respectively, 24°C and 11°C and those for January are -1°C and -11°C.
Parent Material:	Reddish-brown fine loamy and fine silty glacial till.
Soil Classification:	Canada: Gleyed Brunisolic Gray Luvisol, fine clayey, mixed, alkaline, weakly calcareous, cool perhumid family U.S.A.: Typic Cryoboralf, fine clayey, mixed, frigid family F.A.O.: Gleyic Luvisol

Horizon	Depth	Description
LFH	10-0	Black (5YR 2/0m) dark reddish-brown (2.5YR 2/4d).
Ae	0-4	Light reddish-brown (5YR 6/3m) pinkish-gray (5YR 7/2d) sandy loam; common, medium and distinct, light yellowish-brown (2.5YR 6/4m) mottles; weak, medium, subangular blocky; breaking to single grain; very friable; abundant, fine and medium roots; many fine, random pores; abrupt wavy.
ABgj	4-8	Brown (7.5YR 5/4m) loam; common, medium and faint, yellowish-brown (10YR 5/4m) mottles; weak, medium subangular blocky; friable; plentiful very fine and medium roots; common very fine, random pores; gradual wavy.
Bmgj	8-19	Reddish-brown (5YR 4/4m) pinkish gray (5YR 6.5/2d) loam; common fine and faint, brown (7.5YR 5/4m) mottles; micro to coarse roots; common, very fine, random pores; gradual wavy.
IIABg	19-37	Reddish-brown (5YR 4/3m) reddish-brown (5YR 5.5/4d) and brown (7.5YR 5/2d) clay loam; many, fine, distinct, reddish brown (5YR 4/4m) mottles; strong; coarse columnar; breaking to moderate, medium, subangular blocky; firm, few thin clay films; few, micro to coarse, roots; few, micro and very fine, random pores; gradual wavy.

IIBt	37-66	Reddish-brown (2.5YR 4/4m) reddish-brown (5YR 5/4d) clay loam; moderate, medium to coarse, columnar; breaking to weak, medium subangular blocky; firm; few, very thin clay films; few, micro to fine, vertical roots; few, very fine, random pores; manganese concentrations; gravelly; clear smooth.
IIBm	66-90	Reddish-brown (5YR 4/3m) reddish-brown (5YR 5/4d) clay loam; weak, coarse, columnar; breaking to weak, fine subangular blocky; very firm; few, very thin clay films; manganese concentrations; gravelly and cobbly; gradual smooth.
IICk	90-115	Reddish-brown (5YR 4/3m) reddish-brown (5YR 5/4d) clay loam; weak, medium, subangular blocky; very firm; very few, very fine and fine, vertical roots; common, micro and very fine random pores; few, very thin clay films; gravelly and cobbly; gradual smooth.
IIC	115-154	Reddish-brown (5YR 4/3m) reddish-brown (5YR 4.5/4d) clay loam; massive, few, very thin clay films; common, very fine, random pores; gravelly and cobbly. Consistence (m): very firm.

TABLE 23. MINERALOGICAL DATA FOR GLEYED BRUNISOLIC GRAY LUVISOL, QUEENS SERIES
DONNEÉS MINERALOGIQUE DU LUVISOL GRIS BRUNISOLIQUE GLEYIFIÉ, SERIE QUEENS

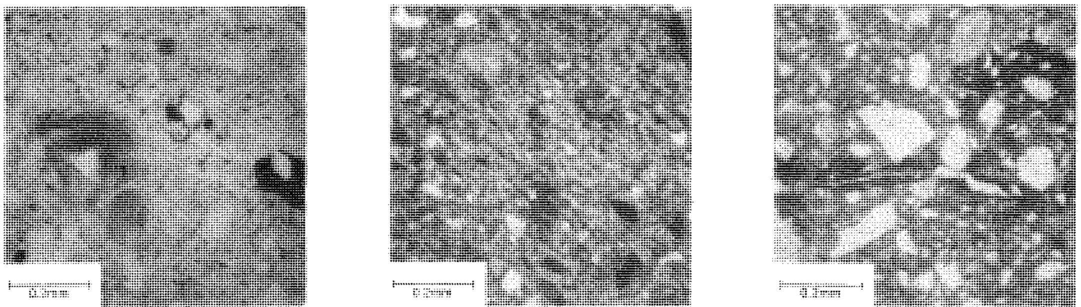
Horizon	Fraction 2-0.2um					Fraction < 0.2um	
	mica	chlorite	kaolin	smectite	vermiculite	quartz	amorphous
Ae	02		01	03	01	02	
Bmgj	01	01	01		02	01	03
IIABg	02	01	00	00	01	01	03
IIBt	03	01	01	00	01	01	03
IIBm	02	01	00	00	01	01	03
IICk	02	01	01	00		01	03
IIC	01	01	00	00		01	03

TABLE 24. ANALYTICAL DATA OF THE GLEYED BRUNISOLIC GRAY LUVISOL (QUEENS), SITE 3
DONNEES ANALYTIQUES DU LUVISOL GRIS BRUNISOLIQUE (QUEENS), A SITE 3

Horizon	pH $CaCl_2$	pH H_2O	Org. Matter Loss on ign. / matière organique perte au feu %	Org. C / carbone organique %	Exchangeable Cations / Cations échangeables, Buffered - Tamponnée Ca (meq/100g)	Mg (meq/100g)	K (meq/100g)	Na (meq/100g)	C.E.C. / Capacité d'échange cationique meq/100g
LFH	3.5	3.6	64.5	44.0	9.23	1.98	1.33	.95	103.1
Ae	3.2	3.6	4.0	2.08	.32	.16	.10	.27	9.9
ABgj									
Bmgj	4.3	4.6	3.6	.62	.13	.25	.13	.31	11.4
IIABg	4.3	4.8	3.3	.18	1.40	.42	.16	.41	11.6
IIBt	5.1	5.6	1.7	.15	10.24	1.78	.17	.20	15.9
IIBm	6.6	7.1	1.8	.13	10.53	1.63	.12	.16	18.2
IICk	7.6	7.9	1.8	.28	18.95	1.26	.13	.19	14.1
IIC	7.5	7.6	1.9	1.18	23.21	1.34	.16	.12	13.2

Horizon	Pyrophosphate Fe %	Pyrophosphate Al %	Moisture / Humidité 1/3 atm. %	Bulk Density / Densité apparente g/cm³	Saturated Hydraulic Conductivity / Conductivité hydraulique saturée cm/hr	>2mm %	Particle Size Distribution - Analyse granulométrique, Sand - Sable VSC (% <2mm)	CS	MS	FS	VFS	Total	Silt / Limon	Clay / Argile
LFH	.03	.06				4.8								
Ae	.03	.06	33.7	1.53	18.38	7.2	3.28	4.99	5.17	27.58	18.58	59.6	33.4	7.0
ABgj				1.65	0.71									
Bmgj	.18	.15	45.5	1.60	23.30	7.5	2.06	3.33	3.26	15.04	14.70	38.4	40.0	21.6
IIABg	.07	.15				10.6	2.58	3.64	3.52	14.67	14.39	38.8	29.8	31.4
IIBt	.03	.10		1.86	0.59	14.3	2.46	2.89	2.68	12.24	11.22	31.5	31.3	37.2
IIBm	.02	.08	29.7	1.95	0.08	20.3	3.22	2.00	2.89	11.47	12.22	32.8	34.0	33.2
IICk	.02	.07	32.8	2.00	9.91	18.4	2.58	3.35	3.09	12.85	10.83	32.7	33.7	33.6
IIC	.01	.07				22.3	3.63	3.83	3.18	11.38	11.47	32.5	32.5	34.0

Figure 42. Micromorphology of the Gleyed Brunisolic Gray Luvisol at Site 3.



a. plane light   b. X polarizers   c. plane light

Bmgj This horizon is dense pale brown material (Fig. 42a) with (O-C) vughs and (R) channels. Sesquioxidic nodules (150-2000μm) (1 in Fig. 42a) are (O) with half sharp and the rest diffuse irregardless of size. Yellowish brown to black moderately humified organic material (200-4500μm) is (O). There is (R-O) gravel (moderately weathered igneous, shale, ferruginous sandstone, siltstone).
-1- silasepic porphyroskelic

IIBt This horizon is very dense reddish brown material with (O) vughs (150-500μm) and (R) skew planes. Void and engulfed argillans (<240μm with most 60μm) are (R-O) and weakly to moderately oriented. Manganese oxides are (VR) occuring as nodules (<500μm) and skew plane and embedded grain mangans (<100μm).
-1- insepic porphyroskelic

IICk This horizon is dense reddish brown material (Fig. 42b) with (O) metavughs (100-1000μm) and (O-C) skew planes. Thin (<140μm with most 60μm) moderately oriented vugh and skew plane argillans are (R-O) and sometimes occur as neocutans. Carbonates are (O) and occur as nodules in the s-matrix, calcareous gravel, nodular accumulations in skew planes, neocalcans, and neocalcargillans. Manganese oxides are (VR) and occur as nodules (<300μm) and void and embedded grain neomangans (<100 mm) (Fig. 42c).
-1- mosepic porphyroskelic

SITE 4: GLEYED ELUVIATED DYSTRIC BRUNISOL ON WATER WORKED TILL (KENTVILLE, A)

Soil Name:	Kentville sandy loam.
Location:	Central Nova Scotia in the eastern portion of the Annapolis Valley. 45° 03' 52" N. Lat., 64° 29' 02" W. Long.
Elevation:	61 m M.S.L.
Landform:	Level morainal
Slope:	Crest of a 2% north-facing slope.
Drainage:	Moderately well to imperfectly drained.
Native Vegetation:	Clyde River-Halifax ecoregion; characterized by red spruce (*Picea rubens*), hemlock (*Tsuga canadensis* (L.) Carr.), white pine (*Pinus strobus* L.), balsam fir (*Abies balsamea* (L.) Mill) and red maple (*Acer rubrum* L.). Presently under forage crops.
Climate:	Station: Kentville, C.D.A. 45° 04' N. Lat., 64° 29' W. Long. Elevation: 49 m. M.S.L. Precipitation: mean annual precipitation 108 cm of which 85 cm occurs in the form of rainfall. The season of maximum precipitation falls between April and November. Temperature: mean annual temperature is 7°C. The mean daily maximum and minimum temperatures for the month of July are, respectively, 25°C and 13°C and those for January are -1°C and -12°C.
Parent Material:	Reddish-brown coarse loamy and coarse silty water-worked glacial till.
Soil Classification:	Canada: Gleyed Eluviated Dystric Brunisol, coarse loamy, mixed, neutral, humid family U.S.A.: Dystric Eutrocrept, coarse loamy, mixed, mesic family F.A.O.: Eutric Cambisol

Horizon	Depth	Description
Ap1	0-6	Light yellowish-brown (10YR 6/4d) brown (10YR 4/3m) sandy loam; weak, fine prismatic; breaking to moderate, medium platy; friable to firm; abundant roots; very few, very fine, vertical pores; gravelly; clear smooth.
Ap2	6-24	Light brown (7.5YR 6/4d) brown (10YR 4.5/3m) sandy loam; weak to moderate, medium platy; friable to firm; abundant roots; very few, very fine, vertical pores; gravelly; clear wavy.
Aegj	24-31	Dark brown (7.5YR 4.5/4m), pale brown (10YR 6/3d) sandy loam; common, fine, faint yellowish red (5YR 4/8d) reddish-yellow (5YR 6/8m) mottles; moderate, fine platy; friable to firm; plentiful roots; very few, very fine, vertical pores; gravelly; clear wavy.
Bxjgl	31-41	Yellowish red (5YR 4/6m) strong brown (7.5YR 5/6d) sandy loam; common, fine, distinct, reddish yellow (7.5YR 6/8d) mottles, moderate, fine platy, breaking to moderate fine subangular blocky; manganese concentrations; firm; few thin clay films, few, fine and medium roots; many very fine horizontal pores, gravelly, abrupt smooth.

Bxjg2	41-54	Reddish brown (5YR 4/4m) yellowish red (5.0YR 4/6d) sandy loam; common fine and medium distinct brownish yellow (10YR 6/8d) yellowish red (5YR 4/8m) mottles moderate fine platy; breaking to moderate fine subangular blocky; firm; many thin clay films; very few, micro and very fine, roots; many very fine horizontal pores, gravelly, clear wavy.
Bm	54-79	Yellowish red (5YR 6/4m) yellowish-red (5YR 5/6d) sandy loam; moderate, fine, platy, breaking to moderate, fine subangular blocky; friable to firm; few thin clay films; very few, micro and very fine roots; common, very fine, horizontal pores; gravelly; clear wavy.
BC	79-104	Yellowish red (5YR 4/8m) yellowish red (5YR 5/6d) sandy loam; weak, fine, platy; friable, few, thin clay films; common, very fine, horizontal pores; gravelly; gradual wavy.
C	104-130	Dark red (2.5YR 3/6m) yellowish-red (5YR 4.5/6d) loamy sand; weak to moderate, medium platy; friable; gravelly; gradual wavy.
IIC1	130-150	Yellowish red (5YR 4/6m) yellowish-red (5YR 5/6d) sandy loam; stratified; moderate coarse, platy; friable; gravelly; gradual wavy.
IIC2	150-161	Reddish brown (5YR 4/4m) yellowish-red (5YR 5/6d) sandy loam; stratified; structureless, medium single grained; very friable; gravelly; gradual wavy.
IIC3	161-165	Yellowish red (5YR 5/6m) reddish-yellow (5YR 6/6d) sand; stratified; moderate coarse platy; friable; gravelly; abrupt smooth.
IIIC	165+	Dark red (2.5YR 3/6m) reddish-brown (5YR 5/4d) sandy clay loam; moderate coarse platy; gravelly.

TABLE 2 5. MINERALOGICAL DATA OF THE KENTVILLE A SOIL
DONNEES MINERALOGIQUE DU SOL KENTVILLE A

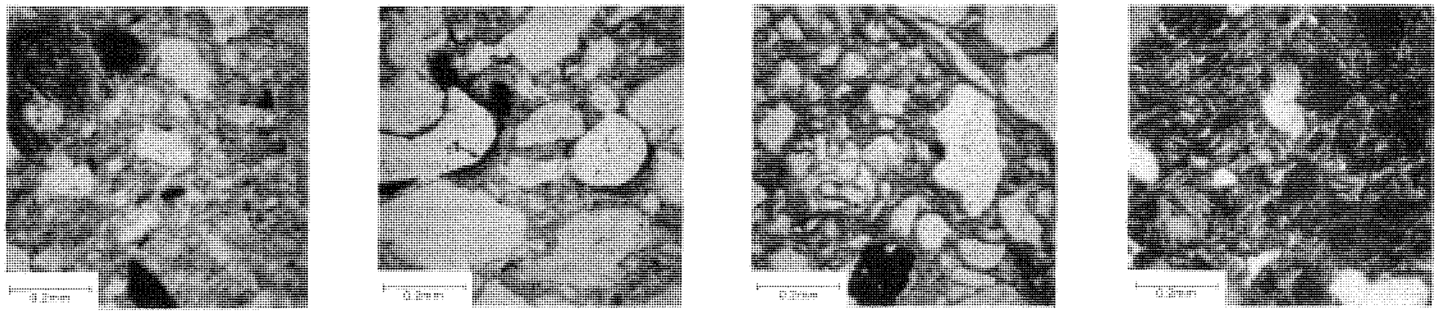
Horizon	Fraction 2-0.2um					Fraction <0.2µm	
	mica	chlorite	kaolin	smectite	vermiculite	quartz	amorphous
Ap1	00	01	00	01	01	01	05
Ap2	00	01	00	01	01	01	05
Aegj	01	01	00	01	01	01	04
Bxjg1	01	01	00	01	01	01	04
Bxjg2	01	01	00	02	01	01	03
Bm	02		01	03	01	01	01
BC	02	01	00	04	01	00	00
C	02	01	00	04	01	01	
IIC1	02	01	00	03		01	02
IIC2	01	01	00	03		01	02
IIC3	00	01	00	03		01	03
IIIC	01	01	00	04		01	01
(fracture plane in BC)	02		00	04		00	01

TABLE 26. ANALYTICAL DATA OF THE GLEYED ELUVIATED DYSTRIC BRUNISOL (KENTVILLE A), SITE 4
DONNEES ANALYTIQUES DU BRUNISOL DYSTRIQUE ELUVIEE GLEYIFEE (KENTVILLE A), A SITE 4

Horizon	pH $CaCl_2$	pH H_2O	Org. Matter Loss on ign. / matière organique perte au feu %	Org. C / carbone organique %	Exchangeable Cations / Cations échangeables Buffered - Tamponnée Ca (meq/100g)	Mg	K	Na	C.E.C. / Capacité d'échange cationique meq/100g
Ap1	5.8	5.9	6.6	4.3	6.17	2.46	.61	.29	10.4
Ap2	5.2	5.5	3.9	2.5	5.02	1.57	.14	.23	13.5
Aegj	4.6	5.1	3.1	1.6	3.18	1.15	.12	.22	7.4
Bxjg1	4.9	5.6	2.0	.20	4.32	1.89	.14	.27	9.8
Bxjg2	5.1	5.7	1.9	.17	6.09	2.36	.14	.27	10.2
Bm	5.3	6.2	1.5	.15	5.72	2.87	.16	.39	10.2
BC	5.6	6.3	1.0	.12	4.58	1.99	.14	.31	8.2
C	5.8	6.4	.9	.16	3.94	1.57	.14	.27	6.2
IIC1	5.7	6.4	1.3	.12	5.28	1.83	.20	.41	9.1
IIC2	5.7	6.1	0.7	.05	5.02	1.73	.19	.32	9.2
IIC3	5.6	6.1	0.4	.13	2.01	.63	.10	.29	3.6
IIIC	5.7	6.2	1.8	.15	8.78	1.99	.29	.39	16.0

Horizon	Pyrophosphate Fe %	Pyrophosphate Al %	Moisture / Humidité 1/3 atm. %	Bulk Density / Densité apparente g/cm^3	Saturated Hydraulic Conductivity / Conductivité hydraulique saturée cm/hr	>2mm %	Particle Size Distribution - Analyse granulométrique: Sand - Sable VSC (% <2mm)	CS	MS	FS	VFS	Total	Silt / Limon	Clay / Argile
Ap1	.20	.15		1.73	3.81	8.5	9.08	14.47	10.61	17.23	8.55	60.7	26.4	12.9
Ap2	.20	.19		1.76	4.90	12.8	11.36	14.89	10.24	18.05	10.35	64.9	21.3	12.8
Aegj	.19	.19		1.59	.69	20.6	10.35	13.53	98.94	17.74	9.34	60.9	25.8	12.3
Bxjg1	.04	.12	20.9	1.72	3.25	9.4	10.11	14.39	10.94	19.39	9.97	64.8	19.9	15.3
Bxjg2	.03	.14		1.86	39.89	11.9	12.83	16.11	11.49	22.31	10.16	72.9	12.8	14.3
Bm	.04	.15		1.88	9.96	12.6	10.94	15.52	11.46	19.56	9.61	67.1	19.2	13.7
BC	.02	.09	17.8	1.84	1.22	10.8	11.65	18.30	14.00	25.04	7.89	76.9	13.6	9.5
C	.02	.10	13.8	1.93	.1476	12.8	14.57	19.16	14.55	25.29	7.53	81.1	11.1	7.8
IIC1	.01	.06	19.8	1.91		7.8	10.69	16.64	12.67	23.20	8.19	71.4	10.5	18.1
IIC2	.02	.09	20.5	1.87	10.38	8.6	12.47	18.55	12.39	19.91	7.78	71.2	14.5	13.4
IIC3	.02	.13				6.1	12.13	27.22	22.97	25.04	4.35	91.7	5.3	3.0
IIIC	.02	.08				9.3	7.65	12.76	9.64	18.97	8.18	57.2	22.5	20.3

Figure 43. Micromorphology of the Kentville A soil at Site 4.



a. plane light b. plane light c. plane light d. X polarizers

Ap2 This horizon is very dense brown material (Fig. 43a) with a wide range of particle size that includes some gravel (shale, sandstone, and basic volcanic rocks). There are (R) channels and (O) vughs (100-700μm with most 200μm). Brown to black organic material (<2000μm) is (O) with most of it embedded in the s-matrix. Ferruginous nodules (<400μm) are (R) with about half of them sharp and the rest diffuse.
-1- skel-insepic porphyroskelic

Aegj This horizon is dense brown material of similar particle size to the Ap2 with (R-O) large channels and (O) vughs and skew planes. Sesquioxidic nodules (<2mm with most about 500μm) are (C) and equant with more sharp than diffuse. Organic material (<2mm) is (O-C) and most is well humified black material that is embedded in the s-matrix. There are (O) areas that contain more birefringent clay and less coarse material than the rest of the horizon.
-1- skel-insepic porphyroskelic

Bxjgl This horizon is moderately packed brownish gray material most (75%) of which is dense with (C) vughs (100-1500μm with most 300μm) (Fig. 43b) and the rest is loosely packed. Weakly to moderately oriented silty argillic to ferriargillic material is (C) occurring as vugh cutans (5-140μm) (1 in Fig. 43b), as bridges, and partial to complete intergranular fillings in the loose areas. There is a (R-O) gravel (ferruginous sandstones) and diffuse ferruginous nodules are (VR).
-1- silasepic porphyroskelic

Bm This horizon is moderately packed brown material with (C) vughs (100-1000μm) and (O) skew planes. The general appearance of the s-matrix is highly birefringent clay almost filling the intergranular spaces (Fig. 43c). Moderately to strongly oriented argillans (<160μm) are (C) and occur as embedded grain cutans and on almost all void surfaces. Large (500-2000μm) irregular diffuse manganiferous-sesquioxidic nodules are (VR).
-1- strong mosepic porphyroskelic

C This horizon is moderately packed brown material with (O) horizontal joint planes (<500μm wide) and (C) small vughs (usually <300μm). The general appearance (Fig. 43d) is that of highly birefringent clay almost filling the intergranular spaces and coating almost all of the sand and voids.
-1- strong mosepic porphyroskelic

SITE 5: GLEYED ELUVIATED DYSTRIC BRUNISOL ON WATER WORKED TILL (KENTVILLE, B)

Soil Name:	Kentville sandy loam.
Location:	Central Nova Scotia in the eastern portion of the Annapolis Valley. 45° 03' 52" N, 64° 29' 01" W.
Elevation:	61 m. M.S.L.
Landform:	Level morainal.
Slope:	Crest of a 2% north-facing slope.
Drainage:	Imperfect to poor.
Vegetation:	Clyde River-Halifax ecoregion; characterized by red spruce (*Picea rubens*), hemlock (*Tsuga canadensis* (L.) Carr.), white pine (*Pinus strobus* L.), balsam fir (*Abies balsamea* (L.) Mill.) and red maple (*Acer rubrum* L.). Presently under forage crops.
Climate:	Station: Kentville, C.D.A. 45° 04' N. Lat., 64° 29' W. Long. Elevation: 49 m. M.S.L. Precipitation: mean annual precipitation 108 cm of which 85 cm occurs in the form of rainfall. The season of maximum precipitation falls between April and November. Temperature: mean annual temperature is 7°C. The mean daily maximum and minimum temperatures for the month of July are, respectively, 25°C and 13°C and those for January are -1°C and -12°C.
Parent Material:	Reddish-brown coarse loamy and coarse silty water worked glacial till.
Soil Classification:	Canada: Gleyed Eluviated Dystric Brunisol, coarse loamy, mixed, neutral, cool humid family U.S.A.: Typic Eutrochrept, coarse loamy, mixed, mesic family F.A.O.: Gleyic Cambisol

Horizon	Depth	Description
Ap1	0-11	Grayish-brown (7.5YR 5/2m) brown (10YR 5/3d) sandy loam; moderate medium prismatic breaking to weak medium platy; friable to firm; abundant, fine and medium roots; common fine vertical pores; gravelly; clear smooth.
Ap2	11-25	Dark grayish-brown (10YR 4/2m) brown (10YR 5/3d) loamy sand; moderate medium prismatic, breaking to weak fine platy; friable to firm; abundant, fine and medium roots; few fine vertical pores; gravelly; clear wavy.
Aeg	25-29	Brown (7.5YR 5.5/4m) light gray (10YR 6.5/2d) sandy loam; many fine and medium distinct, strong brown (7.5YR 6/6d) strong brown (7.5YR 5/6m) mottles; moderate medium subangular blocky breaking to weak fine platy; friable; plentiful fine and medium roots; common fine horizontal pores; gravelly; abrupt wavy.
ABxgj	29-39	Reddish-brown (5YR 5/4m) light reddish-brown (5YR 6/4d) sandy loam; common, fine and medium, distinct, yellowish-red (5YR 4/8m) reddish-yellow (5YR 6/8d) mottles; moderate medium platy; breaking to moderate fine subangular blocky; firm; few thin clay films; few, very fine and fine roots; common, fine, horizontal pores; manganese concentrations; gravelly; clear wavy.
Bxjgl	39-51	Reddish-brown (5YR 4/4m) sandy loam; few, fine, distinct, strong brown (7.5YR 5/6m) strong brown (7.5YR 5/6d) mottles; moderate, medium, platy, breaking moderate, fine, subangular blocky; firm; few thin clay films; very few, micro roots; many fine, horizontal pores; manganese concentrations; gravelly; clear wavy.

