#57-1

Soils of the REGIONAL MUNICIPALITY OF HALDIMAND-NORFOLK

Volume I

Report No. 57 • Ontario Institute of Pedology

Ministry of Agriculture and Food
ONTARIO
Jack Riddell, Minister
Clay Switzer, Deputy

Agriculture Canada
Research Branch
Direction de la recherche

THE SOILS OF THE REGIONAL MUNICIPALITY OF HALDIMAND-NORFOLK

VOLUME 1

REPORT NO. 57
OF THE
ONTARIO INSTITUTE OF PEDOLOGY

Research Branch, Agriculture Canada
Soil and Water Management Branch,
Ontario Ministry of Agriculture and Food
Department of Land Resource Science, University of Guelph

by
E.W. Presant
and
C.J. Acton
Land Resource Research Institute
Research Branch, Agriculture Canada
Guelph, Ontario

1984

Land Resource Research Institute Contribution No. 84-13

INTRODUCTION

The soil survey conducted to gather information for the maps and text of this report was actually a resurvey of the former counties of Norfolk and Haldimand. The original surveys for these counties were completed during the 1920's and 1930's and, although soil maps and reports were compiled from the soils information, only the maps were published. These maps and their extended legends were published at scales of approximately 1:125 000 (1,2).

The decision to resurvey Norfolk and Haldimand counties, now combined into the Regional Municipality of Haldimand-Norfolk, was made in response to increasing demands for better and more detailed soils information than the old maps could supply. Hence, soil mapping at a scale of 1:25 000 was begun in 1974 and completed in 1980. Preliminary soil maps, incorporating this new soils information, were made available during this time period.

The report is divided into two volumes. Volume 1 includes descriptions of the environmental setting of the soils, generalized descriptions of the soils, and soil interpretations. Volume 2 contains detailed morphological, chemical and physical descriptions of typical soils, as well as tables of statistical means and engineering test data. In addition to the report, there are thirteen soil maps published at 1:25 000 scale, and one soil map with generalized soil information at 1:100 000 scale.

HOW TO USE THE SOIL MAPS AND REPORT

Resource managers, such as farmers or foresters, usually know the characteristics and variations of soils on their own properties, or in the immediate vicinity. Without a soil map and report, comparison with other soils in the region is very difficult. With the help of a soil map, regional similarities and differences between soils can be shown. Such information can be an aid in buying or renting land, or in transferring management techniques to similar soils, thereby reducing the risks of managing new land.

To use the soil maps and report most efficiently the following procedure is suggested:

(1) Locate the area of interest on the "Soil Map Index" included with each volume. Note the number of the soil map on which your area of interest is located.

(2) Obtain the appropriate soil map, and locate your specific area of interest. Natural and cultural features on the map, such as streams, contours, roads, buildings, lots and concessions, should assist in location.

(3) Note the map unit symbols within the map unit delineation that includes your area of interest.

(4) Consult the legend on the map to aid in understanding the symbol and in determining the soil components, their slopes, parent materials, and drainage.

(5) If more information is required on the soil components, locate them by name in Volume 1 of the report. A generalized description of each soil is presented in Volume 1, as well as some comments on land use, and suitability for certain uses.

(6) For specific soil interpretations, refer also to Volume 1. It contains soil capability for common agricultural field crops, soil suitability for special agricultural and horticultural crops, soil erosion interpretations, soil interpretations for drainage, and soil interpretations for forest land management.

(7) For detailed morphological, chemical and physical descriptions of typical soils, as well as tables of statistical means and engineering test data, users are referred to Volume 2.

Users should understand that each soil exhibits a range of properties, and that boundaries between map units, even though they represent the best estimate of where soils change, may only be approximately located. They should also be aware that there could be inclusions of unidentified soil components, as large as a few hectares in area, within any map unit, because of the map scale and the nature of the soil mapping. Most soils information is based on the examination of soil characteristics to a depth of about 100 cm below the surface.

ACKNOWLEDGEMENTS

Many individuals contributed to this project. Most members of the Ontario Institute of Pedology were very helpful, especially G. Patterson, B. van den Broek, M. Langman, J. Hansen, M. McKnight and A Montgomery, who were responsible for much of the field mapping and preliminary map preparation. They were ably assisted in the field by B. Maclean, R. Denis, S. James, G. Winnicki, J. Kiss, D. Aspinall and S. Lee.