Bxjg2	51-75	Reddish-brown (5YR 4/4m) sandy loam; few, fine, faint, yellowish-red (5YR 5/8m) strong brown (7.5YR 5/6d) mottles; moderate, medium, platy, breaking to moderate, fine, subangular blocky; firm; common, very thin clay films; very few, micro, roots; many, fine horizontal pores; manganese concentrations; gravelly; gradual smooth.
BC1	75-91	Yellowish-red (5YR 5/6d), yellowish-red (5YR 5/6m) sandy loam; weak to moderate, medium, platy, breaking to moderate, fine subangular blocky; friable; few, very thin, clay films; manganese concentrations; gravelly, gradual smooth.
BC2	91-103	Yellowish-red (5YR 5/6d), yellowish-red (5YR 4/6m) sandy loam; coarse pseudo-platy, breaking to weak fine subangular blocky; firm; manganese concentrations; gradual smooth.
C	103-122	Yellowish-red (5YR 5/6d) dark red (2.5YR 3/6m) sandy loam; medium pseudo-platy, breaking to weak fine subangular blocky; firm; manganese concentrations; gravelly; gradual wavy.
IIC1	122-134	Reddish-yellow (5YR 5.5/6d) yellowish-red (5YR 4/6m) sandy loam; stratified; medium pseudo-platy; firm; gravelly; gradual wavy.
IIC2	134-157	Yellowish-red (5YR 5/6d) reddish-brown (5YR 4/4m) sandy loam; stratified; medium to coarse pseudo-platy; firm; gravelly; gradual smooth.
IIC3	157-165+	Yellowish-red (5YR 5/6d) reddish-brown (5YR 4/4m) sandy loam; stratified; medium to coarse pseudo-platy; firm; gravelly.

TABLE 27. MINERALOGICAL DATA OF THE GLEYED ELUVIATED DYSTRIC BRUNISOL, KENTVILLE B, SITE 5

DONNEES MINERALOGIQUE DU BRUNISOL DYSTRIQUE ELUVIEE GLEYIFIEE, SERIE KENTVILLE B, SITE 5

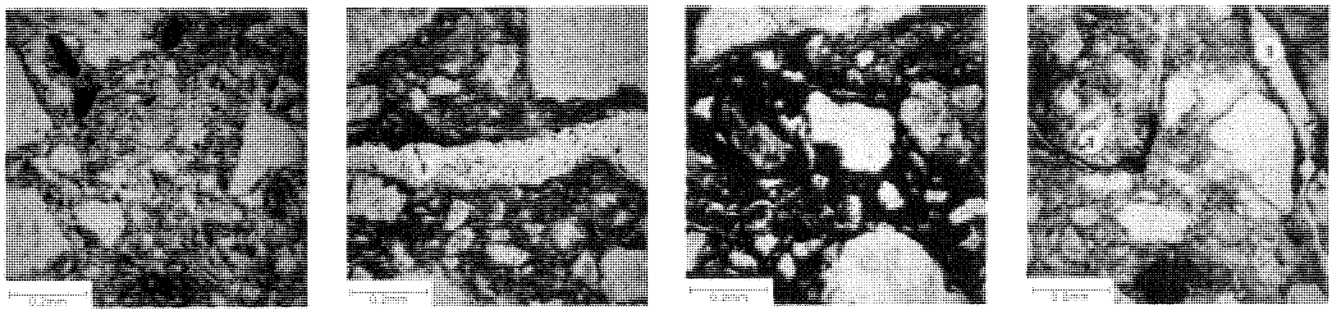
Horizon	Fraction 2-0.2um					Fraction <0.2um	
	mica	chlorite	kaolin	smectite	vermiculite	quartz	amorphous
Ap1	01	01	00	01	01	01	04
Ap2	01	01	01	01	01	01	03
Aeg		01	00	01	01	00	05
ABxgj	01		00	00	01	01	05
Bxjg1	01		00	02	01	01	03
Bxjg2	01		00	01	01	01	03
BC1	02	01	00	03		01	0
BC2	02	01	00	03		01	01
C	02	01	00	04		01	00
IIC1	02		00	03		01	02
IIC2	02	01	00	04		01	00
IIC3	02	01	00	04		01	
A+B in C	01		00	04		01	01
B fracture plane in BC	02		00	04		00	01

TABLE 28. ANALYTICAL DATA OF THE GLEYED ELUVIATED DYSTRIC BRUNISOL (KENTVILLE, B), SITE 5
DONNÉES ANALYTIQUES DU BRUNISOL DYSTRIQUE ÉLUVIÉ GLEYIFIÉ (KENTVILLE B), À SITE 5

Horizon	pH $CaCl_2$	pH H_2O	Org. Matter Loss on ign. / matière organique perte au feu %	Org. C / carbone organique %	Exchangeable Cations / Cations échangeables, Buffered - Tamponnée (meq/100g) Ca	Mg	K	Na	C.E.C. / Capacité d'échange cationique meq/100g
Ap1	6.2	5.8	5.0	2.90	7.12	3.02	.59	.30	14.7
Ap2	5.7	5.9	3.7	1.46	5.21	1.53	.13	.33	13.1
Aeg	5.0	5.6	1.9	.76	2.86	1.00	.11	.27	10.6
ABxgj	4.7	5.2	1.8		2.93	1.15	.13	.27	11.6
Bxjg1	5.2	5.7	2.0	.37	7.57	2.60	.19	.35	12.3
Bxjg2	4.9	5.5	1.7	.41	6.23	3.20	.21	.37	10.7
BC1	6.0	6.9	1.7	.22	7.38	2.31	.14	.32	13.8
BC2	6.1	7.1	1.5	.17	6.30	1.93	.14	.40	11.7
C	6.6	7.3	1.3	.23	7.70	2.35	.19	.40	13.1
IIC1	7.3	8.0	1.1	.04	12.08	1.36	.17	.44	10.6
IIC2	6.6	7.1	1.1	.06	5.28	1.30	.14	.40	13.1
IIC3	6.2	6.8	1.3	.02	5.79	1.43	.18	.37	12.3
A+B in C	5.8	6.5	1.0	.16	5.79	1.68	.11	.35	8.1
B in BC	6.2	6.8	0.8	.03	3.63	1.00	.10	.40	11.5

Horizon	Pyrophosphate Fe %	Pyrophosphate Al %	Moisture / Humidité 1/3 atm. %	Bulk Density / Densité apparente g/cm^3	Saturated Hydraulic Conductivity / Conductivité hydraulique saturée cm/hr	>2mm %	Particle Size Distribution - Analyse granulométrique, Sand - Sable (% <2mm) VSC	CS	MS	FS	VFS	Total	Silt / Limon	Clay / Argile
Ap1	.18	.16		1.53	.005	10.9	10.67	13.64	10.23	19.35	12.71	66.6	21.3	12.1
Ap2	.17	.13	29.0	1.85	1.18	17.6	11.52	16.29	11.47	22.46	13.36	75.1	18.1	6.8
Aeg	.13	.20	24.1	1.75	5.26	15.4	11.82	13.34	8.65	17.36	10.92	62.1	27.3	10.6
ABxgj	.07	.17		1.77	.81	6.7	9.89	11.99	9.12	18.88	11.62	61.5	25.3	13.2
Bxjg1	.03	.13	21.2	1.82	1.41	12.8	11.67	15.14	10.59	19.38	9.31	66.1	19.4	14.5
Bxjg2	.03	.10		1.90	11.80	10.7	12.15	15.40	10.88	18.52	8.94	65.9	20.1	14.0
BC1	.02	.10	18.2	1.95	.03	15.7	9.96	15.67	11.59	20.80	9.08	67.1	15.8	17.1
BC2	.02	.10		1.94	.26	18.6	10.77	18.03	12.26	20.55	7.99	69.6	14.7	15.7
C	.02	.06	17.9	2.10	.023	10.3	12.40	18.11	12.21	20.87	7.40	71.0	14.4	14.6
IIC1	.02	.08		2.00		2.9	11.65	19.05	12.21	20.23	8.46	71.6	15.7	12.7
IIC2	.01	.06				8.5	12.96	18.55	11.22	18.30	8.97	70.0	17.2	12.8
IIC3	.02	.08				4.6	9.46	12.07	7.94	21.16	10.48	61.1	26.1	12.8
A+B in C	.02	.10		1.94	.14	11.7	11.16	16.11	13.27	27.33	12.23	80.1	15.1	4.8
B in BC	.02	.06				10.7	10.40	14.45	12.37	29.47	15.51	82.2	11.0	6.8

Figure 44. Micromorphology of the Kentville B soil at Site 5.



a. plane light b. plane light c. plane light d. plane light

Ap2 This horizon is light brown material consisting mainly (75%) of dense to moderately packed material (Fig. 44a) with (C) vughs (100-1000μm with most 300-400μm) and channels. The remaining areas are loosely packed skeleton grains with incomplete intergranular material. Brown to black organic material (<3mm) is (0-C) and most is fine (<80μm) and embedded in the s-matrix. Sepic matrans are (0) being more noticeable in the loose areas. Sesquioxidic nodules (50-1000μm) are (VR) and the larger ones (>400μm) are sharp while the smaller are diffuse.
-1- weak argillasepic porphyroskelic
-2- matrigranoidic porphyroskelic

Aeg This horizon is dense to moderately packed pale grayish brown material with (C) vughs (100-1500μm with most 300μm) and (R-0) skew planes and channels. Sesquixodic nodules (100-3000μm) are (C) and generally diffuse and irregular. Strongly weathered basic volcanic rock fragments are (C) as gravel and coarse sand appear as macro-sesquioxidic or ferruginous nodules. Brown to black organic material (100-2000μm) is (0), and most of it is embedded in the s-matrix. Vughs and embedded grain moderately oriented argillans (<80μm) are (R) and material of similar appearance is (0) as patches (<200μm) and stringers (<1000μm) (clay nodules).
-1- weak argillasepic porphyroskelic

Bxjg1 This horizon is dense to moderately packed material with (C) vughs (100-1500μm), (0) horizontal joint planes, and (0) skew planes. The colour varies from brown to very dark brown depending on the amount of sesquioxides, iron rich clay, and, in some cases, manganese oxides. This variation occurs as (F) large diffuse nodules that appear to grade into each other. Cutans (<160μm) are (C) and consist, in decreasing order of abundance, of moderately to strongly oriented argillans, compound argillans-ferriargillans, thin ferriargillans (<40μm), some thin ferrans (<25μm), and some thin mangans (<25μm). Vugh cutans are more abundant than planar void cutans.
-1- skel-mosepic porphyroskelic

Bxjg2 This horizon is dense brown material with (0) vughs (100-1000μm), (0) horizontal joint planes (Fig. 44b), and (0) skew planes. Large (<5mm) diffuse nodules (Fig. 44c) are (0) and consist of sesquioxides with some manganese oxides. Cutans are (0) with moderately to strongly oriented argillans (<120μm) more abundant than thin (<50μm) ferriargillans, compound argillans-ferriargillans, and mangans. Planar void cutans (1 in Fig. 44b) are more abundant than vugh cutans. The clay in the s-matrix is highly birefringent. There is (R-0) gravel (shale, basic volcanic rock, and sandstones).
-1- strong skel-mosepic porphyroskelic

BC1 This horizon is dense brown material with (0) vughs (100-1000μm) and (0) horizontal joint planes (Fig. 44d). Cutans are (R-0), consist of thin (<50μm) mangans (1 in Fig. 44d) and moderately oriented argillans, and occur mostly on the planar voids. Irregular diffuse manganiferous nodules (100-300μm) are (R). The clay in the s-matrix is highly birefringent.
-1- skel-mosepic porphyroskelic

IIC3 This horizon is dense brown material with (0) vughs (100-1500μm) and (0) horizontal joint planes. Cutans are (R) consisting mainly of moderately oriented vugh argillans (<50μm) with some planar void argillans and neoargillans (<120μm). Irregular diffuse sesquioxidic nodules (.5-2mm) are (VR). The clay in the s-matrix is highly birefringent and there appears to be more coarse sand in this horizon than in those above.
-1- skel-mosepic porphyroskelic

SITE 6: FERRO-HUMIC PODZOL ON LAURENTIAN TILL (LAURENTIDES)

Soil Name:	Laurentides loamy sand
Location:	Average hill (local relief, 150 to 200 m) Lat. 47° 16' N., Long. 71° 9' 30" W.
Altitude:	700 m M.S.L.
Landform:	Hill with moraine mantle
Gradient:	15%, slope top
Drainage:	Well drained
Vegetation:	Balsam fir (*Abies balsamea* L.), white birch (*Betula papyrifera* Marsh.), white spruce (*Picea glauca* (Moench) (Voss.), and occasionally, black spruce (*Picea mariana* (Mill.) BSP.), ferns (*Dryopteris spinulosa*) and other acidophiclic grasses, including *Oxalis montana*.
Climate:	Montmorency Forest forestry station Lat. 47° 19' N., Long. 71° 09' W. Altitude: 670 M.S.L. Precipitation: mean annual precipitation 140 cm including 47 cm as snow. Temperature: the mean maximum and minimum temperatures are 20°C and 7.7°C respectively for July and -9°C and -22°C for January.
Matrix material:	Glacial till, loamy sand
Soil Classification:	Canada: Orthic Ferro-Humic Podzol, mixed, acid, sandy cool humid family U.S.A.: Humic Cryorthod, mixed, sandy family F.A.O.: Orthic Podzol

Horizon	Depth	Description
Bhf1	5-11	Very dark reddish brown (5YR 2/2 m), dark brown (7.5YR 3/2 d); sandy loam; fine to medium granular; friable; few fine and medium roots; abrupt wavy boundary; 2 to 12 cm thick; pH 3.9.
Bhf2	11-17	Dark reddish brown (2.5YR 2/4 - 5YR 3/2 m), brown (7.5YR 4/4 d); sandy loam, weak, very fine to medium, granular; loose, firm in places; few, fine to medium roots; clear wavy boundary; 3 to 7 cm thick, pH 4.4.
Bf1	17-27	Dark brown to dark reddish brown (7.5YR 4/4 - 5YR 4/4 m), yellowish brown (10YR 5/4 d); loamy sand; fine and medium granular to fine subangular blocky; few, very fine roots; clear smooth boundary; 7 to 12 cm thick; pH 4.6.
Bf2	27-40	Dark yellowish brown (10YR 4/4 m), light yellowish brown (10YR 6/4 d); sandy loam; fine to medium subangular blocky; gradual smooth boundary; 10 to 15 cm thick; pH 4.7.
BC	40-56	Olive brown (2.5Y 4/4 m), light yellowish brown (2.5Y 6/4 d); loamy sand; fine and medium subangular blocky to medium platy; gradual smooth boundary; pH 5.0.
Cx	56-120	Olive to dark olive (5Y 4/3-5Y 3/3 m; 5Y 5/3 d); loamy sand; weak coarse pseudoplaty; firm, hard; some stones; pH 5.

TABLE 29. MINERALOGICAL DATA OF THE ORTHIC FERRO HUMIC PODZOL, LAURENTIDES SERIES
MINERALOGIE DU PODZOL FERRO-HUMIQUE ORTHIQUE, SERIE LAURENTIDE

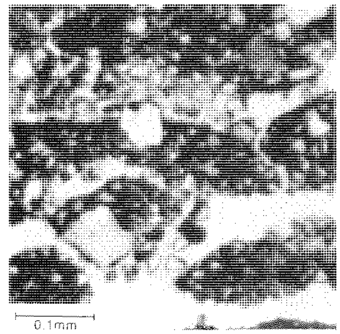
Horizon	Fraction 250-100µm						
	quartz	feldspar	magnetite -ilmenite	Hypersthene	Hornblende	Augite	Others -autres
Ae	03	02	01	01	00	00	00
Bhf1	03	02	01	01	01	01	00
Bhf2	03	02	01	01	01	01	01
Bf1	03	03	01	01	01	00	00
Bf2	03	02	01	01	01	00	00
Bc	03	02	01	01	01	00	01
Cx	03	02	01	01	01	00	01

TABLE 30. ANALYTICAL DATA OF THE ORTHIC FERRO-HUMIC PODZOL (LAURENTIDE), SITE 6
DONNEES ANALYTIQUES DU PODZOL FERRO-HUMIQUES ORTHIQUES (LAURENTIDES) A SITE 6

Horizon	pH $CaCl_2$	Tot. N %	Org. Matter Loss on ign. / matière organique perte au feu %	Exchangeable Cations / Cations échangeables, Buffered - Tamponnée: Ca (meq/100g)	Mg (meq/100g)	K (meq/100g)	C.E.C. / Capacité d'échange cationique: Buffered / Tamponnée meq/100g	P. Charge / Charge permanente	Pyrophosphate Fe %	Pyrophosphate Al %	Oxalate Fe %	Oxalate Al %	Dithionite Fe %	Dithionite Al %
Ae	3.5	0.05	1.15	0.36	0.16	0.11	2.8	2.45	0.02	0.02	0.05	0.02	0.02	0.02
Bhf1	3.6	0.50	15.70	0.51	0.27	0.21	108.0	33.04	3.31	1.50	3.63	1.14	3.53	1.42
Bhf2	4.1	0.36	13.77	0.47	0.14	0.11	78.0	16.81	2.36	3.39	2.75	2.79	2.95	3.53
Bf1	4.2	0.22	6.55	0.50	0.12	0.06	49.7	6.20	1.48	2.83	1.87	2.40	2.12	3.01
Bf2	4.3	0.12	2.77	0.55	0.12	0.06	31.0	3.74	0.56	0.94	1.02	1.51	1.24	1.58
BC	4.3	0.06	1.00	0.55	0.14	0.08	16.8	2.37	0.17	0.58	0.57	0.97	0.77	0.63
Cx	4.7	0.02	0.94	0.57	0.13	0.09	9.0	1.29	0.03	0.22	0.45	0.53	0.54	0.32

Horizon	Particle Size Distribution - Analyse granulométrique, Sand - Sable: VCS	CS	MS % <2mm	FS	VFS	Total	Silt / Limon	Clay / Argile	Moisture / Humidité: Max %	1/3 atm %	1 atm %	15 atm %	Saturated Hydraulic Conductivity / Conductivité hydraulique saturée cm/hr	Bulk Density / Densité apparente g/cm^3
Ae	8	13	13	29	16	79	20	1	70.2	29.1	26.1	6.7	102	0.98
Bhf									76.3	32.3	29.4	11.4	56	0.75
Bhf1	7	13	14	24	14	72	21	7						
Bhf2	8	12	13	24	15	72	19	9						
Bf1	9	15	13	24	17	78	17	5	60.2	26.1	22.0	7.3	29	1.36
Bf2	9	14	11	20	14	68	27	5	49.7	21.4	16.4	4.6	24	1.39
BC	4	11	11	25	20	71	27	2						
Cx	7	14	13	27	19	80	18	2						

Figure 45. Micromorphology of the Ferro-Humic Podzol (Laurentides) at Site 6.



plane light

L-F-H This horizon contains loosely packed plant residues. Of these, some have kept their original morphology, most are in the process of humification (Bal's coniatic arrangement), some are highly humified (Bal's coniatic arrangement), some are highly humified (Bal's phellemic arrangement), and none is completely humified. The humifying material is reddish brown. Some of the largest residues are hollow inside and these vughs contain reddish brown fecal pellets (100-80μm in diameter). The plant residues tend to assemble into diffuse globular accumulations. There are some areas with diffuse boundaries where the beginnings of a mixture of organic residues and mineral grains can be seen.
-1- phyto-humigranic

Ae The horizon contains rather dense (20% porosity) angular grains. It is 2-5% gravels (quartz and quartz-dominated rock fragments). Very coarse-grained and coarse-grained sand (same mineralogical composition as the gravels) is present. Medium sands to coarse-grained silts: feldspars (orthoclase, plagioclases, perthite, myrmekite) and quartz dominate; pyroxene, hornblendes and opaques are present; the surface of the minerals, except for the opaques and the quartz, is irregular and jagged; many of the perthites have circular to elongated spaces, which once were probably the location of the sodic plagioclases; the minerals are often cracked and even broken. Fine silts and clays form a polymorphous basal mass; some quartz grains, feldspar, micaceous flakes, strongly contrasting ferruginous and organic particles and a mass of fine light gray particles are distinguishable. This basal mass displays a tendency to agglomerate. There are some roots, some of which are in the process of humification. There are a very small number of inherited nodules (1-2mm), from the plasmic silasepic vo-skelsepic aggregate, consisting of sands, silts and clays.
-1- granular to agglomeroplasmic
-2- humigranic - silasepic matrigranoidic - orthogranic

Bfh1-Bfh2 This horizon contains loosely packed material (35% porosity at the summit of the horizon) which becomes more dense at the bases of cracked gravels (granite fragments) and often cracked sands (granite, quartz and feldspar fragments); most of the cracks are filled in with illuviated material; the surface of the grains is often rough. Reddish brown humifying roots (coniatic aggregate). Fragments of humifying to fully humified plant tissues (15%) (pleistoplasmatic aggregate). Orthic nodules (70-200μm) of the plasmic/silasepic type, varying in shape from circular to elongated and round to subangular, yellowish brown at the top, dark brown in the middle and brownish yellow at the base of the horizon, composed of organic matter, very fine grains of sand, silt, and clay (which are the result of podzolization) some randomly distributed micaceous flakes the size of the silt particles. Inherited nodules of the silasepic vo-skelsepic type (pediorelic) are present; their number increases with depth, their shape varies, size is from 0.01 to 2mm; composed of granis of sand (feldspars, quartz, hornblende, pyroxenes, opaques), silts and clay, some randomly distributed micaceous flakes the size of the silt particles; these nodules are similar to the inherited nodules found in the Ae horizon. All the units in this horizon are covered with matrans (50μm), reddish brown in colour; the matrans are either continuous or hat-shaped.
-1- agglomeroplasmic
-2- humigranic-matrichlamydic-matrigranic

Bf1-Bf2 These units are similar to those described above, but the surface of the grains is not so rough, and there are fewer cracks. There are a small number of roots in various stages of humification. Fully humified plant fragments the size of large silt particles are present. A lesser number of brownish yellow nodules, which are frayed in appearance, are present. Yellowish brown basal mass, with random basic relative distribution of elements. Inherited nodules similar to those previously described, of the plasmic silasepic vo-skelsepic type, are found here in greater abundance; they range in shape from elliptical to horizontally elongated and in diameter from 1 to several millimetres; at the base of Bf2 they are very abundant. The units are surrounded with matrans, which are often fragmented; the components of the matrans are similar to those of the orthic nodules; plasmic silasepic skelsepic aggregate; continuous or hat-shaped matrans.
-1- Bf1: agglomeroplasmic
-1- Base of Bf2: porphyroskelic silasepic with vertical and horizontal joint planes
-2- Bf1: humigranic - silasepic skelsepic matrichlamydic - matrigranic
-2- Top of Bf2: matrichlamydic - matrigranoidic
-2- Base of Bf2: partly accommodated matrigranoidic - matrifragmic

Bc Horizontal layered organization alternating between horizontally elongated fragments and horizontal planes from 0.1 to 3mm in width. Gravels, sands and silts similar to those described in Bf2 are present. Porosity here exceeds 30%. Fragment thickness varies from a few hundred microns to a few millimetres, and the major axis may be up to one centimetre; the components of these fragments and their aggregates are similar to those of the inherited nodules of the upper horizons; they are yellowish gray in colour. Orthic nodules are situated, locally and very partially, in the spaces; the s-matrix is comparable to that of the inherited nodules in Bf2. The gravels are cracked here as well. There are continuous or hat-shaped matrans on the upper portions of some large grains.
-1- porphyroskelic silasepic with vertical and horizontal joint planes.
-2- layered silasepic skelsepic matrichlamydic/matrifragmoidic

C Horizontal layered organization, more regular and finer than in the BC horizon, alternating between fragments on the order of from 200 to 500μm long, with some specimens of as much as a centimetre, and horizontal planes 100 to 300μm wide. The composition of these fragments is similar to that of those in the BC horizon. There are continuous or hat-shaped matrans, with the cap not necessarily at the top of the grain.
-1- porphyroskelic silasepic with horizontal joint planes
-2- layered silasepic skelsepic matrichlamydic/matrifragmoidic

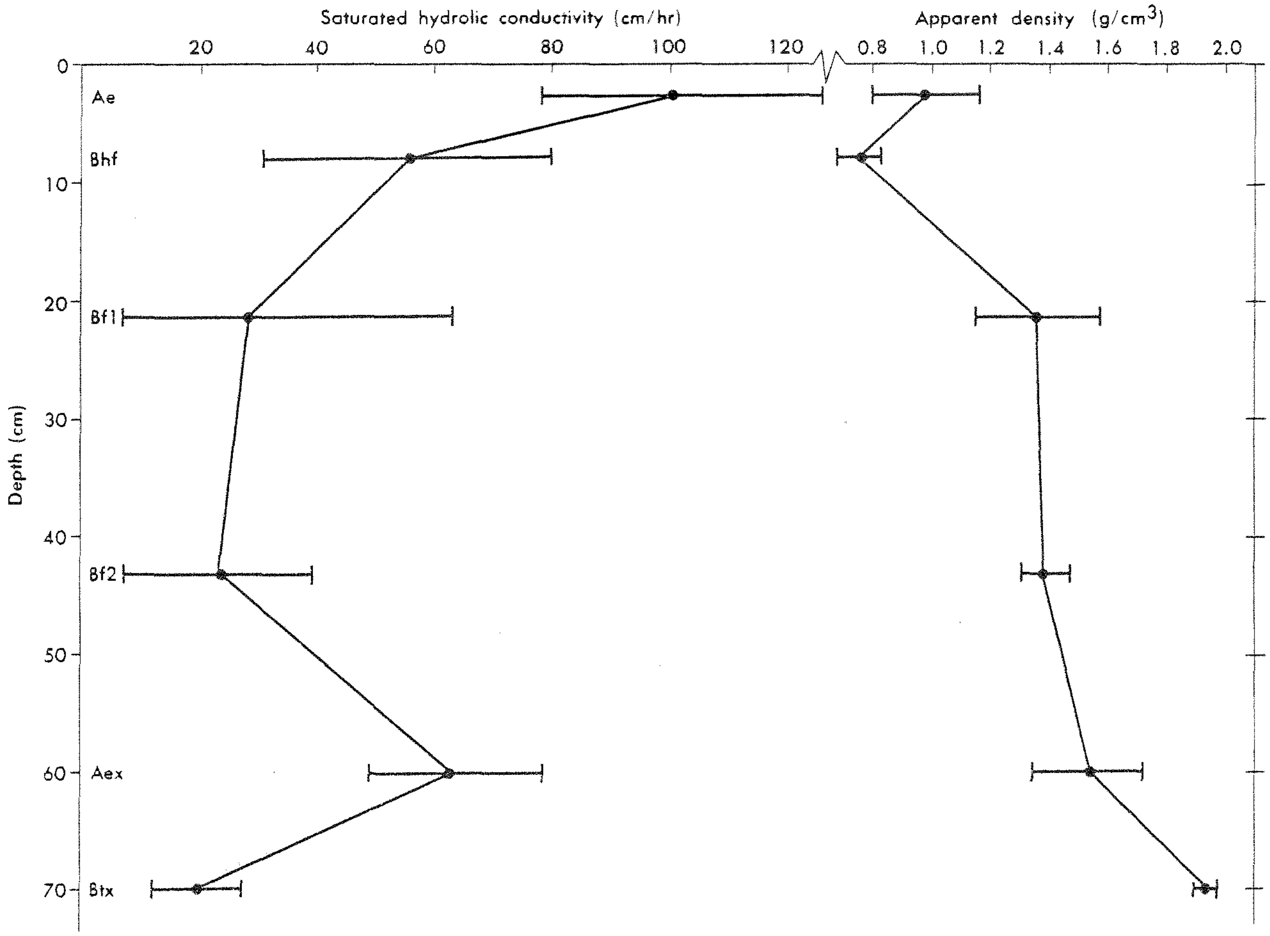


FIG. 46 LAURENTIDE PROFILE

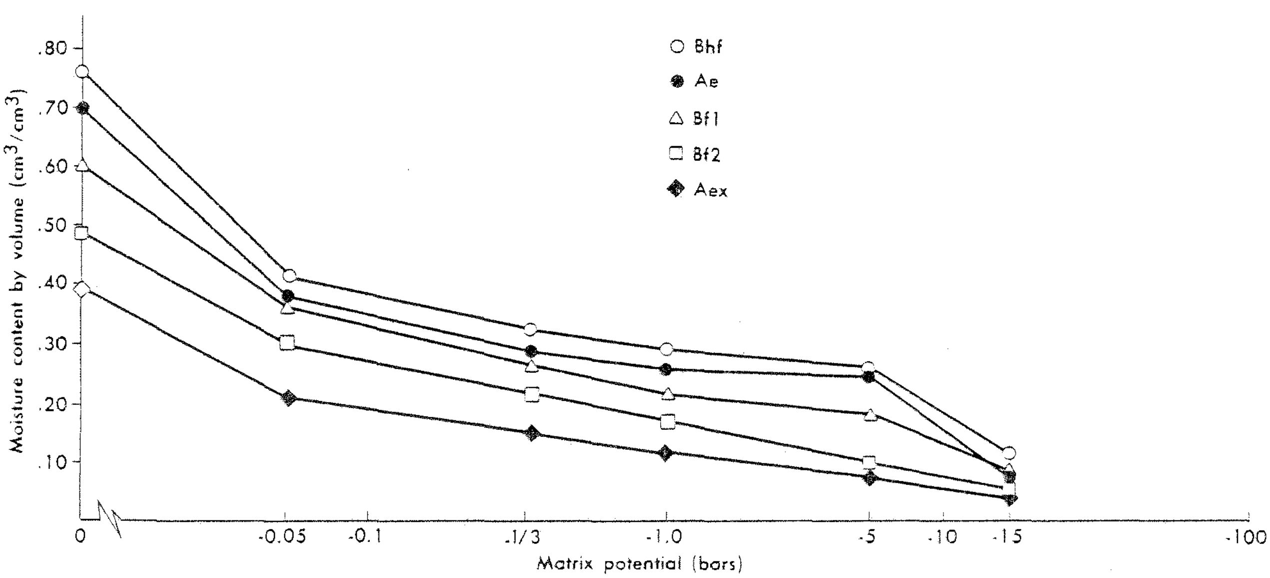


FIG. 47 MOISTURE RETENTION CURVE FOR LAURENTIDE PROFILE

A. Minerology of sand fraction 0.25-0.1 mm of Laurentide profile*

	Horizon				
	Ae	Bhf	Bf1	Bf2	Cx1
Light minerals					
(d<2.96)	82	79	83.5	81	79
Quartz	59	54	45.5	52.5	43
Feldspars	23	25	38	28.5	36
Heavy minerals					
(d>2.96)	18	21	16.5	19	21
Magnetite Ilmenite	9	9	5.5	8.5	8
Hypersthene	4	5	3	3	4
Hornblende	2	3	3	4	4
Augite	2	3	2.5	2	2
Other	1	1	2.5	1.5	3

*Expressed in % by weight (oxides of iron and organic matter removed)

Minerologic analysis by R. Ledoux and J. Trencia

B. X-ray diffractogram of clay fraction (< 2μm) of Laurentide profile: Ae and Bhf 400 cps; Bf1, Bf2 and Cx,200 cps; Cu radiation 40Kv, 20mA

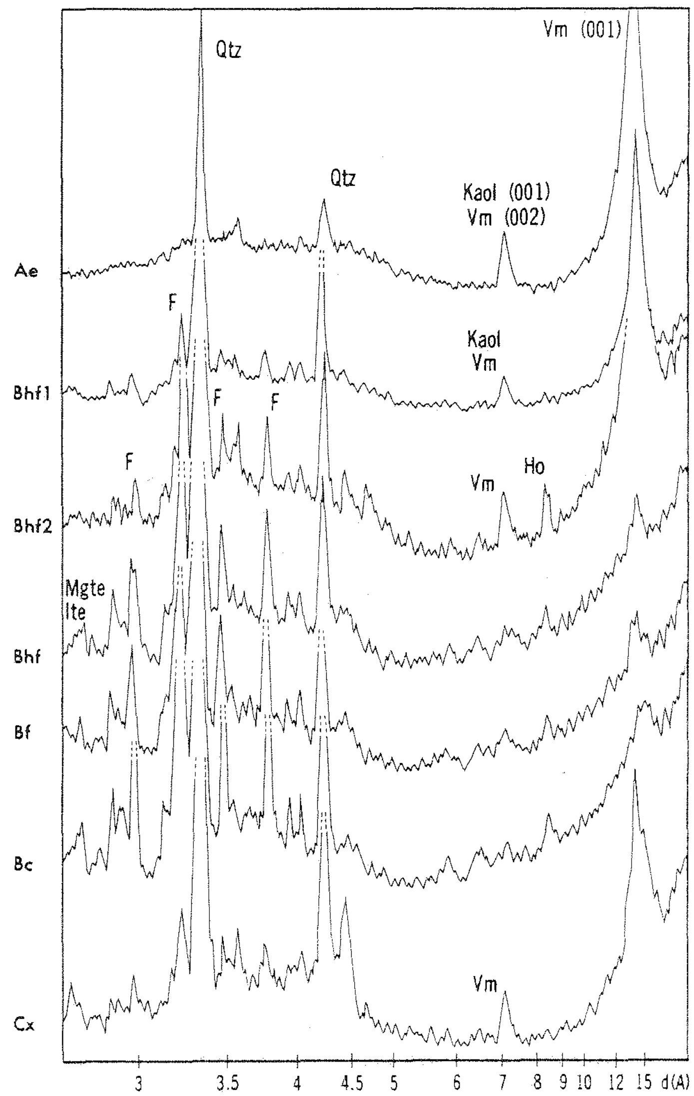


FIG.48

SITE 7: ORTHIC HUMIC GLEYSOL ON MARINE CLAY (STE-ROSALIE)

Soil Name:	Ste-Rosalie clay loam
Location:	Michon Farm, St. Thomas d'Aquin, St. Hyacinthe county. Lat. 45^{o} 39' 20" N., Long. 72^{o} 58' 15" W.
Altitude:	36 m M.S.L.
Landform:	Horizontal marine
Gradient:	Gradient 0.5%, midslope, northern exposure
Drainage:	Poorly drained
Vegetation:	Field crops. White elm (*Ulmus americana* L.), ash (*Fraximus* sp.), and red oak (*Quercus rubra* L.).
Climate:	St. Hyacinthe station Lat. 45^{o} 38' N., Long. 72^{o} 57' W. Altitude: 31 m M.S.L. Precipitation: the mean annual precipitation is 980 mm evenly distributed over the year. Temperature: the mean maximum and minimum temperatures are 26 C and 15 C respectively for July and -5 C and -15 C for January.
Matrix Material:	Moderately acid to neutral marine clay
Soil Classification:	Canada: Orthic Humic Gleysol, very fine clayey, mixed, neutral; mild subaquic family. U.S.A.: Typic Haplaquoll (Cryaquoll), very fine clayey; mixed, mesic family F.A.O.: Humic Gleysol

Horizon	Depth	Description
Ap	0-20	Very dark grayish brown (10YR 3/2) clay loam; strong fine granular; firm, friable, plastic, sticky; permeable; abundant fine vertical roots; abrupt smooth boundary.
(Aeg)		Traces. Mixed with Horizon Ap.
Bg1	20-25	Dark grayish brown (2.5Y 4/2) clay; many, medium, distinct yellowish brown mottles (10R 5/6); weak, medium angular blocky; plastic, sticky; common, fine, vertical roots between aggregates; gradual smooth boundary.
Bg2	25-31	Olive gray (2.5Y 5/2) clay; many, medium, distinct yellowish brown mottles (10YR 5/6); moderate medium angular blocky; plastic, sticky; common, fine, vertical roots; gradual smooth boundary. Mainly distinguished from horizon Bg1 by moderate development of its structure.
Bg3	.31-71	Olive gray (5Y 5/2) clay; common, distinct yellowish brown mottles (10YR 5/6); moderate, medium angular blocky; plastic, sticky, slightly friable; gradual smooth boundary; abundant pores throughout aggregate clusters.
Cg	71-90	Olive gray (5Y 5/2) clay; moderate coarse angular blocky; plastic, sticky, slightly friable; gradual smooth boundary; abundant fine pores throughout the aggregate clusters.

Ckg1	9-120	Olive gray (5Y 5/2) clay; coarse to very coarse angular pseudoblocky; plastic, sticky, slightly friable; abundant fine pores with no particular orientation; weakly effervescent. Aggregates do not separate readily from one another.
Ckg2	120-141	Same description as for Ckg1 except that structure consists of coarse to very coarse angular pseudoblocks. Water table at 120 cm.
Ckg3	141-179	Same description as for Ckg2; very coarse primary structure.
Ckg4	179-190	Same characteristics as for Ckg3 and gradual disappearance of structure forms; liquid and sticky clay at 190 cm.

TABLE 31. MINERALOGICAL DATA OF THE ORTHIC HUMIC GLEYSOL, STE-ROSALIE SERIES
MINERALOGIE DU GLEYSOL ORTHIQUE HUMIQUE, SERIE STE-ROSALIE

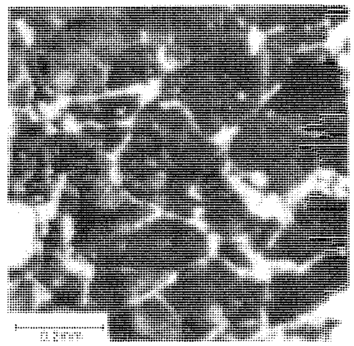
Horizon	Fraction 50-2µm						Fraction 2-0.2µm					Fraction <0.2µm		
	quartz	feldspar	illite	chlorite	hornblende	smectite	quartz	feldspar	illite	chlorite	smectite	illite	chlorite	smectite
Ap1	03	02	01	00	01		03	02	01	01	01	03	03	02
Ap2	03	02	01	01	01		02	02	01	01	01	03	02	02
Bg1	03	02	01	01	01	01	02	02	01	01	01	02	02	02
Bg2	02	02	01	01	01	01	02	02	01	01	01	02	02	03
Bg3	03	02	01	01	01	01	02	02	01	02	01	02	02	03
Cg	02	02	01	01	01	01	02	02	01	02	01	02	02	03
Ckg1	02	02	01	02	01	01	02	02	01	02	01	02	03	02
Ckg3	02	02	01	02	01	01	02	02	01	02	01	02	03	01
Ckg4	02	02	01	02	01	01	02	02	01	02	01	02	03	01

TABLE 32. ANALYTICAL DATA OF THE ORTHIC HUMIC GLEYSOL (STE-ROSALIE), SITE 7
DONNEES ANALYTIQUES DU GLEYSOL ORTHIQUE HUMIQUE, STE-ROSALIE, SITE 7

Horizon	pH $CaCl_2$	pH H_2O	Org. C carbone organique %	Tot. N %	$CaCO_3$ Eq. %	Exchangeable Cations - Cations échangeables: Neutr. Salt - Sel Neutre. Ca (meq/100g)	Neutr. Salt - Sel Neutre. Mg (meq/100g)	Buffered - Tamponée Ca (meq/100g)	Buffered - Tamponée Mg (meq/100g)	K (meq/100g)	C.E.C. Capacité d'échange cationique Buffered - Tamponnée meq/100g	Dithionite Fe %	Dithionite Al %	Dithionite Mn %	Fertility Analysis - Analyses de fertilité: Inorg. P ppm	Avail. K - K assimilable ppm
Ap1	5.7	6.1	2.2	0.2	0.6	10.2	2.6	9.4	2.2	0.4	15.0	0.7	0.1	0	40.0	137.5
Ap2	6.1	6.6	2.0	0.2	1.6	11.1	2.3	11.0	2.3	0.4	15.6	0.7	0.1	0	30.0	150.0
Bg1	6.4	7.1	0.4	0.1	1.2	16.2	6.6	17.5	7.4	0.4	26.8	1.5	0.2	0	9.0	137.5
Bg2	6.4	6.9	0.5	0.1	1.2	17.3	7.8	19.8	9.4	0.4	31.4	1.3	0.2	0	10.5	135.0
Bg3	6.3	7.2	0.5	0.0	1.3	16.9	11.8	18.0	12.3	0.5	32.8	1.3	0.2	0	10.0	212.5
Cg	6.3	7.6	0.4	0.0	2.8	13.0	11.1	13.0	10.9	0.8	25.3	0.7	0.1	0	17.0	300.0
Ckg1	7.5	8.1	0.4	0.0	4.0	13.7	7.6	19.2	9.7	0.6	29.7	0.5	0.1	0	3.0	250.0
Ckg2	7.5	8.1	0.5	0.0	4.5	13.3	7.1	29.0	9.1	0.6	38.8				3.5	250.0
Ckg3	7.6	8.1	0.5	0.0	4.2	13.2	7.1	28.0	9.1	0.7	37.9				4.5	275.0
Ckg4	7.6	8.1	0.5	0.0	4.7	13.1	7.1	28.0	9.1	0.7	37.9				4.0	287.5

Horizon	Particle Size Distribution - Analyse granulométrique: Sand - Sable VCS (% <2mm)	CS	MS	FS	VFS	Total	Silt Limon Total	Clay Argile Total	(<0.2u)	Bulk Density Densité apparente g/cm³	Moisture Humidité 1/3 Atm. %	15 Atm. %	Saturated Hydraulic Conductivity - Conductivité hydraulique saturée cm/hr
Ap1	2	6	8	12	8	36	34	30	10	1.52	20.2	9.3	11.7
Ap2	2	5	5	12	8	35	37	28	10				
Bg1	1	5	5	8	5	25	22	53	17	1.42	25.7	19.8	50.0
Bg2	1	4	4	6	5	20	23	57	17	1.30	29.2	24.1	74.3
Bg3	0	0	0	1	1	3	23	74	21	1.30	32.0	23.2	40.0
Cg						0	22	78	19	1.31	36.0	23.4	13.6
Ckg1						0	25	75	14	1.15	44.3	23.4	5.4
Ckg2						0	27	73	16				
Ckg3						1	28	72	16				
Ckg4						0	29	71	12				