Field sampling and laboratory analyses were carried out by R. Viitala, B. Hohner and C. Heath of Agriculture Canada, and J. Gillespie and M. Markle of the University of Guelph. Engineering test data were provided by the Aggregates Section laboratory of the Highway Engineering Division of the Ontario Ministry of Transportation and Communications.

Cartographic assistance, throughout the project, was provided by D. Irvine and A. McLennan of the University of Guelph. Personnel from the Ontario Institute of Pedology, who contributed substantially to the data compilation and analysis, were M. Schmidt, J. Cook, J. Greuel, A. Munson, P. Allen and A. Sanderson. Special thanks are extended to J. Cook who was also responsible for the typing and word processing of the report.

The assistance of R. Chard, extension horticulturist with the Ontario Ministry of Agriculture and Food, in developing interpretations for special crops, was much appreciated. The assistance of M. Watson, N. Sheidow and J. Elliott, of the Tobacco Research Station, Delhi, in developing tobacco interpretations, was also appreciated. The preparation of the soil erosion section, by G. Wall, Agriculture Canada, and I. Shelton and J. Greuel, of the Institute of Pedology, was greatly appreciated. Thanks are also extended to P. Chisholm and R. Irwin, of the School of Engineering, University of Guelph, for their section on drainage interpretations, and to T. Taylor of the Ontario Ministry of Natural Resources, and K. Jones of Agriculture Canada, for their section on interpretations for forest land management.

Appreciation is expressed to all members of the Cartographic Section of the Land Resource Research Institute, Agriculture Canada, Ottawa, who were involved in the cartography and map digitization. Special thanks to B. Edwards who supervised this work, and to A. Villeneuve who worked with the maps throughout the project. Appreciation is also extended to J.H. Day of the same Institute for his suggestions throughout the project, and critical review of the manuscript.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

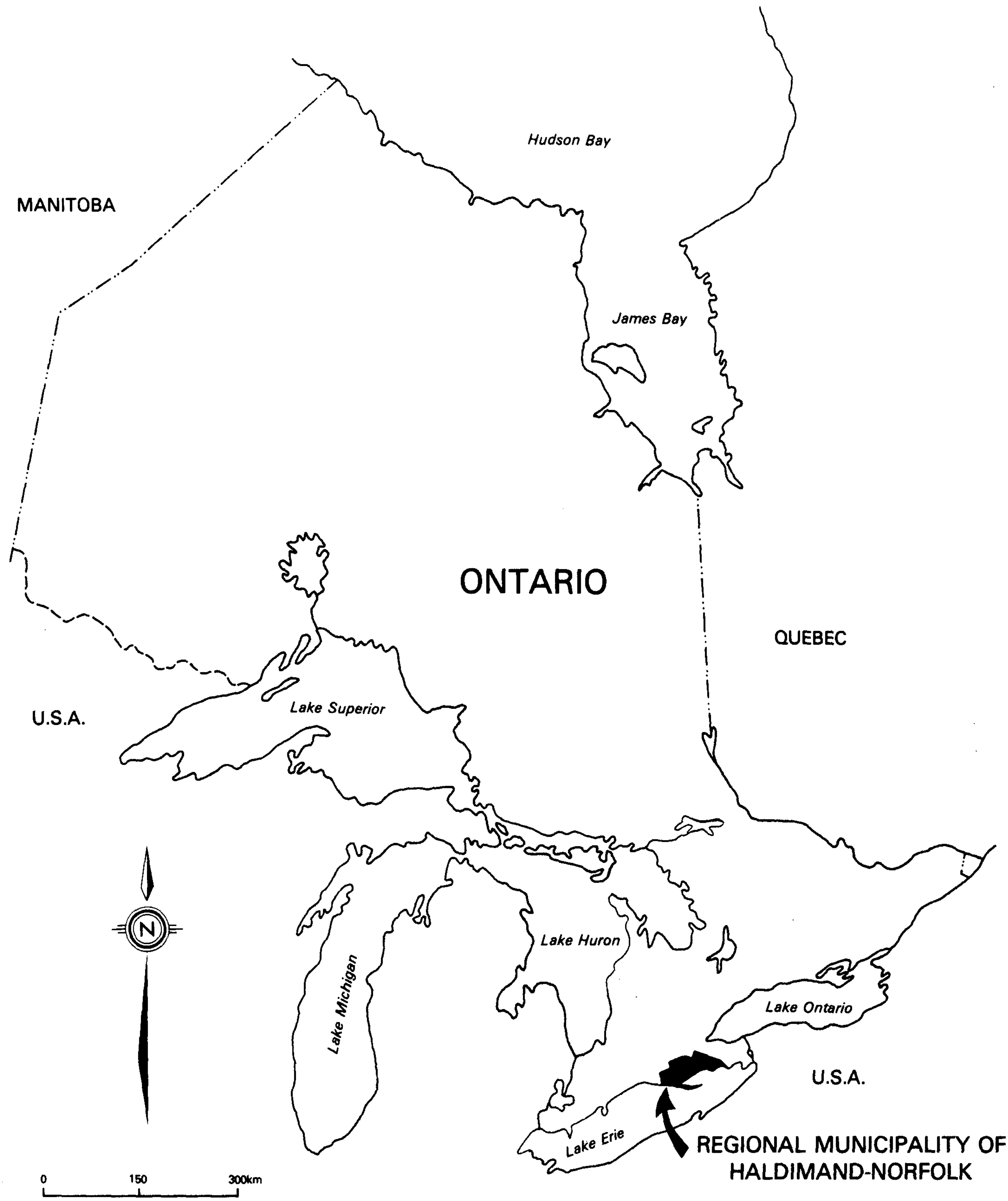


Figure 1. General location of the Regional Municipality of Haldimand-Norfolk.

GENERAL DESCRIPTION OF THE AREA

Location, Size and Population

The Regional Municipality of Haldimand-Norfolk is located in southern Ontario along the northern shore of Lake Erie (Figure 1). It lies between 79°45′ and 81°15′ W. and between 42°30′ and 43°15′ N. It is bounded on the south by Lake Erie, on the east by the Regional Municipality of Niagara, on the north by the Regional Municipality of Hamilton-Wentworth, Brant and Oxford counties, and on the west by Elgin County. According to 1981 Census of Canada figures, the total area of the Region is 291 229 hectares (ha) [719 645 acres (ac)]. Total farmland in 1981 was 225 603 ha (557 477 ac), about 77% of the total land area.

The population of the municipality was 89 460 in 1981. The greatest urban population centres in 1976 were the towns of Simcoe and Delhi. Smaller population centres were Dunnville, Hagersville, Caledonia, Port Dover, Cayuga, Waterford and Jarvis. A large new industrial complex was initiated near Nanticoke in the early 1970's by the building of an Ontario Hydro generating plant. The Townsend town site (5350 ha) is an area of land north of the new industrial complex that was purchased by the Ontario government in 1975 to accommodate the anticipated population growth resulting from the Nanticoke industrial development. The main towns, roads and municipal boundaries of the Regional Municipality of Haldimand-Norfolk are shown in Figure 4.

Figure 3. Residential housing in the new town of Townsend, near Jarvis

Agricultural Development and Land Use

The first white settlers began to move into the areas now within the Regional Municipality of Haldimand-Norfolk sometime around 1800. At the time, heavily forested Haldimand County had been granted to the Six Nations Indians. Norfolk County also was covered by magnificent forests of white pine, oak and other hardwoods. Lumbering was the chief industry during those early years when the forest was being cleared for settlement and agricultural development.

Figure 2. Ontario Hydro generating plant near Nanticoke

The first settlements were along the shores of Lake Erie and the Grand River. Many of the first settlers were United Empire Loyalists from the United States. Others, particularly in Haldimand County, originated from Germany, Holland and Great Britain. By 1812 the population of Norfolk County was 3,000.

Most of the early farms combined general farming with some livestock, usually sheep and cattle. Indian corn was a staple food until grist mills were built, then wheat and other small grains became important crops. There was some fruit growing and, as markets were created, market gardening on the sandier soils.

By 1921[1], 64 % of the improved land in Norfolk County was growing field crops, chiefly hay, oats, winter wheat and buckwheat. Substantial areas of rye, grain corn, mixed grain, potatoes and barley were also grown. About 30% of improved land was classed as pasture, idle, or fallow land, and the remaining 5 % was fruit and vegetables.