Figure 49. Micromorphology of the Orthic Humic Gleysol (Sainte-Rosalie) at Site 7.



plane light

Ap Clays, silts and sands form a polymorphous basal mass. The argillaceous minerals, which are highly birefringent, are constituted mainly of micas. The larger grains, normally 0.5mm, in decreasing order of abundance, include quartz, orthoclase, microline, sodic plagioclases, green hornblende and secondary calcite. These grains are rounded to subangular. Their concentration here is low: the plasmic aggregate is vo-ma-mosepic; the argillaceous mass is crossed by skew planes and contains many argillaceous concretions (0.5-1.0mm) - continuous extinction - often tinged with iron oxides and/or hydroxides. In places where sand grains are abundant, the basal mass is crossed by skew planes and contains many vughs; the plasmic aggregate is agillasepic. Nodules (0.1-2.0mm) rich in iron oxides and/or hydroxides are present. The upper portion of the Ap horizon contains many fecal pellets left by earthworms; in the lower portion, the fecal pellets are concentrated uniquely in elongated vughs (pedotubules). The organic materials are either fresh (recent growth) or highly humified (old growth); the decomposed organic matter is quickly integrated into the s-matrix.
-1- porphyroskelic vo-ma-mosepic with skew planes and vughs
-2- mullgranic/matrifragmoidic/porphyroskelic with skew planes and vughs

Bg1-Bg2 The mineral composition here is similar to that in the Ap horizon. There are fewer large grains, and these are concentrated in certain places in the soil. The structure is well developed; the primary peds (0.5-2.00mm) form well-defined polygons with four or five sides. There are more nodules rich in iron oxides and/or hydroxides than in the Ap horizon; these nodules are usually less than 0.5mm in size. Argillaceous concretions - continuous extinction - are practically non-existent. Ped and nodule neostrians are often found. Organic tissues are rare and highly humified. There are few fecal pellets. The peds in Bg2 are better accommodated than those in Bg1.
-1- porphyroskelic vo-in-clino-bimasepic with joint planes, chambers, channels and vughs
-2- mullgranic/matrifragmic

Bg3 The micromorphology of this horizon differs from that of Bg2 in the following respects: the absence of areas of large grains, the absence of argillaceous concretions, the smaller size of its primary peds (4mm and smaller), the absence of organic matter and the presence of the fragmic aggregate.
-1- porphyroskelic vo-in-clino-bimasepic with joint planes, chambers, channels and vughs
-2- matrifragmic aggregate

SITE 8: TYPIC MESISOL ON ORGANIC MATERIALS (LANSON)

Soil Name:	Lanson.
Location:	5.2 miles (8.4km) by road south of Ste-Clothilde de Chateauguay, Hemingford township, Huntingdon county. 45° 06' N. Lat., 73° 39' 45" W. Long.
Elevation:	58 m M.S.L.
Landform:	Horizontal fen., mesic.
Slope:	0%
Drainage:	Very poorly drained.
Vegetation:	Most vegetation has been removed. Dominant tree species are birch (*Betula* sp.), tamarack (*Tsuga canadensis*), white pine (*Pinus strobus*) and red maple (*Acer rubrum*).
Climate:	Station: Ste-Clothilde C.D.A. 45° 10' N. Lat., 73° 41' W. Long. Elevation: 56 m. M.S.L. Precipitation: mean annual precipitation is 954 mm with a maximum in July. Temperature: mean annual temperature is 5.8 C. The mean daily maximum and minimum temperatures for the month of July are, respectively 26.2 C and 13.8 C and those for January are -5 C and -14.8 C.
Parent material:	Strongly acidic organic on marine (lacustrine) clay loam.
Soil Classification:	Canada: Typic Mesisol, humic, euic, mild peraquic family. U.S.A.: Typic Medihemist, euic, mesic family F.A.O.: Dystric Histosol

Horizon	Depth	Description
Omp	0-34	Horizon dry; black (5YR 2.5/1) pressed wet oxidized; highly decomposed; abrupt smooth boundary.
Om1	34-44	Horizon moist; black (5YR 2.5/1) pressed wet oxidized; 50% wood fragments; slightly decomposed; soft woody material 50 cm thick, >50% by volume; pyrophosphate index 0; clear smooth boundary.
Om2	44-77	Horizon moist; black (5YR 2.5/1) pressed wet oxidized; 40-50% sedge and reed and wood fragments; moderately decomposed; soft woody material 5 cm thick, 20-50% by volume; pyrophosphate index 0; gradual smooth boundary.
Om3	77-107	Horizon wet; black (5YR 2.5/1) pressed wet oxidized; 40% sedge and reed; moderately decomposed; pyrophosphate index 0; gradual smooth boundary.
Om4	107-136	Horizon wet; dark reddish gray (5YR 4/2) natural wet reduced; black (5YR 2.5/1) natural wet oxidized; 40% sedge and reed; moderately decomposed; pyrophosphate index 0; gradual smooth boundary.
Om5	136-170	Horizon wet; dark brown (7.5YR 3/2) natural wet reduced; dark reddish brown (5YR 2.5/2) natural wet oxidized; 40% sedge and reed; pyrophosphate index 0; gradual smooth boundary.
Oh	170-192	Horizon wet; dark brown (7.5YR 3/2) natural wet reduced; dark reddish brown (5YR 2.5/2) natural wet oxidized; 40% sedge and reed; moderately decomposed; pyrophosphate index 0; abrupt smooth boundary.
IICg	192-210	Clay loam.

TABLE 33. ANALYTICAL DATA OF THE TYPIC MESISOL, (LANSON), SITE 8
DONNEES ANALYTIQUES DU MESISOL TYPIQUE (LANSON), A SITE 8

Horizon	pH $CaCl_2$	pH H_2O	Fibre Rubbed / Frottée %	Fibre Unrubbed / Nonfrottée %	Ash / Cendres %	Bulk Density / Densité apparente g/cm^3	Field Moisture / Humidité Champ %
Omp	6.4	6.2	17	37	26	0.36	65.8
Om1	5.1	4.7	19	57	9	0.20	79.1
Om2	5.1	4.7	10	63	9	0.16	90.6
Om3	5.4	5.0	17	35	8	0.14	98.0
Om4	5.6	5.1	15	35	11	0.14	99.3
Om5	5.1	4.9	31	47	7	0.13	96.8
Om6			7	46	11	0.14	99.8
Oh	4.9	4.8					

Horizon	Elemental Analysis - Analyse élémentaire Al %	Fe %	Mg %	Ca %	C %	S %	N %	C/N	Heavy Metals - Métaux lourds (ppm) Pb	Se	Mn	Zn	Cu	Cha/Cfa	Nha/Nfa	Fa E_4/E_6	Ha E_4/E_6
Omp	0.4	0.4	0.6	3.2	42.9	0.6	2.0	21.4	28.2	1.1	462.0	50.0	75.0	11.32	9.25	3.46	3.83
Om1	0.2	0.2	0.4	2.5	50.0	0.8	2.3	21.8	<10.0	1.0	199.5	56.2	<5.0	7.29	6.58	4.40	5.17
Om2	0.1	0.3	0.4	3.1	47.2	0.8	2.2	21.7	10.7	0.9	306.0	18.7	<5.0				
Om3	0.1	0.4	0.2	2.5	49.8	1.1	3.0	16.9	<10.0	1.1	250.0	43.7	<5.0				
Om4	0.2	0.5	0.2	3.2	49.2	1.3	2.9	16.8	<10.0	1.8	275.0	25.0	<5.0				
Om5	0.1	0.8	0.1	1.7	50.1	2.3	3.0	16.8	10.0	0.7	125.0	31.2	<5.0	3.73	3.07	5.52	3.06
Oh	0.1	1.3	0.1	2.1	49.0	2.7	3.1	15.5	<10.0	1.3	162.0	37.5	37.5				

SITE 9: ORTHIC MELANIC BRUNISOL ON TILL (GRENVILLE)

Soil Name:	Grenville loam.
Location:	Central Experimental Farm, Ottawa 45° 23' 20" N. Lat., 75° 25' 18" W. Long.
Elevation:	36 m. M.S.L.
Landform:	Undulating morainal.
Slope:	Crest of a 4% slope with southwest aspect.
Drainage:	Well drained, moderately pervious.
Vegetation:	Plowed base. Red maple (*Acer rubrum*), birch (*Betula* sp.), beech (*Fagus* sp.) and poplar (*Populus* sp.).
Climate:	Station: Ottawa C.D.A. Location: 45° 23" N. Lat., 75° 43" W. Long. Elevation: 79 m. M.S.L. Precipitation: mean annual precipitation is 840 mm of which 79% occurs in the form of rainfall. Temperature: mean annual temperature is 5.7 C. The mean daily maximum and minimum temperatures for July are, respectively, 26.4 C and 14.6 C and those for January are -6.4 C and -15.5 C.
Parent Material:	Moderately to strongly calcareous till.
Soil Classification:	Canada: Orthic Melanic Brunisol, coarse loamy, mixed, strongly calcareous, mild humid family U.S.A.: Typic Eutrocrept, coarse loamy, mixed, mesic family F.A.O.: Eutric Cambisol.

Horizon	Depth	Description
Ap	0-25	Very dark grayish brown (10YR 3/2m) sandy loam; weak fine to medium cloddy structure; slightly sticky, friable, slightly hard; slightly plastic; very few very fine roots; very few very fine discontinuous pores; abrupt wavy boundary.
Bm	25-44	Brown (10YR 4/3m) loam; weak fine to medium cloddy structure; slightly sticky, friable, slightly hard; slightly plastic; very few very fine roots; few medium tubular pores vertically oriented; few medium spherical worm casts around root channels; abrupt wavy boundary.
Ck	44-100	Olive gray (10YR 4/2m), light gray (10YR 7/2d) sandy loam; structureless; massive; slightly sticky, friable, slightly hard; slightly plastic; very few very fine roots; very few very fine discontinuous pores.

TABLE 34. ANALYTICAL DATA OF THE ORTHIC MELANIC BRUNISOL (GRENVILLE), SITE 9
DONNEES ANALYTIQUES DU BRUNISOL MELANIQUE ORTHIQUE (GRENVILLE) A SITE 9

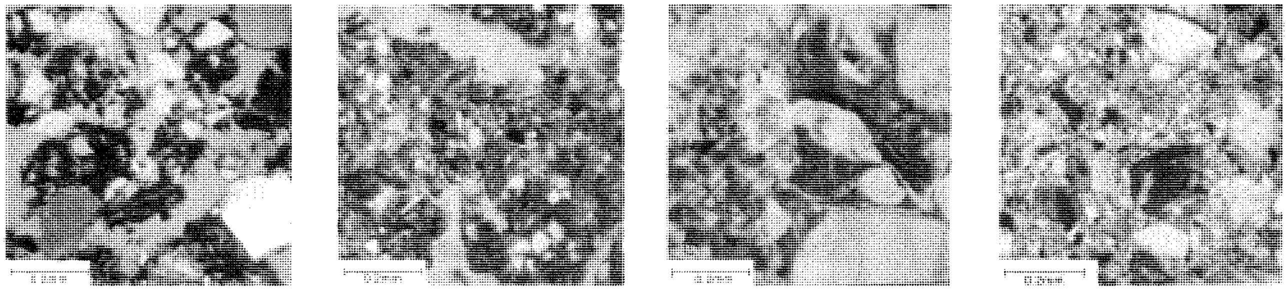
Horizon	pH $CaCl_2$	pH H_2O	Org. C / carbone organique %	Total N %	$CaCO_3$ EQ %	Calcite %	Dolomite / Dolomie %	Dithionite Fe %	Dithionite Al %
Ap	7.1	7.8	1.4	0.1				0.1	0.1
Bm	7.0	7.4	1.1	0.1				0.1	0.1
Ck	7.5	8.1	0.1	0	23.4	21.2	2.2	0	0

Particle Size Distribution - Analyse granulométrique

Horizon	Sand - Sable VCS	CS	MS	FS	VFS	Total	Silt / Limon Total	Clay / Argile Total	Clay / Argile (<0.2u)
	% <2mm								
Ap	3	6	8	19	22	58	29	13	3
Bm	2	6	9	19	14	50	30	20	6
Ck	7	10	11	20	15	63	27	10	3

Horizon	Plastic Limit / limité de plasticité %	Liquid Limit / limité de liquidité %	Shrink. Limit / limite de retrait %	Unified Class. / Classement unifié	Bulk Density / Densité apparent g/cm³	Saturated Hydraulic Conductivity / Conductivité hyraulique saturée cm/hr
Ap			2.8	07	1.59	1.2
Bm			3.5	09	1.45	15.5
Ck	18.0	21.6	1.7	07	1.86	2.5

Figure 50. Micromorphology of the Orthic Melanic Brunisol at Site 9.



a. partly X b. partly X c. plane light d. X polarizers

Ahp This horizon is loosely packed, dark brown material consisting of variable size sand and fine mull-like material that occurs as discontinuous to continuous matrans (<100μm) on all sand grains, bridges between grains, and loose to incomplete intergranular fillings and aggregates (<1mm) (Fig. 50a). Moderately humified dark brown organic fragments (<2mm) are (O-C) and heavy minerals are abundant with green hornblende dominant over biotite, garnet, pyroxene and epidote. Pedological features include (R) nodules (1-2mm) of B horizon material, (R) sand clusters, (R) weakly oriented equant clay nodules (400μm), (O) gravel (calcareous and non-calcareous sandstone, siltstone, and granitic fragments), and (R) carbonates as sand and gravel.
-1- agglomeroplasmic
-2- matriplectic##matrigranoidic

Bm This horizon is loosely packed orange-brown material with (C) vughs, (C) skew planes, and (R) channels. About half of this horizon consists of dense fused aggregates and peds (<2mm) (Fig. 50b), and the rest consists of areas that are almost dense, areas of isolated to partially accommodated peds, and areas of A horizon material. Moderately oriented argillans (<150μm) are (O) and occur on all types of voids (Fig. 50c). Manganiferous nodules (<250μm with most <100μm) are (VR) and generally occur in clusters. Gravel is (R) and heavy minerals are abundant.
-1- mosepic porphyroskelic aggregates
-2- matrigranoidic porphyroskelic##matrigranoidic

Ck This horizon is dense, dirty gray, calcareous material (Fig. 50d) with (C) vughs (<1mm) and (R) skew planes. The s-matrix is highly calcareous and probably half of the sand grains are carbonates. Gravel is (C) and consists of shale, calcareous sandstone, dolomitic limestone, and clastic limestone. Ferruginous nodules (<250μm) are (VR) and heavy minerals are still abundant.
-1- silasepic porphyroskelic

SITE 10: ORTHIC SOMBRIC BRUNISOL ON SAND VENEER OVER MARINE CLAY (MANOTICK)

Soil Name:	Manotick sand.
Location:	Central Experimental Farm, Ottawa. 45° 22' 18" N. Lat., 75° 43' 42" W. Long.
Elevation:	36 m. M.S.L.
Landform:	Level marine, eroded
Slope:	2%, west aspect.
Drainage:	Moderately well drained.
Vegetation:	Alfalfa, grass, hay.
Climate:	Station: Ottawa C.D.A. Location: 45° 23' N. Lat., 75° 43' W. Long. Elevation: 79 m. M.S.L. Precipitation: mean annual precipitation is 840 mm of which 79% occurs in the form of rainfall. Temperature: mean annual temperature is 5.7 C. The mean daily maximum and minimum temperatures for the month of July are, respectively 26.4 C and 14.6 C and those for January are -6.4 C and -15.5 C.
Parent Material:	Slightly acidic marine sand over slightly acidic to neutral marine clay. Chemical weathering is weak.
Soil Classification:	Canada: Orthic Sombric Brunisol, sandy over clayey, mixed, neutral, mild humid family U.S.A.: Umbric Dystrocrept, sandy over clayey, mixed, mesic family F.A.O.: Humic Cambisol

Horizon	Depth	Description
Ahp	0-7	Dark brown (7.5YR 3/2m), (10YR 4.5/3d) sand; structureless; nonsticky, loose; nonplastic; plentiful fine roots vertically oriented; many interstitial pores; abrupt smooth boundary.
Bm	7-63	Strong brown (7.5YR 5/6m), light yellowish brown (10YR 6/4d) sand; structureless; nonsticky, loose; non plastic; few fine roots vertically oriented; many interstitial pores; gradual smooth boundary.
Bmgj1	63-70	Yellowish brown (10YR 4.5/4m) sand; common, fine brown (10YR 5/3m) mottles; structureless; nonsticky, loose; non plastic; many interstitial pores; gradual smooth boundary.
Bmgj2	70-85	Brown (10YR 5/3m), light brownish gray (2.5YR 6/2d) loamy sand; common fine brown (10YR 5/3m) mottles; structureless; nonsticky, loose, nonplastic; few fine roots vertically oriented; many interstitial pores; gradual smooth boundary.
Bmgj3	85-95	Dark yellowish brown (8.5YR 4/4m), very pale brown (10YR 7/4d) sand; common fine brown (10YR 5/3m) mottles; structureless; nonsticky, loose; nonplastic; few fine roots vertically oriented; many interstitial pores; abrupt smooth boundary.
IIC	95-150	Grayish brown (2.5YR 5/2m), light gray (10YR 7/2d) clay; moderate to strong fine to medium angular pseudoblocky; sticky, firm, very hard; plastic; few pores.

TABLE 35. ANALYTICAL DATA OF THE ORTHIC SOMBRIC BRUNISOL (MANOTICK), SITE 10
DONNEES ANALYTIQUES DU BRUNISOL SOMBRIQUE ORTHIQUE (MANOTICK) A SITE 10

Horizon	pH $CaCl_2$	pH H_2O	Org. C / carbone organique %	Total N %	Exchangeable Cations / Cations échangeables — Neutra. Salt / Sel Neutr. Ca (meq/100g)	Mg (meq/100g)	Al (meq/100g)	C.E.C. / Capacité d'échange — P. Ch / Charge permanente (meq/100g)	Dithionite Fe %	Dithionite Al %
Ap	4.9	5.9	1.4	0.1	3.2	0.3	0.0	3.7	0.1	0.2
Bm	5.8	6.3	0.3	0	1.5	0.1	0.0	1.8	0.1	0.1
Bmgj1	5.7	6.1	0.1	0	1.3	0.1	0.0	1.5	0.0	0.1
Bmgj2	5.7	6.2	0.1	0	3.1	0.3	0.0	3.5	0.0	0.1
Bmgj3	5.5	6.1	0.2	0	1.6	0.1	0.0	1.9	0.1	0.1
IIC	5.8	6.3	0.2	0.1	33.0	1.6	0.0	35.3	0.0	0.0

Horizon	Particle Size Distribution - Analyse granulométrique — Sand - Sable VCS	CS	MS	FS	VFS	Total	Silt / Limon Total	Clay / Argile Total	Clay / Argile (<0.2u)	Bulk Density / Densité apparente g/cm³	Moisture / Humidité 1/10 Atm. %	Moisture / Humidité 1/3 Atm. %	Plastic Limit / Limite de plasticité	Liquid Limit / Limite de liquidité	AASHO Class. / AASHO Classement	Saturated Hydraulic Conductivity / Conductivité hydraulique saturée cm/hr
	% <2mm															
Ap	4	31	29	18	4	86	9	5		1.31	7.9	5.9			7	145.0
Bm	5	32	39	16	1	93	3	4		1.37	7.2	6.3			5	102.0
Bmgj1	1	20	46	24	3	94	3	3							5	
Bmgj2	0	20	36	21	5	82	11	7	1		11.0	8.8			7	79.8
Bmgj3	3	42	28	16	3	91	6	3			9.2	7.5			5	71.0
IIC	0	4	7	10	6	97	25	48	8	1.17			26.8	49.0	10	71.7

SITE 11: ORTHIC HUMIC GLEYSOL ON LOAM VENEER OVER MARINE CLAY (BAINSVILLE)

Soil Name:	Bainsville loam.
Location:	Central Experimental Farm, Ottawa 45° 22' 18" N. Lat., 75° 43' 42" W. Long.
Elevation:	36 m. M.S.L.
Landform:	Undulating marine.
Slope:	Middle position of a 1% slope with west aspect.
Drainage:	Poorly drained.
Vegetation:	Alfalfa
Climate:	Station: Ottawa, C.D.A. Location: 45° 23' N. Lat., 75° 43' W. Long. Elevation: 79 m. M.S.L. Precipitation: mean annual precipitation is 840 mm of which 79% occurs in the form of rainfall. Temperature: mean annual temperature is 5.7 C. The mean daily maximum and minimum temperatures for the month of July are, respectively 26.4 C and 14.6 C and those for January are -6.4 C and -15.5 C.
Parent Material:	Loam over clay marine deposit that is weakly weathered and slightly to moderately acidic.
Soil Classification:	Canada: Orthic Humic Gleysol, very fine clayey, mixed, neutral, mild humid family U.S.A.: Typic Haplaquoll, very fine clayey, mixed, mesic family F.A.O.: Mollic Gleysol.

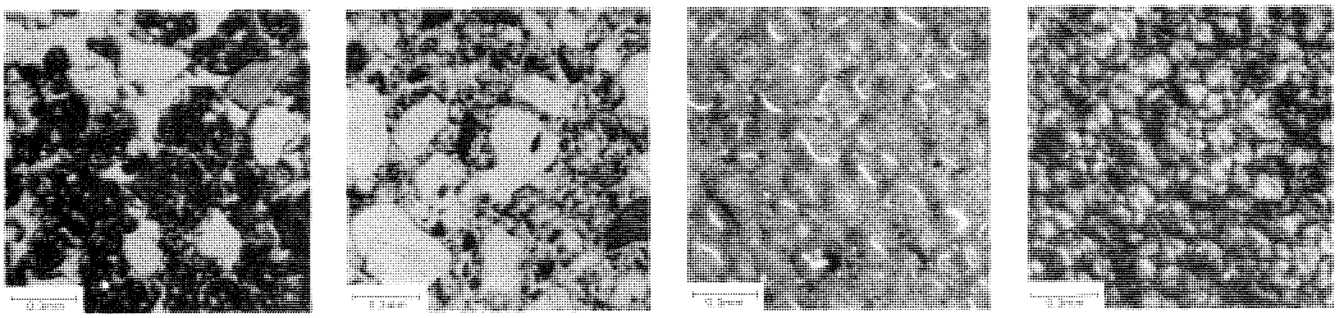
Horizon	Depth	Description
Ahp	0-25	Very dark grayish brown (10YR 3/2m) loam; very coarse cloddy; slightly sticky, friable, slightly hard; slightly plastic; abundant medium roots randomly oriented, exped; many medium continuous interstitial pores randomly distributed exped; abrupt smooth boundary.
IIBg1	25-50	Olive gray to olive (5YR 4/2.5m) clay loam; many olive brown (2.5YR 4/4m) fine, distinct mottles; weak, fine to medium, angular blocky; sticky, firm, hard; plastic; plentiful fine roots vertically oriented, exped; common fine continuous interstitial pores vertically oriented, exped; many very dark gray (10YR 3/1m) coarse worm casts in local concentration; gradual, smooth boundary.
IIBg2	50-60	Olive gray (5YR 5/2m) heavy clay; many olive brown (2.5YR 4/4m) fine distinct mottles; moderate, medium to coarse, angular blocky; very sticky, very firm, very hard; very plastic; plentiful fine roots horizontally distributed exped; common fine continuous interstitial pores vertically oriented, exped; many very dark gray (10YR 3/1m) coarse worm casts in local concentration; diffuse smooth boundary.
IIBg3	60-90	Olive gray (5YR 5/2m) heavy clay; moderate, medium to coarse, angular blocky; very sticky, very firm, very hard; very plastic; few fine roots horizontally oriented, exped; few fine continuous interstitial pores vertically oriented, exped; many very dark gray (10YR 3/1m) coarse worm casts in local concentration; abrupt smooth boundary.
IICg	90-120	Olive gray (5YR 5/2m) heavy clay; moderate medium to coarse angular pseudoblocky; very sticky, very firm, very hard; very plastic; few fine roots vertically oriented, exped; few fine discontinuous interstitial pores vertically oriented, exped; common very dark gray (10YR 3/1m) coarse worm casts in local concentration.

TABLE 36. ANALYTICAL DATA OF THE ORTHIC HUMIC GLEYSOL, (BAINSVILLE) SITE 11
DONNEES ANALYTIQUES DU GLEYSOL HUMIQUE ORTHIQUE (BAINSVILLE) A SITE 11

Horizon	pH $CaCl_2$	Org. C / carbone organique	Total N	Exchangeable Cations / Cations échangeables, Buffered - Tamponnée			C.E.C. / Capacité d'échange cationique, Buffered / Tamponée (meq/100g)
				Ca	Mg	K	
		%	%	meq/100g			
Ahp1	5.9	4.1	0.4	25.6	2.4	0.4	27.0
Ahp2	6.0	3.0	0.4	25.0	2.4	0.4	26.6
Ahp3	6.0	3.6	0.4	25.5	2.2	0.3	27.0
Ahp4	6.1	3.8	0.3	28.3	2.4	0.3	27.9
Ahp5	6.4	2.5	0.3	25.0	2.0	0.3	24.9
IIBg1	6.4	2.5	0.3	25.0	1.9	0.3	24.8
IIBg2	6.5	0.6	0.1	26.5	2.1	0.5	25.4
IIBg3	6.5	0.5	0.1	27.5	2.3	0.6	25.5
IIBg4	6.5	0.4	0.1	29.4	2.3	0.6	26.9
IIBg5	6.6	0.3	0.1	29.3	2.6	0.7	27.3
IICg	6.6	0.2	0.1	29.2	2.4	0.7	27.2

Horizon	Particle Size Distribution / Analyse granulométrique			Porosity / Porosité	Saturated Hydraulic Conductivity / Conductivité hydraulique saturée	Moisture / Humidité			Bulk Density / Densité apparente	Specific Gravity / Poids spécifique
	Sand / Sable Total	Silt / Limon Total	Clay / Argile Total	Total		1/10 atm.	1/3 atm.	15 atm.		
	% <2mm			%	cm/hr	%	%	%	g/cm^3	g/cm^3
Ahp1	36	38	26	55.9	34.9	35.8	31.7	15.1	1.15	2.61
Ahp2				53.8	11.6	36.0	31.0		1.21	2.62
Ahp3				53.0	13.7	37.2	33.6	16.5	1.27	2.70
Ahp4				48.3	22.9	36.6	32.5	17.3	1.37	2.65
Ahp5	41	36	23	49.8					1.37	2.73
IIBg1				50.6	33.0	32.1	28.4	17.5	1.35	2.73
IIBg2				53.0	41.5	19.9	16.8		1.31	2.79
IIBg3	22	42	36	55.5				25.5	1.22	2.74
IIBg4				59.3	17.4	42.4	39.0	26.5	1.18	2.90
IIBg5	6	34	60	58.9	19.3	45.9	43.9	26.0	1.18	2.87
IIC	3	31	66	58.9	11.0	52.3	51.0	25.2	1.16	2.82

Figure 51. Micromorphology of the Orthic Humic Gleysol at Site 11.



a. plane light b. plane light c. plane light d. X polarizers

Ap1 This horizon is loosely packed, dark brown material in which the fine matrix material occurs as dense aggregates (<3mm with most 0.5-1mm) that exhibit varying degrees of fusion with themselves and with skeleton grains (250-1000μm) (Fig. 51a). There are (O) areas where the aggregates and skeleton grains are isolated. Organic material is (O-C) occuring as semidecomposed fragments (<2mm) and small humified aggregates generally less than 80μm. Most of the organic material occurs within the aggregates. Partial matrans (<80μm) occur on most of the free skeleton grains. Sharp nodules (<2mm) are (VR) and consist of either clay, ferruginous, or manganiferous material. Osepic fabric is present in a couple of clay nodules. Heavy minerals are (C) with hornblende dominant.
-1- weak skelsepic porphyroskelic aggregates.
-2- ortho-matrigranic-matrigranoidic.

Ap2 This horizon is moderately packed, brown material consisting of dense aggregates as in the Ap1, but the fusion is generally strong and in some areas the s-matrix appears dense with (C) vughs. Organic material is (O-C) occuring mainly as small humified aggregates within the larger aggregates with (R) clusters of fecal pellets. Most of the free skeleton grains have partial matrans (<80μm). Heavy minerals and nodules are similar to those in the Ap1 except that the nodules are now (R) with oosepic fabric still present.
-1- weak skelsepic porphyroskelic aggregates
-2- matrigranoidic porphyroskelic-matrigranoidic

IIBg This horizon is moderately packed, brown material with mixed and separated complex fabrics. At 63X magnification the appearance is that of moderately packed medium to coarse sand and aggregates (<2mm) that exhibit varying degrees of fusion. In many areas the fusion is strong and the result is a dense matrix with (O-C) vughs and skew planes. At 25X magnification the dominant fabric is that of accommodated peds in most areas. There is more and larger sand grains in this horizon and the s-matrix appears to have more clay. Nodules (<1mm) are (R) and consist of either clay, sesquioxides, or manganiferous material. The clay nodules contain some sesquioudic nodules. Most of the free grains have partial sepic matrans (<80μm) and biotite is now a prominent heavy mineral.
-1- skelsepic agglomeroplasmic with porphyroskelic areas
-2- matrigranoidic porphyroskelic-matrigranoidic//matrifragmic.

IIIBg1 This horizon is moderately packed, grayish brown material in which the fine matrix material occurs as silty aggregates (<500μm) which are commonly fused to form larger moderately packed aggregates (<2mm). There are areas in which small silty aggregates occur as incomplete intergranular fillings between the medium to coarse sand grains (Fig. 51b) and other areas of fused to accommodated aggregates similar to those found in the IIBg. Nodules, matrans, and heavy minerals are similar to those found in the IIBg.
-1- skelsepic agglomeroplasmic
-2- matrigranoidic matriplectic-matrigranoidic.

IIIBg2 This horizon is loosely packed, light brown clay material which, for the most part, consists of accommodated peds (<7mm) separated by (C-F) skew planes. The rest consists of loose and fused peds. The peds are very dense with (O) vughs and (VR) oosepic fabric. The amount of very fine sand and coarse silt in the peds is quite variable ranging from very little in some to large clusters in others. Nodules (<1500μm) are (R) with sesquioxidic more abundant than manganiferous. Heavy minerals are still (C) with hornblende dominant.
-1- ma-vosepic porphyroskelic
-2- matrigranic-matrigranoidic//matrifragmic

IIICg This horizon is light brown, dense, heavy clay material with (C) skew planes, (O) vesicles (<200μm) and (O) metavughs (<500μm) that reduce the overall porosity to moderate. Oosepic fabric (Fig. 51d) dominates this horizon and the oolites are less than 400μm. Small (100-150 x 10-15μm) banana-shaped or U-shaped voids (Fig. 51c) directly associated with the oolites are very (F). Fine sand is (VR) and sharp to diffuse sesquioxidic nodules (<2mm) are (R-O).
-1- oosepic porphyroskelic.

SITE 12: GRAY BROWN LUVISOL AND EUTRIC BRUNISOL ON GLACIOFLUVIAL SANDS (PONTYPOOL PEDONS 1 AND 2)

Soil Name:	Pontypool
Location:	Lot 27, concession VIII, Town of Whitchurch-Stowffville, Regional Municipality of York; 44° 03' 30" N. Lat., 79° 15' 45" W. Long.
Elevation:	340 m. M.S.L.
Landform:	Hummocky glaciofluvial.
Slope:	Upper landscape position of a 2% slope.
Drainage:	Well drained.
Vegetation:	Hardwood forest including hard maple (*Acer saccharum*), beech (*Fagus grandifolia*), cherry (*Prunus serotina*), white ash (*Fraxinus americana*) and red oak (*Quercus borealis*). Data for the species distribution and stand density for the hardwood woodlot at this site are given in Table 6.
Climate:	Station: Oak Ridges 43° 58' N. Lat., 79° 28' W. Long. Elevation: 340 m. M.S.L. Precipitation: mean annual precipitation is 820 mm with a maximum in July. Temperature: mean daily maximum for July: 27.5 C. Mean daily minimum for January is -11.5 C.
Parent Material:	Glaciofluvial fine sand.
Soil Classification:	Pedon 1: Canada: Brunisolic Gray Brown Luvisol, coarse loamy, mixed, weakly calcareous, mild humid family U.S.A.: Typic Hapludalf, coarse loamy, mixed, mesic family F.A.O.: Albic Luvisol. Pedon 2: Canada: Orthic Eutric Brunisol, sandy, strongly calcareous, mixed, mild humid family U.S.A.: Typic Eutrochrept, sandy, mixed, mesic family F.A.O.: Eutric Cambisol.

Pedon 1

Horizon	Depth	Description (Pedon 1)
LFH	2-0	Undecomposed and partially decomposed leaves, twigs and roots; structureless; loose; abrupt smooth boundary.
Ahe	0-5	Very dark brown (10YR 2/2m); sandy loam; very weak medium granular breaking to fine granular and single grain; loose; clear wavy boundary.
Bm1	5-18	Dark yellowish brown to yellowish brown (10YR 4.5/5m); loamy sand; very weak, medium, subangular blocky breaking to very weak, medium, granular; very friable; gradual wavy boundary.
Bm2	18-34	Yellowish brown (10YR 5/5m); sandy loam; very weak, medium, subangular blocky, breaking to very weak, medium, granular; very friable, gradual wavy boundary.
Ae	34-72	Pale brown to very pale brown (10YR 6.5/3m) sandy loam; very weak, medium subangular blocky, breaking to very weak, medium, granular; very friable; abrupt wavy boundary.

Bt	72-77	Yellowish brown (10YR 5/6m) and strong brown (7.5YR 5/8m); fine sandy loam; weak to moderate, medium, subangular blocky, breaking to weak to moderate, medium, granular; friable; abrupt irregular boundary.
Ck	77+	Light brownish gray to light gray (10YR 6.5/2m); sand; structureless and very weak subangular blocky crushing to single grain; loose.

<u>Pedon 2</u>

Horizon	Depth	Description (Pedon 2)
LFH	2-0	Undecomposed and partially decomposed roots; structureless; loose; abrupt smooth boundary.
Ah	0-5	Very dark brown (10YR 2/2m); loamy sand; structureless; loose; abrupt smooth boundary.
Ahe	5-12	Dark brown (10YR 3/3m); sand; weak, fine to medium, granular; loose; abrupt; smooth boundary.
Bm1	12-26	Dark yellowish brown (10YR 4/4m); fine sand; very weak, medium, subangular blocky, breaking to very weak, fine to medium, granular; very friable; clear wavy boundary.
Bm2	26-43	Yellowish brown (10YR 5/5m); sand; very weak medium, subangular blocky, breaking to very weak, fine to medium, granular and single grain; very friable; gradual wavy boundary.
Bm3	43-70	Yellowish brown (10YR 5/4m); sand; very weak, medium, subangular blocky, breaking to very weak, fine to medium, granular and single grain; very friable; diffuse broken boundary.
Bm4	70-110	Brown (10YR 5/3m); common coarse distinct yellowish brown (10YR 5/6m) mottles; fine sand; very weak, medium, subangular blocky, breaking to very weak, fine to medium, granular and single grain; very friable; abrupt wavy boundary.
Ck	110+	Light brownish gray to pale brown (10YR 6/2.5m); very fine sand; very weak, medium, subangular blocky, breaking to very weak, fine granular and single grain; very friable.

TABLE 37. MINERALOGICAL DATA OF THE BRUNISOLIC GRAY BROWN LUVISOL, PONTYPOOL PEDON 1
MINERALOGIE DU LUVISOL GRIS BRUN BRUNISOLIQUE, PONTYPOOL, PEDON 1

Horizon	Fraction 2-0.2µm					Fraction <0.2µm		
	mica	chlorite	kaolin	vermiculite	quartz	feldspar	amphibole	amorphous
Ahe			00	01	02			04
Bm1			00	01	02			04
Bm2		00	00	01	02			04
Ae	00	01	00	01	02			04
Ae1		00	00	01	02			04
Ae2	00	01	00	01	02			04
Bt	00	01	00		01			04
Ck	00	01	00		03	01	01	02

TABLE 38. ANALYTICAL DATA OF THE BRUNISOLIC GRAY BROWN LUVISOL, (PONTYPOOL PEDON I), SITE 12
DONNÉES ANALYTIQUES DU LUVISOL GRIS BRUN BRUNISOLIQUE, (PONTYPOOL PEDON I), À SITE 12

Horizon	pH $CaCl_2$	pH H_2O	Org. C / carbone organique %	Total N %	$CaCO_3$ Eq. %	Exchangeable Cations / Cations échangeables, Buffered - Tamponnée: Ca (meq/100g)	Mg (meq/100g)	K (meq/100g)	Pyrophosphate Fe %	Pyrophosphate Al %	Oxalate Fe %	Oxalate Al %	Oxalate Mn %
LFH	5.5	6.0	11.6	0.4		17.8	2.0	0.5	0.2	0.2			
Ahe	5.0	5.6	2.3	0.2	0.2	4.0	0.4	0.1	0.2	0.2	0.3	0.3	0.2
Bm1	5.0	6.0	0.6	0.1	0.1	1.8	0.2	0.0	0.2	0.2	0.4	0.4	0
Bm2	5.1	6.0	0.3	0	0.1	1.5	0.1	0.0	0	0.1	0.2	0.2	0
Ae	5.4	6.1	0.1	0	0.1	1.8	0.1	0.1	0	0	0.1	0.1	0
Ae1	5.3	6.0	0.3	0	0	1.3	0.1	0.0	0	0.1	0.1	0.2	0
Ae2	6.2	6.6	0.1	0	0.2	2.5	0.1	0.0	0	0	0.1	0.1	0
Bt	6.4	6.7	0.2	0	0.2	4.5	0.3	0.0	0.1	0	0.1	0.1	0
Ck	7.3	8.1	0	0	0.6	13.0	0.3	0.1	0	0	0	0	0

Horizon	Particle Size Distribution - Analyse granulométrique, Sand - Sable: VCS (% <2mm)	CS	MS	FS	VFS	Total	Silt / Limon Total	Clay / Argile Total	Bulk Density / Densité apparente g/cm^3	Field Moisture / Humidité Champ %
LFH										
Ahe	0	0	3	28	38	70	25	6	1.05	20.9
Bm1	0	0	3	29	40	72	25	3	1.25	13.9
Bm2	0	0	2	21	43	66	32	2	1.33	6.9
Ae	0	0	0	27	36	63	34	3	1.44	8.0
Ae1	0	0	0	18	40	58	40	2		
Ae2	0	0	0	30	38	68	29	3		
Bt	0	0	0	35	24	59	31	10	1.45	6.8
Ck	0	0	0	47	39	87	11	2	1.50	6.5

TABLE 39. MINERALOGICAL DATA OF THE ORTHIC EUTRIC BRUNISOL, PONTYPOOL, PEDON II
MINERALOGIE DU BRUNISOL EUTRIQUE ORTHIQUE, PONTYPOOL, PEDON II

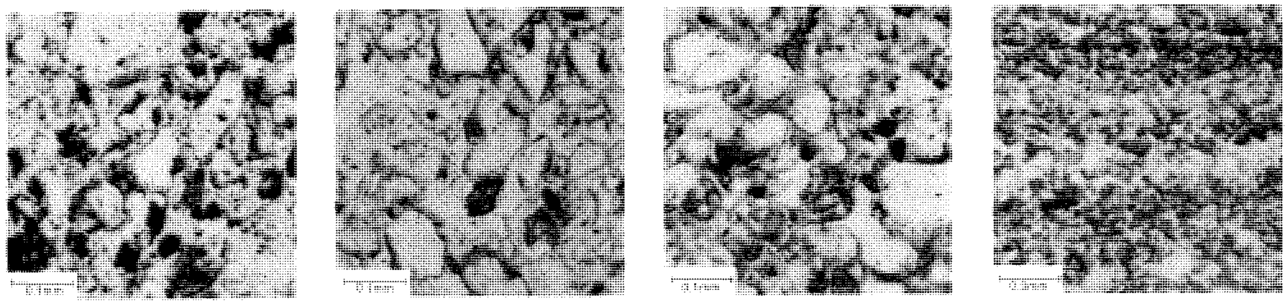
Horizon	Fraction 2-0.2µm				Fraction <0.2µm		
	mica	chlorite	kaolin	vermiculite	quartz	feldspar	amorphous
Ah		01	00	01	00	00	04
Ahe		01	00	01	00		04
Bm1		01	00	01	00		04
Bm2			00	01			04
Bm31			00	01		00	04
Bm32		01	00	00	01		04
Bm4	00	00	00	00	00		04
Ck	00		00	00		01	04

TABLE 40. ANALYTICAL DATA OF THE ORTHIC EUTRIC BRUNISOL (PONTYPOOL, PEDON II), SITE 12
DONNEES ANALYTIQUES DU BRUNISOL EUTRIQUE ORTHIQUE (PONTYPOOL, PEDON II), A SITE 12

Horizon	pH $CaCl_2$	Org. C / carbone organique %	Total N %	$CaCO_3$ Eq. %	Exchangeable Cations / Cations échangeables: Buffered - Tamponnée Ca (meq/100g)	Mg (meq/100g)	K (meq/100g)	Pyrophosphate Fe %	Pyrophosphate Al %	Oxalate Fe %	Oxalate Al %	Oxalate Mn %
LFH		6.3	0.5		13.5	1.4	0.3	0.2	0.1			
Ah	4.9	2.9	0.1	0.1	4.3	0.6	0.2	0.2	0.2	0.2	0.2	0.2
Ahe	4.9	0.8	0	0.1	2.3	0.2	0	0.1	0.2	0.2	0.2	0.1
Bm1	5.3	0.3	0	0	2.0	0.1	0.1	0.1	0.2	0.3	0.3	0
Bm2	5.4	0.3	0	0.1	1.5	0.1	0	0	0.2	0.1	0.3	0
Bm31	6.6	0.2	0	0.3	4.0	0.1	0	0	0.1	0.1	0.2	0
Bm32	6.0	0.1	0	0.2	1.5	0.1	0.1	0	0	0.1	0.1	0
Bm4	6.7	0.1	0	0.2	2.0	0.2	0.1	0	0	0.1	0.1	0
Ck	7.4	0.1	0	22.3	14.2	0.2	0.1	0	0	0	0	0

Horizon	Particle Size Distribution - Analyse granulométrique: Sand - Sable VCS (% <2mm)	CS	MS	FS	VFS	Total	Silt / Limon Total	Clay / Argile Total	Bulk Density / Densité apparente g/cm^3	Field Moisture / Humidité Champ (%)
LFH										
Ah	0	0	1	41	38	81	13	6	1.05	25.7
Ahe	0	0	1	44	41	86	11	4	1.10	20.8
Bm1	0	0	2	51	36	88	10	2	1.26	16.3
Bm2	0	0	0	48	42	90	8	2	1.32	11.8
Bm31	0	0	0	44	45	89	8	2	1.41	9.1
Bm32	0	0	0	43	46	89	9	2		
Bm4	0	0	0	53	35	88	9	3	1.38	8.2
Ck	0	0	0	35	50	85	12	2	1.41	7.3

Figure 52. Micromorphology of the Gray Brown Luvisol at Site 12



a. partly X b. plane light c. plane light d. plane light

LHF The top part of the horizon consists of very loosely packed, large (<15mm), highly elongated, horizontally aligned, slightly decomposed organic material with fine sand occasionally adhering to some of the organic material. This grades to a very loosely packed mixture of large organic fragments, organic aggregates (<500μm), and fine sand. Clusters of fecal pellets are (R).
-2- humi-ortho-phytogranic

Ahe This horizon is pale loosely packed material consisting of fine sand and humified organic material as thin (<25μm) partial to complete matrans on most grains, and organic aggregates that occur as bridges between grains and loose intergranular material (Fig. 52a). Raw to humified organic fragments (1mm) are (O) and sclerotia are (VR). Heavy minerals are (C) with hornblende dominant.
-1- intertextic
-2- humigranoidic matriplectic//matrichlamydic

Bm1 This horizon consists of loosely packed fine sand and (O-C) brown and black organic aggregates (<150μm) as loose intergranular material and occasional bridges between grains. Partial to complete brown matrans (<40μm) occur on most grains and are isotropic. Large (<1mm) organic fragments are (R-O) and mycorrhiza mantles, fungal hyphae, and sclerotia are all (VR-R). Heavy minerals are (C).
-1- granular with thin matrans
-2- matrichlamydic

Bm2 This horizon consists of loosely packed fine sand grains with thin (<25μm) partial to complete isotropic brown matrans on most grains (Fig. 52b) and (O) organic material as roots and fragments that exhibit varying degrees of humification. Sesquioxidic-manganiferous nodules are (R) and sclerotia are (VR). Heavy minerals are (C).
-1- granular with thin matrans
-2- matrichlamydic

Ae This horizon is similar to the above except:
1. There are more partial than complete matrans.
2. The amount of uncoated grains has increased but coated grains are more abundant.