By the early 1900's, much of the cleared sandy land in Norfolk County was badly depleted of plant nutrients, and was being severely eroded by wind. Many of these eroded sandy farms were abandoned, which accounts for the large proportion of idle and pasture land in the 1921 Census. By the 1920's reforestation of these eroded sands was in full swing. In 1925, 60 ac of a new crop called flue-cured tobacco were grown on sands; by 1930 the area of flue-cured tobacco had increased to 14,000 ac. The increased production of tobacco, accompanied by the use of strip cropping techniques, windbreaks and reforestation, stabilized the sands and greatly increased the agricultural value of the sandy land.

[1]*Data compiled from Census of Canada, 1921*

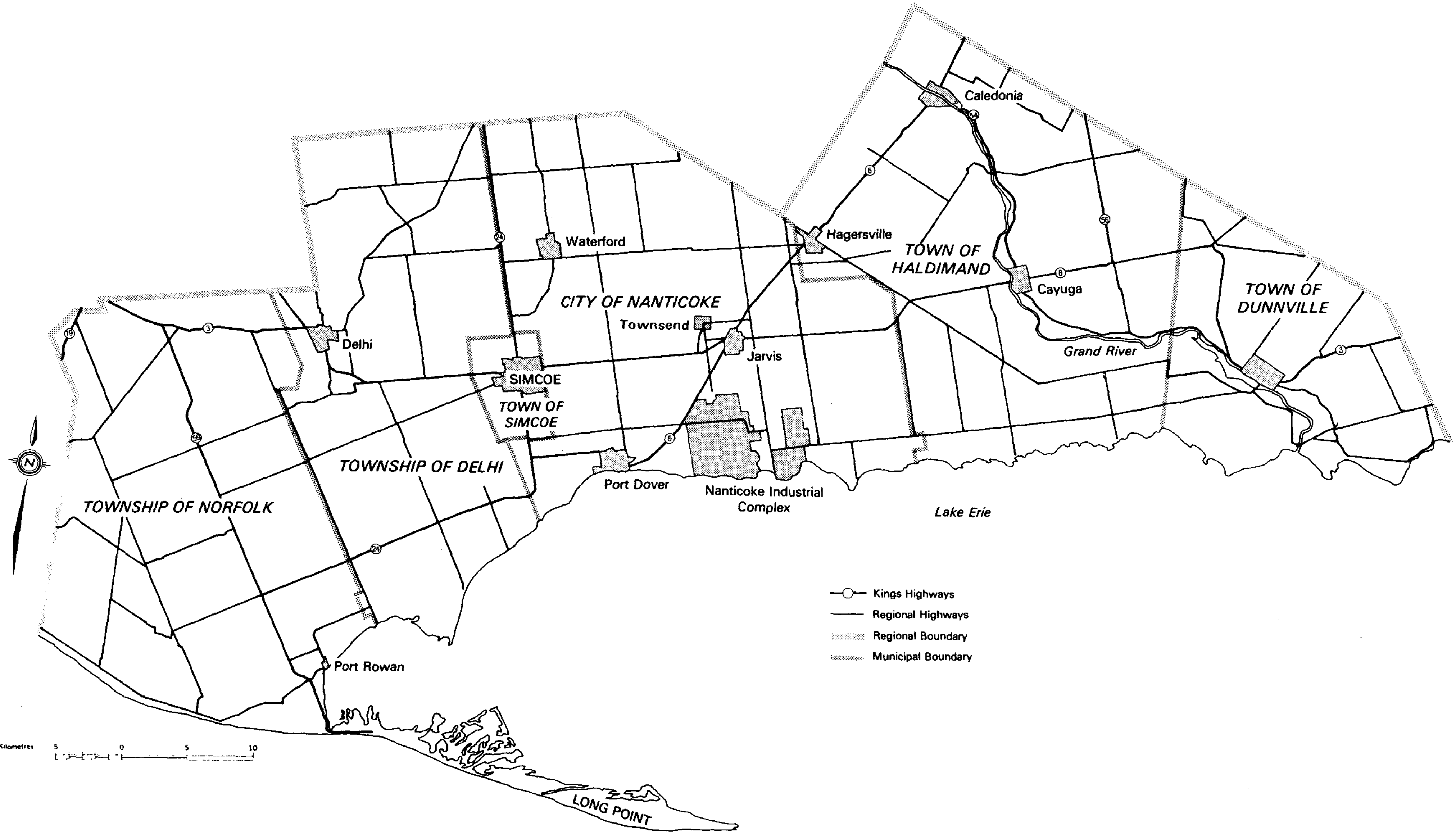


Figure 4. Main towns, roads and municipal boundaries of the Regional Municipality of Haldimand-Norfolk.