Ae-Bt The top part of this horizon consists of loosely packed, clean, fine sand with some silt. The lower part has areas of loosely packed fine sand grains with thin matrans and areas in which both birefringent clay and isotropic brown material coats the grains and extends to form bridges between grains (Fig. 52c). With depth the coatings and bridges become less abundant and eventually disappear. Fine sand size carbonate grains appear and become more abundant with depth. Heavy minerals and organic material are as in the above three horizons.
-1- granular with agglomeroplasmic areas
-2- matrichlamydic//matriplectic//orthogranic

C The top part of this horizon is moderately packed material consisting of fine sand and silt with brown material as thin (<25μm) matrans and weak bridging between grains. With depth the bridges and coatings become less abundant and eventually disappear. Heavy minerals and organic material are as in the above horizons. There is an irregular but sharp boundary to the calcareous sedimentary parent material.
-1- agglomeroplasmic with granular areas
-2- matrichlamydic//matriplectic

Ck This horizon consists of layers of very fine sand that are variable in thickness and common silty laminae (Fig. 52d). Quartz and carbonate grains are the dominant minerals with minor amounts of feldspar and heavy minerals. Minor areas in this horizon consist of secondary carbonate with very little sand.
-1- granular
-2- orthogranic

SITE 13: GRAY BROWN LUVISOL ON FINE TEXTURED LACUSTRINE VENEER OVERLYING GLACIAL TILL (CASHEL)

Soil Name:	Cashel
Location:	David Dunlap Observatory, University of Toronto property, south of Richmond Hill, Lot 17, Concession 1, Markham Township, Regional Municipality of York; 43° 48' 50" N. Lat., 79° 22' 30" W. Long.
Elevation:	229 m. M.S.L.
Landform:	Undulating glacial till plain with lacustrine veneer.
Slope:	Middle position of a 2% slope.
Drainage:	Moderately well drained.
Vegetation:	Sugar maple (*Acer saccharum*), ironwood (*Ostrya virginiana*) and Hawthorn (*Crataegus* sp.)
Climate:	Station: Richmond Hill 43° 53' N. Lat., 79° 27' W. Long. Elevation: 233 m. M.S.L. Precipitation: mean annual precipitation is 780 mm with a maximum in August. Temperature: mean daily maximum for July is 26 C. Mean daily minimum for January is -11 C.
Parent Material:	Calcareous silty clay lacustrine deposit overlying silty clay glacial till.
Soil Classification:	Canada: Orthic Gray Brown Luvisol, fine clayey, mixed, strongly calcareous, mild humid family U.S.A.: Typic Hapludalf, fine clayey, mixed, mesic family F.A.O.: Orthic Luvisol.

Horizon	Depth	Description
LFH	2-0	Thin layer of partially decomposed leaves and twigs.
Ah	0-14	Black (10YR 2/1m); silt loam to silty clay loam; moderate, medium, granular, breaking to moderate, fine, granular; sticky; clear smooth boundary.
AB	14-28	Brown to dark brown (10YR 4/3m); silty clay loam; moderate, fine to medium, subangular blocky, breaking to moderate, fine granular; very sticky; gradual broken boundary.
Bt1	28-40	Dark brown to very dark brown (7.5YR 3/2m) clay; moderate to strong, fine to medium, angular blocky, breaking to moderate to strong, granular; very sticky; gradual wavy boundary.
IIBt2	40-54	Very dark grayish brown (10YR 3/2m); clay; moderate to strong, medium to coarse, angular blocky, breaking to moderate to strong, fine to medium granular; very sticky; abrupt, irregular boundary.
IICkg	54	Brown to pale brown (10YR 5.5/3m); silty clay; moderate to strong, coarse prismatic, breaking to moderate to strong, medium to coarse subangular blocky; very sticky.

The soil exposed at this site is fairly typical of soil development under hardwood forest in southern Ontario. The site has been logged of the productive timber and pastured by livestock in past years.

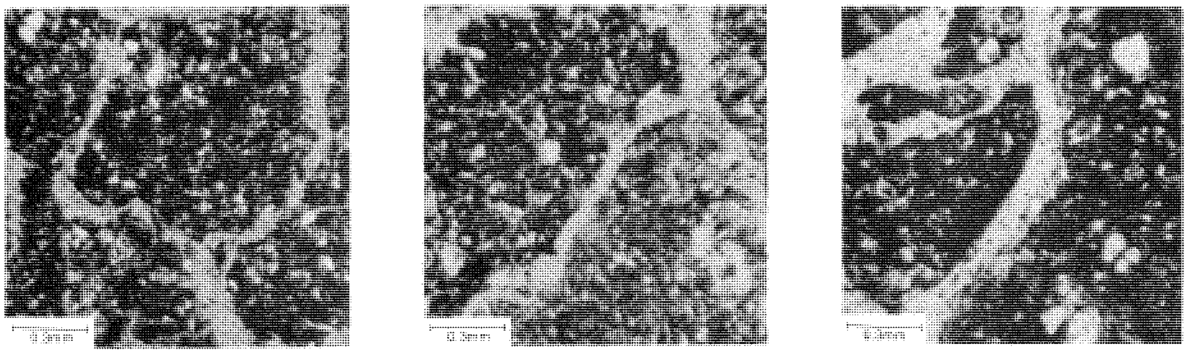
Throughout much of the exposure, the thickness and strength of development of the eluvial horizon is weak in comparison to the prominent textural B horizon (Bt). There is evidence of shallow tree-throw disturbance at the site which may partially account for this anomaly.

TABLE 41. ANALYTICAL DATA OF THE ORTHIC GRAY BROWN LUVISOL, (CASHEL), SITE 13
DONNEES ANALYTIQUES DU LUVISOL GRIS BRUN ORTHIQUE, (CASHEL), A SITE 13

Horizon	pH $CaCl_2$	pH H_2O	Org. C / carbone organique %	Total N %	$CaCO_3$ Eq. %	Exchangeable Cations / Cations échangeables, Buffered - Tamponnée: Ca (meq/100g)	Mg (meq/100g)	K (meq/100g)	Pyrophosphate Fe %	Pyrophosphate Al %	Oxalate Fe %	Oxalate Al %	Mn %
Ah	6.5	6.7	3.7	0.3	0.2	17.3	1.7	0.3	0.1	0.1	0.4	0.3	0.1
AB	6.6	7.1	0.9	0.1	0.2	18.2	1.2	0.3	0.1	0.1	0.5	0.3	0.1
Bt1	6.9	7.2	0.5	0.1	0.8	18.2	1.3	0.4	0.1	0.1	0.5	0.4	0.1
Bt2	7.3	7.6	0.3	0.1	2.7	30.0	1.6	0.5	0	0	0.4	0.4	0.1
Ckg1	7.5	7.7	0.2	0	33.0	22.5	1.0	0.2	0	0	0.1	0.1	0
Ckg2	7.4	7.9	0.1	0	38.3	21.5	1.1	0.2	0	0	0.1	0.1	0
Ckg3	7.6	8.0	0.1	0	42.1	24.0	1.5	0.2	0	0	0.1	0.1	0

Horizon	>2mm %	Particle Size Distribution - Analyse granulométrique, Sand - Sable (% <2mm): VCS	CS	MS	FS	VFS	Total	Silt / Limon Total	Clay / Argile Total	Bulk Density / Densité apparente g/cm^3
Ah	02	0	2	4	6	7	19	54	27	0.83
AB	05	0	2	4	5	5	16	46	38	0.99
Bt1	08	0	2	2	4	3	11	38	51	1.25
Bt2	10	1	1	3	4	4	13	34	54	1.23
Ckg1	16	1	1	3	5	5	15	40	45	1.40
Ckg2	18	1	1	3	6	6	17	38	44	1.45
Ckg3	16	2	1	3	6	5	17	37	46	

Figure 53. Micromorphology of the Gray Brown Luvisol at Site 13.



a. partly X b. partly X c. plane light

Ah This horizon is moderately packed dark brown material consisting mainly of accommodated peds (0.5-4mm) separated by (C-F) skew planes and (C) channels (Fig. 53a). Fused peds are common in some areas and loose aggregates (50-250μm) occur in some of the channels. The aggregates and peds are moderately packed but occasionally dense. Moderately to well humified brown to black organic material (<150μm) is (C-F) in the aggregates and peds and the finest of this material masks the birefringence of the plasma. Large (<10 mm) organic fragments are (C) in the channels. The grain size of this horizon is generally less than fine sand.
-1- silasepic porphyroskelic peds
-2- mullgranic//mullgranoidic//matrifragmic

AB This horizon is pale to medium brown moderately packed material consisting of accommodated peds (2-5mm) separated by (C) skew planes. The organic content ranges from rare in some peds to extremely abundant in others (Fig. 53b). The peds are generally moderately packed and contain (O) vughs with (R) moderately oriented argillans (<40μm). Channels are (O) and contain (O) large organic fragments (<5mm). Sesquioxidic nodules (<500μm) are (VR) and shale fragments are (VR).
-1- argillasepic porphyroskelic with (C) skew planes
-2- matrifragmic

Bt1 + IIBt2 This horizon is moderately packed medium brown material consisting of variable size (1-10mm) peds that show varying degrees of accommodation as well as fusion. The skew planes separating the peds range in width from 50 to 600μm. The peds are very fine grained with little if any sand and contain (F) metavughs. Translocated clay is (C) and occurs as moderately oriented planar void and vugh argillans (25-300μm) and engulfed argillans (<500μm). Small brown to black humified organic fragments (10-200μm) are (C) within the peds and (R-O) in the voids. Ferruginous nodules (<200μm) are (R) and a few contain manganiferous material.
-1- mosepic porphyroskelic with (C) skew planes
-2- matrifragmoidic//matrifragmic

IIBt2 This horizon is similar to the above horizon except:
1. There is less translocated clay.
2. There is a higher organic content in the top part. There are (O-C) large (<3mm) fragments in the voids and more and larger (<500μm) humified material in the peds. A few of the peds look like Ah material (Fig. 53c).

IICkg This horizon is grayish brown fine grained calcareous material with (F) vughs and (O) skew planes. The sand content is low and most of it is carbonate grains. Humified organic material, ferruginous nodules, and manganiferous nodules are (R).
-1- silasepic porphyroskelic

SITE 14: GLEYED GRAY BROWN LUVISOL ON DELTAIC SANDS (VINELAND)

Soil Name:	Vineland
Location:	Victoria Farm, B.F. Lot 23, Louth Township, Regional Municipality of Niagara; 43° 11' 20" N. Lat., 79° 23' 30" W. Long.
Elevation:	80 m. M.S.L.
Landform:	Very gently sloping lacustrine plain.
Slope:	0.5%
Drainage:	Imperfectly drained.
Vegetation:	Some species common to the area include elm (*Ulmus* sp.) maple (*Acer* sp.) beech (*Fagus* sp.) oak (*Quercus* sp.) black ash (*Fraxinus nigra*) and chestnut. Most native vegetation has been removed.
Climate:	Station: Vineland. 43° 11' N. Lat., 79° 23' W. Long. Precipitation: mean annual precipitation is 790 mm with a maximum in August. Temperature: mean daily maximum for July is 26.5 C; mean daily minimum for January is -7 C.
Parent Material:	Deltaic stratified loamy very fine sand and very fine sandy loam.
Soil Classification:	Canada: Gleyed Gray Brown Luvisol, coarse loamy, mixed, strongly calcareous, mild perhumid family U.S.A.: Typic Hapludalf to Typic Eutrochrept, coarse loamy, mixed family F.A.O.: Gleyic Luvisol

Horizon	Depth	Description
Apk	0-26	Dark grayish brown (10YR 4/2m); loam to sandy loam; weak to moderate, medium, subangular blocky, breaking to moderate, medium granular; very friable; clear, smooth boundary.
Aeg	26-32	Brown (7.5YR 5/4m) and dark grayish brown (10YR 4/2m); common, medium, distinct yellowish red (5YR 4/4m) mottles; loam to sandy loam; moderate, medium, subangular blocky, breaking to moderate, fine to medium granular; friable; clear, irregular boundary.
Btg	32-47	Reddish brown (5YR 5/4 and 4/4m); common, medium, distinct yellowish red (5YR 5/6m) mottles; loam; moderate, medium subangular blocky, breaking to moderate, fine to medium granular; friable; gradual, broken boundary.
Bg1	47-74	Reddish brown (5YR 4/4m) and brown (7.5YR 5/4m); many, medium, distinct yellowish red (5YR 5/6m) mottles; very fine sandy loam; weak to moderate, coarse subangular blocky, breaking to weak to moderate, fine to medium granular; firm; clear, smooth boundary.
Bg2	74-80	Reddish brown (5YR 5/3m) and pinkish gray to light brown (7.5YR 6/3m); many, medium, prominent yellowish red (5YR 5/8m) mottles; loam to very fine sandy loam; moderate, coarse subangular blocky, breaking to moderate, fine subangular blocky; firm; clear, smooth boundary.
Bg3	80-93	Brown to dark brown (7.5YR 4/4m) and dark yellowish brown (10YR 4/4m); many, coarse, prominent yellowish red (5YR 5/8m) mottles; loamy very fine sand; weak to moderate, coarse subangular blocky breaking to weak, fine granular; firm; clear smooth boundary.
Bg4	93-113	Reddish brown (5YR 5/3m) and dark yellowish brown (10YR 4/4m); many, prominent strong brown (7.5YR 5/8m) mottles; loamy very fine sand; weak to moderate, coarse, massive, breaking to weak to moderate, fine subangular blocky; friable; clear, smooth boundary.
IICkg	113-125	Reddish brown (5YR 5/3m) and brown to dark brown (10YR 4/3m); many prominent strong brown (7.5YR 5/8m) mottles; silt loam; moderate to strong, coarse massive and bedded; firm.

TABLE 42. MINERALOGICAL DATA OF THE GLEYED GRAY BROWN LUVISOL, VINELAND SERIES
MINERALOGIE DU LUVISOL GRIS-BRUN GLEYIFIE, SERIE VINELAND

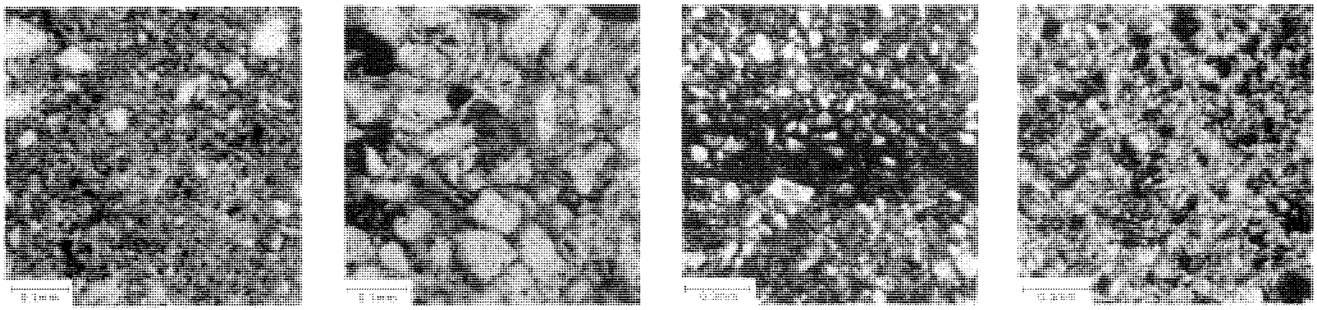
Horizon	Fraction 2-0.2μm					Fraction <0.2μm			
	mica	chlorite	kaolin	smectite	vermiculite	quartz	feldspar	amphibole	amorphous
Apk	00	01	00			02			04
Aeg		01	00		01	02			04
Btg	01	01	00		00	01			04
Bg1	01	01	00		01	01			04
Bg2		01	00	00	01	01			04
Bg3	01		00		01	02	01		04
Bg4	01	01	00	00	00	02	00		04
IICkg	01	01	00			01	00	00	04

TABLE 43. ANALTYICAL DATA OF THE GLEYED GRAY BROWN LUVISOL, (VINELAND), SITE 14
DONNEES ANALYTIQUES DU LUVISOL GRIS BRUN GLEYIFIE, (VINELAND) A SITE 14

Horizon	pH $CaCl_2$	pH H_2O	Org. C / carbone organique %	Total N %	$CaCO_3$ Eq. %	Exchangeable Cations / Cations échangeables, Buffered - Tamponnée: Ca (meq/100g)	Mg (meq/100g)	K (meq/100g)	Pyrophosphate Fe %	Pyrophosphate Al %	Oxalate Fe %	Oxalate Al %	Oxalate Mn %
Apk	7.6	7.7	10.0	0.1	6.1	15.0	0.8	0.5	0	0	0.2	0.1	0
Aeg	7.3	7.7	0.1	0	0.1	3.8	0.5	0.2	0.1	0.1	0.3	0.1	0
Btg	7.3	7.7	0.1	0	0.0	6.5	1.3	0.1	0.1	0	0.4	0.1	0.1
Bg1	6.9	7.6	0.1	0	0.6	5.3	1.3	0.1	0	0	0.2	0.1	0
Bg2	6.8	7.5	0.1	0	0.0	8.3	2.2	0.1	0	0	0.2	0.1	0.1
Bg3	6.8	7.4	0	0	0.2	3.2	0.9	0.1	0	0	0.1	0.1	0.1
Bg4	7.1	7.6	0	0	0.2	3.8	1.0	0.1	0	0	0.1	0	0.1
IICkg	7.5	8.1	0	0	10.4				0	0	0.1	0	0

Horizon	>2mm %	Particle Size Distribution - Analyse granulométrique (% <2mm), Sand - Sable: VCS	CS	MS	FS	VFS	Total	Silt / Limon Total	Clay / Argile Total	Bulk Density / Densité apparente g/cm³	Field Moisture / Humidité Champ %
Apk	4	0	0	0	3	49	52	33	15	1.61	16.9
Aeg	0	0	1	1	1	54	57	35	8	1.64	16.9
Btg	0	1	1	1	2	38	43	45	12	1.64	18.4
Bg1	0	0	0	0	1	67	68	24	8	1.66	18.6
Bg2	0	0	0	1	1	49	51	40	9	1.67	20.5
Bg3	0	0	0	0	1	77	78	18	4	1.56	26.2
Bg4	0	0	0	0	0	72	72	25	3	1.53	28.9
IICkg	0	0	0	0	4	43	47	48	5	1.65	24.9

Figure 54. Micromorphology of the Gleyed Gray Brown Luvisol at Site 14.



a.plane light b.plane light c.partly X d.plane light

Vineland

Ap This horizon is moderately packed grayish-brown material with common brown areas. The former area consists of very fine sand and fine matrix material as thin matrans (<20μm) on all grains, bridges between grains, and incomplete intergranular fillings. Silt size carbonate grains occur in the fine matrix material. The brown areas (Fig. 54a) are diffuse nodules (0.2-4mm with most about 1mm) consisting of silt size carbonate grains with a few sand grains. Dark brown to black moderately to well humified organic fragments (<1mm with most about 200-500μm) are (O-C). Sesquioxidic nodules (<2mm), manganiferous nodules (<250μm) and ferruginous sandstones and siltstones are all (VR). Primary carbonate grains (100-2000μm) are (O) throughout the horizon.
-1- intertextic
-2- matriplectic

Ae + Btg This horizon is moderately packed pale grayish-brown material with (C-F) dark brown areas. The pale areas consist of very fine sand and fine matrix material as bridges between grains to incomplete intergranular fillings with areas of complete fillings. The dark areas result from (C-F) nodules. The nodules are mainly sesquioxidic (<3mm with most 0.5-1mm) with many manganiferous nodules (<1mm with most 200-500μm) and occasional weakly to moderately oriented clay nodules (<1mm with most 200-500μm). Weakly oriented argillans are (VR-R) on the (O) vughs and channels. Moderately to well humified organic fragments (<1mm) are (R-O) and carbonate grains are absent.
-1- argillasepic agglomeroplasmic with porphyroskelic areas
-2- matrigefuric porphyroskelic//matrigefuric

Bg1 This horizon is moderately to loosely packed pale material consisting of very fine sand and (C-F) strongly oriented translocated clay as thin coatings, bridges, and partial intergranular fillings (<100μm) (Fig. 54b) and (R-O) vugh argillan (<150μm). Sesquioxidic (200-1000μm) and manganiferous (200-500μm) nodules are (R-O) with the sesquioxidic dominant. Ferruginous very fine sand grains are (C).
-1- granular with free grain argillans

Bg1 The top half of this horizon is similar to the above horizon except that there is a thick (<5mm) band or layer containing (C) nodules (<3mm) of sesquioxidic, manganiferous, and silty-clay material (Fig. 54c). In the bottom part of this horizon there is (O) translocated clay and a moderate amount of silt. Ferruginous very fine sand grains are (C) throughout this horizon.
-1- granular with free grain argillans

Bg4 + IICg This horizon consists of moderately to well packed very fine sand that shows much closer packing than in any of the above horizons (Fig. 54d). With depth the previously mentioned nodules decrease in size (<500μm with most <250 μm) and are very weakly developed. Ferruginous grains are (C) and very fine carbonate grains are (R) at the top and (C) at the bottom of this horizon.
-1- granular
-2- orthogranic

SITE 15: HUMIC LUVIC GLEYSOL ON TILL (TRAFALGAR)

Soil Name:	Trafalgar.
Location:	Rittenhouse Farm, lot 7, Concession III, Clinton Township, Regional Municipality of Niagara, 43^o 10' 20" N. Lat., 79^o 25' 20" W. Long.
Elevation:	90 m. M.S.L.
Landform:	Level plain.
Slope:	0%
Drainage:	Imperfectly drained.
Vegetation:	Most native vegetation has been removed. Species common to the area include elm (*Ulmus* sp.) maple (*Acer* sp.) beech (*Fagus* sp.), oak (*Quercus* sp.), and black Ash (*Fraxinus nigra*) and chestnut.
Climate:	Station: Vineland 43^o 11' N. Lat., 79^o 23' W. Long. Precipitation: mean annual precipitation is 790 mm with a maximum in August. Temperature: mean daily maximum for July is 26.5 C. Mean daily minimum for January is -7 C.
Parent Material:	Reddish silty clay loam glacial till.
Soil Classification:	Canada: Humic Luvic Gleysol, very fine clayey, mixed, alkaline, strongly calcareous, mild subaquic family U.S.A.: Argiaquic Argialboll, very fine clayey, mixed, mesic family F.A.O.: Gleyic Phaeozem

Horizon	Depth	Description
Ap1	0-15	Very dark grayish brown (10YR 3/2m); silty clay; moderate to strong, medium, subangular blocky, breaking to moderate, medium, granular; firm; very plastic; gradual smooth boundary.
Ap2	15-26	Very dark grayish brown (10YR 3/2m) silty clay; moderate to strong, coarse, angular blocky, breaking to moderate to strong, medium angular blocky; very firm; very plastic; abrupt smooth boundary.
Aeg	26-29	Brown to dark brown (10YR 4/3m) and pale red (2.5YR 6/2m); common, medium, prominent brownish yellow (10YR 6/6m) mottles; heavy clay; moderate to strong, coarse, massive; very firm; very plastic; clear, smooth boundary.
Btgj	29-62	Reddish brown (5YR 4/3.5m) and dark reddish gray (5YR 4/2m); silty clay; massive, breaking to weak to moderate, medium angular blocky; very firm; very plastic; clear wavy boundary.
Ckg	62-100	Reddish brown (2.5YR 4/4m) and dark reddish brown to reddish brown (2.5YR 3.5/4m); silty clay loam; massive, breaking to weak to moderate, medium angular blocky; very firm; very plastic.

The dominant red color of the soil parent material masks profile development in this pedon. However, the organic-rich cultivated surface horizon stands out prominently, as well as a discontinuous bleached horizon beneath it. This Aeg horizon is the only portion of the profile in which mottling can be detected, the fact attributed to the reddish hue of the subsoil horizons. The B horizon is not easily detected on the basis of its color, nor on its particle size analyses. However, the presence of common clay skins on ped faces in this horizon indicated it to be a horizon of clay illuviation. This was not substantiated with Fe and Al analyses, but an increase in oxalate extractable Mn also occurred in this horizon.

The dense, fine textured subsoil horizons of this pedon are highly impermeable to water movement, hence contribute to significant periods of water saturation. They have been indicated as gleyed horizons by inference, in spite of the absence of dull colors or mottling, to denote the degree of saturation and reducing conditions which are expected to exist.

Much of the clay in this soil is of the montmorillonite type. Although the soil is well supplied with potassium, much of it is fixed particularly in periods of dry weather, and large amounts of potassium fertilizer are required for a measurable crop response.

TABLE 44. MINERALOGICAL DATA OF THE HUMIC LUVIC GLEYSOL, TRAFALGAR SERIES
MINÉRALOGIE DU GLEYSOL HUMIQUE LUVIQUE, SÉRIE TRAFALGAR

Horizon	Fraction 2-0.2µm				Fraction <0.2µm	
	mica	chlorite	kaolin	smectite	quartz	amorphous
Ap1	02	01	00		02	03
Ap2	01	01	00		02	04
Btg1	02	01	00		02	03
Btg2	03	01	00		02	01
Btg3	05	01	00		02	
Btg4	04	01	00		01	
Ckg1	05	01	00		01	
Ckg2	02	01	00	02		03

TABLE 45. ANALYTICAL DATA OF THE HUMIC LUVIC GLEYSOL, (TRAFALGAR), SITE 15
DONNEES ANALYTIQUES DU GLEYSOL HUMIQUE LUVIQUE (TRAFALGAR) A SITE 15

Horizon	pH $CaCl_2$	pH H_2O	Org. C / carbone organique %	Total N %	$CaCO_3$ Eq. %	Exchangeable Cation / Cation échangeables, Buffered - Tamponnée: Ca (meq/100g)	K (meq/100g)	Mg (meq/100g)	Pyrophosphate Fe %	Pyrophosphate Al %	Oxalate Fe %	Oxalate Al %	Oxalate Mn %
Ap1	6.5	6.7	4.9	0.5	0.2	16.0	1.1	4.3	0.1	0.1	0.4	0.3	0.1
Ap2	6.6	7.1	3.0	0.3	0.2	19.5	0.5	5.9	0.1	0.1	0.5	0.3	0.1
Btgj1	6.9	7.2	0.7	0.1	0.2	11.5	0.3	5.3	0.1	0.1	0.5	0.4	0.1
Btgj2	7.3	7.6	0.3	0.1	2.0	8.3	0.2	4.2	0	0	0.4	0.4	0
Btgj3	7.5	7.7	0.2	0.1	0.5	11.0	0.1	5.3	0	0	0.1	0.1	0
Btgj4	7.4	7.9	0.2	0	2.1	15.0	0.1	4.8	0	0	0.1	0.1	0
Ckg	7.6	8.0	0	0	16.1				0	0	0.1	0.1	0

Horizon	>2mm %	Particle Size Distribution - Analyse granulométrique, Sand - Sable: VCS (% <2mm)	CS	MS	FS	VFS	Total	Silt / Limon Total	Clay / Argile Total	Bulk Density / Densité apparente g/cm^3	Field Moisture / Humidité Champ %
Ap1	0	0	0	0	0	0	6	50	44	1.27	25.1
Ap2	0	0	0	0	0	0	8	43	49	1.31	21.1
Btgj1	0	0	0	0	0	0	2	36	62	1.57	17.9
Btgj2	0	0	0	0	0	0	3	57	40	1.72	11.3
Btgj3	0	0	0	0	0	0	5	50	44	1.75	12.4
Btgj4	1	1	1	2	4	4	11	53	36	1.82	10.0
Ckg	3	3	1	1	3	4	13	57	30	1.82	11.9

APPENDIX C Table 46. LAND USE ASSESSMENT (ACRES) - EVALUATION DE L'UTILIZATION DES TERRES

DECEMBER 1975 - DECEMBRE

	PRINCE EDWARD ISLAND ILE-DU-PRINCE-EDOUARD	NOVA SCOTIA NOUVELLE-ECOSSE	NEW BRUNSWICK NOUVEAU-BRUNSWICK	QUEBEC QUEBEC	ONTARIO ONTARIO
URBAN BUILT-UP AREA	6,207	130,283	397,562	520,710	928,161
MINES, QUARRIES, SAND & GRAVEL PITS	0	4,221	6,283	25,975	40,301
OUTDOOR RECREATION	775	578,077	769,699	9,397,773	2,202,585
HORTICULTURE	0	0	462	633	632
ORCHARDS AND VINEYARDS	198	16,891	2,861	101,868	168,552
CROPLAND	270,527	13,932	177,843	1,032,985	5,141,524
IMPROVED PASTURE & FORAGE CROPS	412,204	971,369	1,121,626	6,641,016	8,088,948
UNIMPROVED PASTURE & RANGE LAND	60,527	218,320	304,784	1,594,502	2,450,894
PRODUCTIVE WOODLAND	546,797	9,542,981	13,468,514	39,646,573	26,492,948
NON-PRODUCTIVE WOODLAND	64,157	1,327,853	959,417	658,645	3,300,100
SWAMP, MARSH OR BOG	24,373	247,762	366,226	341,315	513,466
UNPRODUCTIVE LAND - SAND	492	0	0	2,527	1,498
UNPRODUCTIVE LAND - ROCK	5,393	32,476	7,957	32,598	77,489
WATER	29	3,893	1,908	7,321	11,247
UNMAPPED AREAS (OUTSIDE OF CANADA	0	0	0	14,673,889	18,614,550
TOTAL	1,391,679	13,088,058	17,585,142	74,678,330	68,032,895

SOIL CAPABILITY FOR AGRICULTURE SUBCLASSES
LES SOUS-CLASSES DES POSSIBILITES DES SOLS POUR L'AGRICULTURE
in acres - en acres

PRINCE EDWARD - ILE-DU-PRINCE-EDOUARD

SUBCLASSES SOUS-CLASSES	CLASS CLASSE 1	2	3	4	5	6	7	U*	0±	TOTAL
S	0	645791	207629	40257	3748	0	12292	0	0	909717
SW	0	0	67641	54375	110141	0	13415	0	0	245572
	0	0	0	0	0	0	0	0	16489	16489
I	0	0	47	0	0	0	23736	0	0	23783
Z	0	0	0	0	0	0	0	447	0	447
W	0	0	0	486	54397	0	7828	0	0	62711
T	0	0	74227	25519	19591	0	11107	0	0	130444
TS	0	0	156	2220	0	0	0	0	0	2376
ST	0	0	0	141	0	0	0	0	0	141
TOTAL	0	645791	349700	122998	187877	0	68378	447	16489	1391680

NOVA SCOTIA - NOUVELLE-ECOSSE

SUBCLASSES SOUS-CLASSES	CLASS CLASSE 1	2	3	4	5	6	7	U	0	TOTAL
P	0	0	612847	418276	760	2588	8179927	0	0	9214398
T	0	0	445514	109987	102270	3308	104852	0	0	765931
S	0	356227	1209090	201996	993	0	2108	0	0	1770414
T	0	38176	29476	9547	1008	25696	35	0	0	103938
	0	0	1771	0	0	0	0	0	287189	288960
W	0	140	101226	156480	98049	3795	38680	0	0	398370
R	0	0	19161	147632	0	0	348046	0	0	514839
Z	0	0	0	0	0	0	0	849	0	849
X	0	16278	8316	2557	0	0	239	0	0	27390
WS	0	0	0	1844	0	0	0	0	0	1844
WT	0	0	6	0	0	0	0	0	0	6
PT	0	0	0	0	0	0	908	0	0	908
SW	0	0	210	0	0	0	0	0	0	210
TOTAL	0	410821	2427617	1048319	203080	35387	8674795	849	287189	13088057

Table 46.

NEW BRUNSWICK - NOUVEAU-BRUNSWICK

SUBCLASSES SOUS-CLASSES	CLASS CLASSE 1	2	3	4	5	6	7	U	0	TOTAL
W	0	0	40999	384450	699517	9492	451782	0	0	1586240
S	0	107794	1768902	1023037	13338	1766	11068	0	0	2925905
I	0	26702	4191	0	581	11	7706	0	0	39191
P	0	0	63712	645676	943284	855	946463	0	0	2599990
R	0	0	22002	77375	71829	1106	202096	0	0	374408
	0	0	431	0	0	0	30018	276997	327486	634932
RP	0	0	0	66941	112961	0	403994	0	0	583896
X	0	127	1255	1469	0	0	0	0	0	2851
WP	0	0	2409	275826	85636	0	237818	0	0	601689
PR	0	0	0	99977	301410	0	193407	0	0	594794
D	0	0	72947	2016	0	0	0	0	0	74963
WD	0	0	1	17428	8412	0	1537	0	0	27378
F	0	248844	2202	2210	0	0	0	0	0	253256
T	0	0	327507	615621	500977	2176	221438	0	0	1667719
FM	0	0	8129	40766	0	0	0	0	0	48895
WT	0	0	5405	23051	32707	0	10367	0	0	71530
MF	0	850	14812	81360	0	0	0	0	0	97022
TW	0	0	5384	71137	53242	0	5111	0	0	134874
TR	0	0	14166	48444	72018	0	435736	0	0	570364
TS	0	2403	33685	37885	9027	0	1523	0	0	84523
WS	0	0	71026	486379	252994	0	229528	0	0	1039927
FD	0	0	1177	0	0	0	0	0	0	1177
TP	0	0	16862	80200	220135	652	476352	0	0	794201
PT	0	0	6895	88174	402238	0	358614	0	0	855921
PW	0	0	0	71850	159606	0	156448	0	0	387904
RT	0	0	3665	27667	17845	0	143036	0	0	192213
PD	0	0	8796	6944	1812	0	0	0	0	17552
SC	0	454	1086	34958	0	0	0	0	0	36498
MR	0	0	0	3466	0	0	0	0	0	3466
TM	0	0	0	2329	0	0	0	0	0	2329
ST	0	1996	30065	38920	313	0	0	0	0	71294
MP	0	0	0	1247	0	0	0	0	0	1247
WF	0	0	0	11821	0	0	0	0	0	11821
PM	0	0	0	741	22215	0	846	0	0	23802
PS	0	0	40286	184897	137146	0	6971	0	0	369300
WR	0	0	0	9489	11880	0	4876	0	0	26245
DP	0	0	1513	3353	0	0	0	0	0	4866
RW	0	0	0	30508	22877	0	1878	0	0	55263
FW	0	0	602	488	0	0	0	0	0	1090
DW	0	0	1030	0	0	0	0	0	0	1030
N	0	0	0	0	0	7709	0	0	0	7709
SW	0	0	200572	305676	31715	0	0	0	0	537963
C	0	390	3533	1721	0	0	0	0	0	5644
SP	0	253	65421	78307	11608	0	281	0	0	155870
R	0	0	0	0	0	0	0	7820	0	7820
TD	0	0	541	0	0	0	0	0	0	541
M	0	0	0	758	0	0	0	0	0	758
TF	0	0	0	3262	0	0	0	0	0	3262
TC	0	0	565	1411	1447	0	0	0	0	3423
MT	0	0	0	913	0	0	37	0	0	950
SR	0	3280	0	28377	2100	0	0	0	0	33757
RS	0	0	3441	1648	475	0	0	0	0	5564
XS	0	0	0	895	0	0	0	0	0	895
Z	0	0	0	0	0	0	0	117	0	117
SI	0	4219	1430	0	0	0	0	0	0	5649
TE	0	0	0	0	765	0	0	0	0	765
WI	0	0	0	2558	703	4771	2994	0	0	11026
IS	0	0	0	0	0	0	1449	0	0	1449
WC	0	0	0	0	0	0	955	0	0	955
XW	0	0	127	0	0	0	0	0	0	127
TOTAL	0	397312	2846772	5023626	4202813	28538	4544329	284934	327486	17655810

Table 46.

QUEBEC

SUBCLASSES SOUS-CLASSES	CLASS CLASSE 1	2	3	4	5	6	7	U	O	TOTAL
T	0	16180	352456	221994	1057919	12674	6389514	0	0	8050737
S	0	265945	512119	860359	7697	187	118978	0	0	1765285
	47345	0	0	0	0	0	0	3451333	3774044	7272722
W	0	1524760	505665	257398	588737	0	1592594	0	0	4469154
I	0	4082	11236	5860	9208	0	600408	0	0	630794
SE	0	0	0	760	1592	13489	8604	0	0	24445
SW	0	0	51041	119080	5168	0	16373	0	0	191662
RT	0	0	0	27772	299623	0	12657713	0	0	12985108
ST	0	688	74425	17151	11442	0	254097	0	0	357803
IW	0	0	0	107	0	0	3611	0	0	3718
Z	0	0	0	0	0	0	0	159	0	159
TR	0	0	12344	1578	106644	0	1128260	0	0	1248826
MF	0	0	0	821818	0	0	388	0	0	822206
P	921	0	103883	203247	138300	18	1502621	0	0	1948990
PW	0	0	23521	182842	251871	0	1646427	0	0	2104661
FM	0	0	15939	260427	2165	0	0	0	0	278531
PR	0	0	0	3282	52266	0	965212	0	0	1020760
R	0	0	1582	12376	191011	0	923648	0	0	1128617
DW	0	266	66073	63481	28212	0	0	0	0	158032
R	0	0	0	0	0	0	0	166010	0	166010
MT	0	0	0	1074	29106	0	468971	0	0	499151
WD	0	0	36561	255650	18616	0	0	0	0	310827
FW	0	0	277784	1027097	0	0	625	0	0	1305506
PT	0	0	46127	437262	488201	0	14297616	0	0	15269206
RP	0	0	0	3896	48214	0	36998	0	0	89108
TW	0	0	753	754	1151	0	873	0	0	3531
WP	0	0	64056	183156	44043	0	160236	0	0	451491
TP	0	0	67061	234336	335336	0	8050195	0	0	8687140
WF	0	0	35850	61144	18488	0	0	0	0	115482
PM	0	0	0	0	0	0	6378	0	0	6378
PF	0	0	1090	37866	639	0	0	0	0	39595
F	0	19512	475913	27105	0	0	0	0	0	522530
SC	0	0	2703	2483	0	0	5270	0	0	10456
TF	0	0	8551	10906	857	0	0	0	0	20314
WT	0	0	0	711	763	0	0	0	0	1474
X	0	412949	5228	0	0	0	0	0	0	418177
WC	0	0	0	0	0	0	296	0	0	296
RW	0	0	0	0	1487	0	967	0	0	2454
SP	0	553	19459	6394	6920	0	6987	0	0	40313
WS	0	0	47191	31185	1927	0	12238	0	0	92541
TE	0	444	6237	2966	24020	0	54184	0	0	87851
WR	0	0	304	956	762	0	23673	0	0	25695
TD	0	0	1590	393205	0	0	0	0	0	394795
M	0	0	0	0	235008	0	29263	0	0	264271
FT	0	0	83646	198515	721	0	0	0	0	282882
FP	0	0	57987	95387	0	0	0	0	0	153374
TM	0	0	0	0	5159	0	384	0	0	5543
E	0	367	758	0	2069	0	70573	0	0	73767
FI	0	0	0	6756	0	0	0	0	0	6756
ET	0	0	845	0	589	0	3292	0	0	4726
ES	0	0	0	0	718	0	4051	0	0	4769
TS	0	0	5336	2339	10044	0	7532	0	0	25251
D	0	1663	187912	188806	4329	0	0	0	0	382710
FD	0	0	0	24062	0	0	0	0	0	24062
WI	0	0	0	2369	0	0	0	0	0	2369
MC	0	0	0	0	66166	0	0	0	0	66166
PS	0	0	0	0	0	0	112759	0	0	112759
MP	0	0	0	0	0	0	110241	0	0	110241
DT	0	0	956	86232	0	0	0	0	0	87188
DP	0	0	0	0	3035	0	0	0	0	3035
EP	0	0	0	0	0	0	1084	0	0	1084
ME	0	0	0	2604	183	0	32618	0	0	35405
C	0	358	0	0	0	0	0	0	0	358
SI	0	0	0	3153	0	0	0	0	0	3153
SR	0	0	0	0	0	0	213	0	0	213
RS	0	0	0	0	0	0	4469	0	0	4469
FR	0	0	1231	0	0	0	0	0	0	1231
TOTAL	48266	2247767	3165413	6388113	4100406	26368	51310434	3617502	3774044	74678313

Table 46. ONTARIO

SUBCLASSES SOUS-CLASSES	CLASS CLASSE 1	2	3	4	5	6	7	U	0	TOTAL
	5329320	0	0	0	304	0	0	1758	6333899	11665281
T	0	75026	1001613	225964	170391	186305	78829	0	0	1738128
TE	0	0	0	0	0	2140	30344	0	0	32484
TS	0	0	13264	33240	66269	151620	301212	0	0	565605
S	0	2528353	973748	1006612	138845	6168	33414	0	0	4687140
W	0	2080276	1160211	2586238	871280	9397	162723	1570947	0	8441072
F	0	0	0	0	0	0	0	358769	0	358769
P	0	10787	425412	98072	170103	300846	3297	0	0	1008517
F	0	4992	8068	0	12338	50020	19184	0	0	94602
R	0	104006	39958	113934	16998	1226102	298471	0	0	1799469
Z	0	0	0	0	0	0	0	2919	0	2919
PR	0	0	0	1409	87205	79744	26095842	0	0	26264200
PT	0	0	0	618	14425	124071	3914	0	0	143028
RS	0	0	1089	1774	71675	124610	209487	0	0	408635
TP	0	0	1887	123948	477228	216783	466684	0	0	1286530
ET	0	0	0	0	0	0	2947	0	0	2947
RT	0	0	0	0	142	1394	3551	0	0	5087
TW	0	0	1268	0	2725	0	0	0	0	3993
ST	0	0	7167	2394	1407	10520	121	0	0	21609
WS	0	12653	225412	84944	23583	6642	842	0	0	354076
T	0	0	0	5987	16471	0	2021	0	0	24479
F	0	1292	47575	595512	3537	1339	0	0	0	649255
WP	0	0	1613	1951	4884	9002	0	0	0	17450
WT	0	0	0	0	3109	0	0	0	0	3109
PS	0	0	0	0	690411	10178	0	0	0	700589
SR	0	0	180	349	0	0	0	0	0	529
RW	0	0	0	0	1195	0	1011	0	0	2206
SP	0	0	0	3921	72952	22975	2110	0	0	101958
FM	0	0	23899	1462462	1354609	261063	6168	0	0	3108201
SW	0	5655	635	5866	20598	0	0	0	0	32754
X	0	0	19291	0	0	0	0	0	0	19291
C	0	656996	2661859	0	441	0	0	0	0	3319296
WD	0	0	1578	36066	1952	0	0	0	0	39596
RP	0	0	0	0	14363	1053	0	0	0	15416
DW	0	0	44542	1871	0	0	0	0	0	46413
D	0	0	480043	225	0	0	0	0	0	480268
TD	0	0	6968	54954	162492	408	510	0	0	225332
DT	0	0	0	947	0	0	0	0	0	947
FW	0	0	11129	17700	137854	4219	0	0	0	170902
WF	0	0	10845	13794	117802	1620	0	0	0	144061
RF	0	0	0	0	0	0	2538	0	0	2538
PW	0	0	1925	3503	311	0	0	0	0	5739
FN	0	0	0	2692	0	0	0	0	0	2692
FD	0	0	10117	244	0	0	0	0	0	10361
FW	0	0	1041	0	0	0	0	0	0	1041
PF	0	0	473	0	3264	6868	0	0	0	10605
FP	0	0	0	414	0	0	0	0	0	414
FC	0	0	4089	0	0	0	0	0	0	4089
CD	0	0	272	0	0	0	0	0	0	272
PM	0	0	0	375	1282	0	0	0	0	1667
WR	0	0	0	142	283	0	0	0	0	425
PC	0	0	1253	0	0	0	0	0	0	1253
SI	0	0	294	0	0	0	0	0	0	294
FT	0	0	0	0	410	1643	0	0	0	1643
FS	0	0	0	0	0	289	0	0	0	699
FR	0	0	0	0	0	504	1585	0	0	2089
TF	0	0	459	0	0	0	0	0	0	459
M	0	0	0	162	0	0	0	0	0	162
TR	0	0	0	0	0	0	259	0	0	259
TOTAL	5329320	5480036	7189177	6488284	4733138	2817523	27727064	1934393	6333899	68032834

APPENDIX D NITROGEN DISTRIBUTION IN EASTERN CANADIAN SOILS

Samples for this study were chosen from the different climatic and vegetation zones of the country. Every soil order (major type of soil) in Canada was represented by at least one set of profile samples. They were selected primarily from samples taken from the ISSS tour sites, hence most of the samples were from the more southerly and warmer soils. In all 92 mineral and 18 peat soils were analyzed. The amino acid, amino sugar and ammonia contents were determined by the use of an automatic amino acid analyzer after hydrolysis of the soil by refluxing the sample for 24 hrs with 6 normal HCl. Total and acid-insoluble nitrogen were determined by the Kjeldahl method and clay-fixed ammonium by Bremner's method (Black et al., Methods of Soil Analysis, Amer. Soc. Agron. P1229). Internal standards were run with each sample with the amino acid analysis and the standard error of 28 of these was calculated and found to be less than 2%. We have also found that the acid hydrolysis error is small. Sampling error is, in general, not known although it was found to be small for some peat soils.

Data for the amino compounds were calculated as mg/g soil and as ratios (x-amino N of compound x 100/amino acid N). The latter method eliminated the effect of the wide variability of the nitrogen content of the soil samples and gave the molar ratios of the compound in the soil: i.e. the "average" mineral soil had 11.9 moles of aspartic acid and 9.5 moles of glucosamine per 100 moles of amino acid N (Table 1). The amino sugars are probably associated with the soil "carbohydrate" rather than with the soil "protein" but for comparative purposes they were calculated in the same way as the amino acids.

The resulting data were first grouped according to the nitrogen content of the samples, i.e. greater than 1% N, 0.4-1% N etc. but the amino acid composition of the soil "protein" did not appear to be related to this. The data were then grouped for the LFH, A, B, and C horizons and also for the Ah, Ap, Ae, Bhf, Bh, Bm and Bt layers. Again few significant differences in the amino acid composition could be found.

Data for the average amino acid composition and the standard deviation for 92 mineral soils, 6 LFH and 2 'O' horizons of these and 18 peat soils are shown in Table 1. Since the analytical and sampling errors appear to be relatively small and would not account for all of the standard deviation it appears that there were real but relatively small and random differences in the amino acid composition of the different samples. Inspection of the data for the individual soils supported this conclusion - for instance some samples had very small or barely detectable amounts of hydroxyproline while with other soils it made up 1-2 percent of the amino acid nitrogen. The amino sugar composition was more variable - see the larger relative standard deviation - and the glucosamine/galactosamine ratio varied from 2:1 for the LFH horizons to 1:1 for the peat soils.

In general, however, the soil "protein" which is probably largely the result of microbial degradation and synthesis is remarkably similar in its amino acid composition. For example the amount of tyrosine is usually about ½ that of phenylalanine and isoleucine 2/3 that of leudine. Black and Weiss (Amino Acid Handbook, C.C. Thomas 1956) have stated "Inspection of the data in this monograph indicates that the heterogeneous proteins of actively metabolizing living matter -- have approximately the same overall pattern of amino acids. Special proteins -- are not so well balanced". The soil "protein", probably derived from the heterogeneous proteins of microorganisms and plants, is also similar in composition.

Amino acid nitrogen makes up over half of the total nitrogen of the LFH and 'O' horizons. This underestimates the true protein nitrogen since there is probably some amine nitrogen (about 5%) not included in this. In all the mineral soils probably about 40% is "protein" nitrogen (including amine), 5% is amino sugar nitrogen, 18% hydrolyzable unidentified nitrogen and 13.5% is insoluble in the acid used for hydrolysis. Clay-fixed ammonium made up 17% of the total nitrogen and much of the hydrolyzable ammonium came from this.

The complete data for the nitrogen distribution of these soils is collected in a mimiographed publication of the Soil Research Institute, Canada Department of Agriculture, Ottawa, Ontario by Dr. Fred Sowden.

ANALYTICAL METHODS FOR NITROGEN DISTRIBUTION

For the nitrogen distribution work, ground 1.000 or 2.000 g. air dry samples are refluxed for 24 hr with 130 ml 6 N HCl, filtered through a sintered glass crucible, the residue washed, dried, weighed, and its Kjeldahl-N determined. The filtrates and washings are taken to dryness several times on a rotating evaporator to remove HCl, the residue from this dissolved in 0.05 N HCl and made up to 10 or 25 ml. The forms of nitrogen:- amino acids, amino sugars and ammonium- are determined on aliquots of this using a Technicon amino acid analyser. In some instances, ammonium is also determined on aliquots of the hydrolysates by making them alkaline with MgO, steam-distilling the ammonia and Nesslerizing. These results agree well with the amino acid analyser determination.

The amino acid and amino sugar data are reported in two ways (air dry basis):- as mg/g soil and as molar ratios. For the latter, the total number of micromoles of amino acid nitrogen is calculated and the x-amino N of each amino acid is calculated as a percentage of this. Although the amino sugars are not amino acids, the N of each amino sugar is calculated as a percent of the total amino acid N. These data show (for the first 50 or so samples we have analyzed) that the soil "protein" contains 11.9 molecules of aspartic acid, 5.6 molecules of threonine, 2.5 molecules of arginine (10 molecules of arginine N) -- etc., per 100 molecules of "protein" nitrogen and the soil "carbohydrate" contains 10.2 molecules of glucosamine on the same basis. At the bottom of the table where the data are reported in mg, the sum (or total) mg of x-amino acid and total amino acid N is given. Since half of the amino sugars are decomposed to ammonium and other compounds under the hydrolysis conditions we used, the amino sugar values reported are those found multiplied by 2 in both tables. In the mg table, therefore, part of the N is counted twice - as ammonium and as amino sugar. The mg total N and acid-insoluble N is also shown in this table.

At the bottom of the 'ratio' table, I have reported the percentage of total accounted for in the various forms of nitrogen:- total amino acid, hexosamine (or amino sugar), ammonium, and acid-insoluble N. In this table, a correction is made for the fact that part of the ammonium comes from loss of amino sugar (i.e. half the percentage of amino sugar N is subtracted from the percentage of ammonium N). These nitrogen percentages are calculated from single Kjeldahl-N determinations that we had obtained, primarily to help us select the size of the aliquot to be used for the amino acid determinations. For the Manitoba samples, we have received the total-N data from the Manitoba soil survey laboratory; in some instances, these data differ from ours and appear to give more consistent percentages for the various nitrogen fractions. Perhaps all these "percentage of total N" data should be recalculated when the "official" total N values become available. Although it has little to do with the N analysis, this table also shows the percentage of the sample that was not soluble in boiling 6 N HCl; the amount of sample described (100 - figure shown) would include the moisture contained in the air-dry sample.

TABLE 47. SOILS FROM EASTERN CANADA
Data in Mg/g soil (including total N)

Site	4	4	4	2	2	2	1	1	1	7	7	7	7	6	6
Horizon	Ap2	Bmxj	C	Ae	Bf	Cx	Ap	Bf	C	Ap	Bg1	Bg2	Cg	F	H
	T1103	T1104	T1105	T1106	T1111	T1107	T1108	T1109	T1110	T1114	T1116	T1115	T1117	T1112	T1113
Aspartic Acid	0.423	0.037	0.013	0.482	0.351	Similar to site 4 C, but too low to calculate	0.69	0.321	Similar to site 2 Cx, but too low to calculate	0.63	0.194	0.118	0.051	7.05	8.92
Glutamic Acid	0.386	0.034	0.016	0.460	0.349		0.62	0.319		0.54	0.161	0.090	0.042	7.14	8.12
Serine	0.214	0.022	0.017	0.203	0.151		0.34	0.142		0.29	0.073	0.049	0.020	3.91	5.64
Threonine	0.201	0.017	0.008	0.203	0.145		0.30	0.141		0.25	0.075	0.048	0.023	3.99	5.04
Glycine	0.259	0.020	0.011	0.268	0.204		0.40	0.192		0.39	0.105	0.063	0.032	4.64	5.72
Alanine	0.224	0.015	0.005	0.238	0.193		0.34	0.184		0.31	0.094	0.053	0.029	4.31	5.26
Valine	0.193	0.019	0.007	0.171	0.141		0.28	0.128		0.25	0.060	0.039	0.018	4.48	5.06
Isoleucine	0.116	0.010	0.004	0.106	0.081		0.17	0.092		0.16	0.050	0.030	0.020	2.85	3.24
Leucine	0.180	0.017	0.008	0.182	0.131		0.29	0.133		0.28	0.063	0.040	0.025	4.89	5.53
Tyrosine	0.063	0.002	0.002	0.062	0.033		0.06	0.046		0.11	0.026	0.047	0.016	1.93	2.05
Phenylalanine	0.118	0.009	0.004	0.117	0.078		0.18	0.116		0.18	0.035	0.041	0.020	3.06	3.28
Proline	0.161	0.014	0.005	0.117	0.101		0.19	0.087		0.23	0.075	0.036	0.014	3.67	4.26
OH proline	0.029	0.0	0.0	0.034	0.010		0.03	0.013		0.03	0.0	0.0	0.0	0.49	0.55
Methionine	0.020	0.0	0.0	0.025	0.018		0.03	0.019		0.02	0.007	0.009	0.0	0.37	0.40
Cystine	0.015	0.0	0.0	0.015	0.007		0.04	0.031		0.01	0.012	0.010	0.0	0.60	0.64
Cysteic Acid	0.041	0.017	0.011	0.061	0.043		0.07	0.056		0.08	0.032	0.019	0.017	0.57	0.39
Meth. Sulphox.	0.027	0.0	0.0	0.023	0.017		0.03	0.025		0.03	0.0	0.0	0.003	0.17	0.27
Ornithine	0.036	0.010	0.020	0.036	0.022		0.06	0.021		0.04	0.012	0.014	0.006	0.17	0.35
Lysine	0.172	0.018	0.010	0.168	0.120		0.30	0.123		0.25	0.070	0.060	0.023	2.96	3.61
Histidine	0.068	0.006	0.005	0.064	0.043		0.12	0.055		0.09	0.024	0.023	0.009	1.55	2.51
Arginine	0.155	0.010	0.005	0.139	0.096		0.27	0.108		0.21	0.049	0.036	0.016	3.48	3.48
Misc.	0.083	0.003	0.0	0.081	0.060		0.23	0.070		0.07	0.054	0.055	0.027	0.20	0.37
Total	3.184	0.280	0.151	3.255	2.394		5.04	2.422		4.45	1.271	0.880	0.411	62.48	74.69
Glucosamine	0.605	0.035	0.018	0.405	0.258	0.009	0.85	0.280	0.019	1.01	0.222	0.106	0.046	7.08	14.33
Galactosamine	0.349	0.020	0.013	0.300	0.167	0.007	0.42	0.176	0.014	0.63	0.161	0.061	0.019	3.40	5.73
amino N	0.365	0.032	0.017	0.372	0.277	0.012	0.576	0.274	0.018	0.510	0.146	0.098	0.046	7.09	8.56
Total amino N	0.436	0.038	0.022	0.439	0.322	0.014	0.699	0.326	0.021	0.605	0.171	0.118	0.054	8.55	10.27
Corrected Hexosamine N	0.075	0.004	0.002	0.055	0.033	0.001	0.100	0.036	0.003	0.128	0.030	0.013	0.005	0.82	1.57
Measured Ammon N.	0.274	0.076	0.057	0.267	0.227	0.077	0.427	0.262	0.155	0.484	0.261	0.211	0.202	2.16	3.79
Acid insol. N	0.15	0.044	0.035	0.089	0.049	0.033	0.13	0.12	0.074	0.17	0.033	0.026	0.028	1.48	1.58
Total N	1.10	0.30	0.20	1.00	0.90	0.30	1.60	0.90	0.30	1.50	0.50	0.30	0.30	15.2	18.6

TABLE 48. SOILS FROM EASTERN CANADA

Data in ratios 100 x (amino N of each amino acid (or sugar) / total amino acid N)

Site	4	4	4	2	2	2	1	1	1	7	7	7	7	6	6
Horizon	Ap2	Bmxj	C	Aeg	Bf	Cx	Ap	Bf	C	Ap	Bg1	Bg2	Cg	F	H
	T1103	T1104	T1105	T1106	T1111	T1107	T1108	T1109	T1110	T1114	T1116	T1115	T1117	T1112	T1113
Aspartic Acid	10.20	10.09		11.57	11.49	Conc. of amino acid too low for accurate data	10.40	10.34	Conc. of amino acid too low for accurate data	10.87	11.98	10.47	9.95	8.68	9.13
Glutamic Acid	8.43	8.44		9.97	10.34		8.47	9.27		8.44	9.02	7.21	7.36	7.94	7.52
Serine	6.55	7.71		6.17	6.25		6.54	5.82		6.28	5.66	5.56	4.91	6.10	7.31
Threonine	5.42	5.32		5.45	5.29		5.09	5.09		4.93	5.17	4.73	4.91	5.49	5.77
Glycine	11.08	9.91		11.39	11.82		10.67	10.97		11.89	11.48	9.93	10.98	10.11	10.38
Alanine	8.07	6.24		8.54	9.45		7.64	8.86		8.15	8.61	7.10	8.27	7.92	8.04
Valine	5.30	5.87		4.67	5.22		4.73	4.68		5.01	4.18	3.96	4.01	6.26	5.88
Isoleucine	2.85	2.75		2.57	2.68		2.63	3.03		2.87	3.12	2.66	3.88	3.56	3.36
Leucine	4.42	4.77		4.43	4.33		4.37	4.36		4.86	3.94	3.61	4.91	6.10	5.75
Tyrosine	1.12	0.37		1.10	0.78		0.72	1.09		1.46	1.19	3.08	2.33	1.74	1.54
Phenylalanine	2.29	2.01		2.25	2.05		2.23	3.00		2.54	1.72	2.96	3.10	3.03	2.70
Proline	4.50	4.40		3.23	3.83		3.35	3.26		4.53	5.37	3.73	3.10	5.22	5.04
OH proline	0.68	0.0		0.84	0.35		0.47	0.43		0.46	0.0	0.0	0.0	0.61	0.57
Methionine	0.42	0.0		0.54	0.52		0.37	0.54		0.35	0.41	0.71	0.0	0.41	0.36
Cystine	0.20	0.0		0.20	0.13		0.30	0.56		0.13	0.41	0.47	0.0	0.41	0.36
Cysteic Acid	0.78	3.85		1.16	1.11		0.87	1.42		1.10	1.56	1.36	2.58	0.55	0.32
Meth. Sulphox	0.52	0.0		0.44	0.44		0.40	0.64		0.44	0.0	0.0	0.52	0.17	0.23
Ornithine	0.86	2.75		0.86	0.72		0.87	0.69		0.64	0.74	1.24	1.16	0.20	0.36
Lysine	3.78	4.40		3.67	3.57		4.08	3.61		3.97	3.94	4.85	4.01	3.32	3.36
Histidine	1.41	1.47		1.34	1.22		1.52	1.52		1.37	1.27	1.71	1.42	1.64	2.20
Arginine	2.85	2.20		2.55	2.39		3.10	2.66		2.76	2.30	2.42	2.33	3.27	2.73
Misc.	2.04	0.73		2.00	2.00		3.60	2.30		1.21	3.40	4.97	5.30	0.25	0.39
Total	83.77	83.28		84.94	85.98		82.42	84.14		84.26	85.47	82.73	85.03	82.98	83.30
Glucosamine	10.84	7.16		7.22	6.27		9.53	6.70		12.97	10.17	6.98	6.59	6.47	10.90
Galactosamine	6.27	4.04		5.35	4.05		4.74	4.23		8.09	7.38	4.02	2.71	3.11	4.36
(as % of total N) Corrected T. amino ac. N	39.6	12.7	11.0	43.9	35.8	4.6	43.7	36.2	7.0	40.3	34.2	39.3	18.0	56.3	55.2
(as % of total N) Corrected Hexos. N	6.8	1.4	1.2	5.5	3.7	0.4	6.3	4.0	1.0	8.5	6.0	4.3	1.7	5.4	8.4
(as % of total N) Ammon. N	21.5	24.6	28.0	24.0	23.3	25.4	23.6	27.1	51.1	28.0	49.2	68.0	66.6	11.5	16.1
(as % of total N) Acid insol. N	13.6	14.7	17.5	8.9	5.4	11.0	8.1	13.3	24.7	11.3	6.6	8.7	9.3	9.7	8.5
Insol. in 6 NHCl (as % of soil)	87	79	83	82	83	87	84	82	74	84	72	68	68	53	54

Table 49. Proportions of different nitrogen components of mineral and organic horizons of representative Canadian soils.
Ratios $\left(\frac{\text{amino N of component x 100}}{\text{amino acid N}}\right)$

No. of Soils	Mineral Soils (92)	LFH Horizons (6)	O (TC)[3] Horizons 2	Peat Soils 18
Aspartic Acid	11.9±2.3	9.5±0.7	9.1±1.7	8.7±1.2
Glutamic Acid	8.6±1.1	8.1±0.3	7.8±0.3	6.6±0.7
Serine	5.6±0.9	6.2±0.6	7.0±0.1	6.1±0.7
Threonine	5.5±0.6	5.8±0.2	6.2±0.0	6.4±0.6
Glycine	11.4±0.9	10.7±0.7	10.8±0.2	11.2±1.0
Alanine	8.3±0.8	8.1±0.2	7.9±0.4	9.1±0.3
Valine	4.9±0.7	5.8±0.3	5.8±0.04	6.3±0.4
Isoleucine	3.0±0.4	3.5±0.3	3.7±0.03	4.0±0.4
Leucine	4.8±0.8	6.0±0.5	6.0±0.1	6.0±0.5
Tyrosine	1.1±0.4	1.4±0.3	1.4±0.3	2.0±0.4
Phenylalanine	2.3±0.4	2.8±0.2	2.8±0.1	3.2±0.2
Proline	4.1±0.7	5.1±0.4	5.7±0.2	4.8±0.4
OH-proline	0.4±0.4	0.8±0.2	1.2±0.1	1.3±0.8
Methionine	0.6±0.4	0.6±0.2	0.7±0.01	0.7±0.1
Cystine	0.4±0.3	0.3±0.1	0.4±0.03	0.5±0.2
Cysteic Acid	1.0±0.7	0.5±0.2	0.4±0.01	0.2±0.1
Meth. Sulphox.	0.3±0.3	0.2±0.04	0.2±0.04	0.2±0.1
Ornithine	1.0±1.1	0.4±0.1	0.4±0.01	0.6±0.3
Lysine	3.7±0.5	3.3±0.2	2.9±0.3	3.1±0.2
Histidine	1.4±0.3	1.6±0.4	1.5±0.5	1.5±0.3
Arginine	2.5±0.3	2.9±0.2	2.6±0.1	2.3±0.1
Misc.	2.0±1.1	0.6±0.3	1.1±0.7	1.2±0.3
Glucosamine	9.5±3.0	9.5±3.1	7.4±0.7	8.3±2.9
Galactosamine	5.3±1.9	4.1±1.2	4.6±0.8	8.7±4.3
Amino Acid N[1]	35.9±11.5	51.3±7.5	52.7±2.3	40.7±6.4
Hexosamine N[1,2]	5.3±2.1	7.0±2.7	6.4±0.5	6.8±2.7
Ammonia N[1,2]	27.5±12.9	14.9±2.6	14.4±5.7	11.1±1.7
Acid insol. N[1]	13.5±6.4	15.3±7.3	17.3±1.6	24.0±5.5
Clay-fixed N[1]	17.0	-	-	-
Hyd. unident.	17.8	11.5	9.2	17.4

[1]as percent of total N; [2]corrected for hydrolysis loss; [3]turbic cryosol

CRITERIA FOR QUANTITATIVE ANALYSIS OF Mg^{++} sat'd. ISSC samples

Mica - peak area of the glycerolated 10.Å peak. (001)

Chlorite - peak area of the glycerolated 4.73Å peak. (003)

Kaolinite - Using a glycerolated specimen the 7Å peak area was assumed to represent kaolin after the 4.73Å chlorite peak area times the factor of 1.4, was subtracted. The area remaining at 7Å was divided by 2.32 to read off the kaolinite curve.

Smectite - The glycerolated 18Å peak area was used.

Vermiculite - The glycerolated specimen peak area at 14Å was resolved by removing the 4.73Å of chlorite (divided by 0.62) and determined from established curves.

Quartz - The peak (4.25Å) height of the air dried specimen.

Feldspar - The sum of microcline-type (3.24Å) and plagioclase-type (3.19Å) feldspars.

Amphibole - Peak height of the 8Å peak.

Interstratified minerals - The interstratified components were generally not quantified.

X-ray amorphous material equals 100 percent minus the sum of crystalline components.

Table 50. MINERALOGY CODES

		%
	nil	0
00	trace	0-2
01	minor	2-20
02	minor to moderate	20-40
03	moderate	40-60
04	abundant	60-80
05	very abundant	80-100

These codes are used to record relative percent for the various sizes of minerals.

FORMAT FOR MICROMORPHOLOGICAL DESCRIPTIONS

The descriptions of soil micromorphology begin with a brief paragraph summerizing the main features of the microfabric in general terms. The relative frequencies, sizes or areal extent of features such as voids and nodules are indicated in brackets following the feature described. The technical name of the fabric in (1) Brewer's (1964) and (2) Brewer's and Pawluk's (1975) terminology is given following the general paragraph. On some occasions only the terminology that is best suited or most descriptive is used.

<u>Illumination</u> In these descriptions the following abbreviations are used to correct the illumination used

plane light - light vibrating in one direction
X polarizers - with crossed polarizers
partly X - with partly crossed polarizers

<u>Magnifications used for descriptions</u>

a) 25x - for colour, and arrangement of large peds and/or aggregates
b) 63x - for arrangement of smaller units and more detailed description
c) 125x - for examination of specific features.

<u>Guide to relative frequencies of pedological features</u> - after Stace <u>et al</u> (1968)

a) cutans
more frequent (F) >5% of the area
common (C) 5-2%
occasional (O) 2-0.5%
rare (R) rare but easily located and identified
very rare (VR) section must be searched to positively identify them.

b) nodules
(F) >20% of the area
(C) 10-20%
(O) 5-10%
(R) 2-5%
(VR) <2%

<u>Description of overall porosity</u>

Using only those voids greater than 25μm in diameter
<5% - very dense
5-10% - dense
10-25% - moderately porous or moderately packed
25-40% - highly porous or loosely packed
>40% - extremely porous or very loosely packed

<u>Note</u> a horizon that consists of well packed fine sand and silt at low magnification is silasepic porphyroskelic while at higher magnification it is granular. On some occasions, both fabrics will be stated along with the applicable magnification.

<u>Types of banded fabrics</u> - after Dumanski and St. Arnaud (1966)

1. isoband
2. banded fabric type A

3. banded fabric type B
4. banded fabric type C

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