Table 1 indicates some of the more recent land use trends in the Haldimand-Norfolk Region. The most dramatic trend has been the increase in crop land at the expense of pasture and unimproved land. Much of the pasture land has been converted to field crops such as grain corn and soybeans. Woodlot areas also decreased, possibly due to conversion to field crops.

Table 1. Condition of farmland in the Regional Municipality of Haldimand-Norfolk.

	1966[1] hectares (acres)	%	1981[1] hectares (acres)	%
Total Land Area	291 124 (719 360)		291 229 (791 645)	
Improved Land[2]	195 318 (482 625)	67	189 354 (467 905)	65
Crops	145 070 (358 464)	50	164 138 (405 593)	56
Pasture	25 676 (63 444)	9	9 067 (22 405)	3
Unimproved Land[3]	48 292 (119 327)	17	36 248 (89 572)	12
Woodland	27 518 (67 996)	9.5	25 006 (61 791)	9

[1]*Data compiled from Census of Canada, 1966, 1981.*
[2]*Includes land under crops, pasture, summer fallow and other.*
[3]*Includes woodland and other.*

Table 2. Distribution of crops and numbers of livestock in the Regional Municipality of Haldimand-Norfolk

Total Areas — hectares (acres)	1966[1]	1981[1]
Total field crops	145 070 (358 464)	164 138 (405 593)
Winter wheat	14 111 (34 867)	15 080 (37 263)
Oats (grain)	21 811 (53 894)	5 471 (13 519)
Barley	1 517 (3 749)	6 821 (16 854)
Mixed grain	2 674 (6 607)	3 863 (9 546)
Rye	7 469 (18 456)	17 062 (42 160)
Grain corn	17 827 (44 051)	43 793 (108 215)
Fodder corn	5 108 (12 621)	4 787 (11 828)
Hay	41 821 (103 338)	25 390 (62 737)
Soybeans	864 (2 134)	7 601 (18 783)
Potatoes	475 (1 174)	327 (808)
Tobacco	22 717 (56 132)	25 410 (62 789)
Vegetables	2 782 (6 875)	4 247 (10 495)
Tree fruits	1 494 (3 691)	1 494 (3 692)
Small fruits	324 (801)	256 (633)
Total Animals (number)		
Total cattle	75 066	50 183
Dairy cows and heifers[2]	28 036	20 945
Total pigs	54 751	91 514

[1]*Data compiled from Census of Canada, 1966, 1981.*
[2]*Only dairy cows two years and over, heifers one year and over.*

Recent trends in field crops and livestock are indicated in Table 2. One of the most noticeable trends has been the marked increase in grain corn and soybeans; these apparently have replaced much of the hay, pasture and oats. There have also been noticeable increases in the area planted to tobacco, barley and vegetables.

This recent shift to cash crops, at the expense of forage crops, is also reflected by the decreased numbers of cattle. The sharp increase in the total number of pigs is probably related in part to the increased areas of grain corn.

The most important cash crop in the region, at the present time, is flue-cured tobacco. It is grown entirely on sandy and gravelly soils, but the area planted each year can vary considerably in response to market conditions. Rye has traditionally been the rotation crop grown with tobacco, but winter wheat is sometimes used in some areas of the region.

The area planted to vegetable crops has increased since 1966. In 1981 tomatoes, sweet corn, asparagus and cucumbers were the most popular vegetable crops making up 67% of the total vegetable area. Table 2 indicates no change in the area of land occupied by tree fruits. Small fruits show some decline, possibly reflecting labor problems and adverse market conditions for strawberries.

Two special crops that are increasingly popular are ginseng and peanuts. Ginseng, a very high-value crop, has been grown for many years on the well-drained gravels and loams north of Waterford. Increased demand in recent years has resulted in a considerable expansion of this crop on sands and sandy loams as well. In 1981 more than 80 ha were planted to peanuts on the sands of the Delhi-Waterford area. Peanuts may be an important crop in the future on these sandy soils as a supplement to, or replacement for, tobacco.

Figure 5. Ginseng plantings are increasing in the Waterford-Scotland area

Table 3 indicates some recent trends in the number and size of farms. There is a definite trend to fewer farms but little indication of the amalgamation of smaller farms to form larger units.

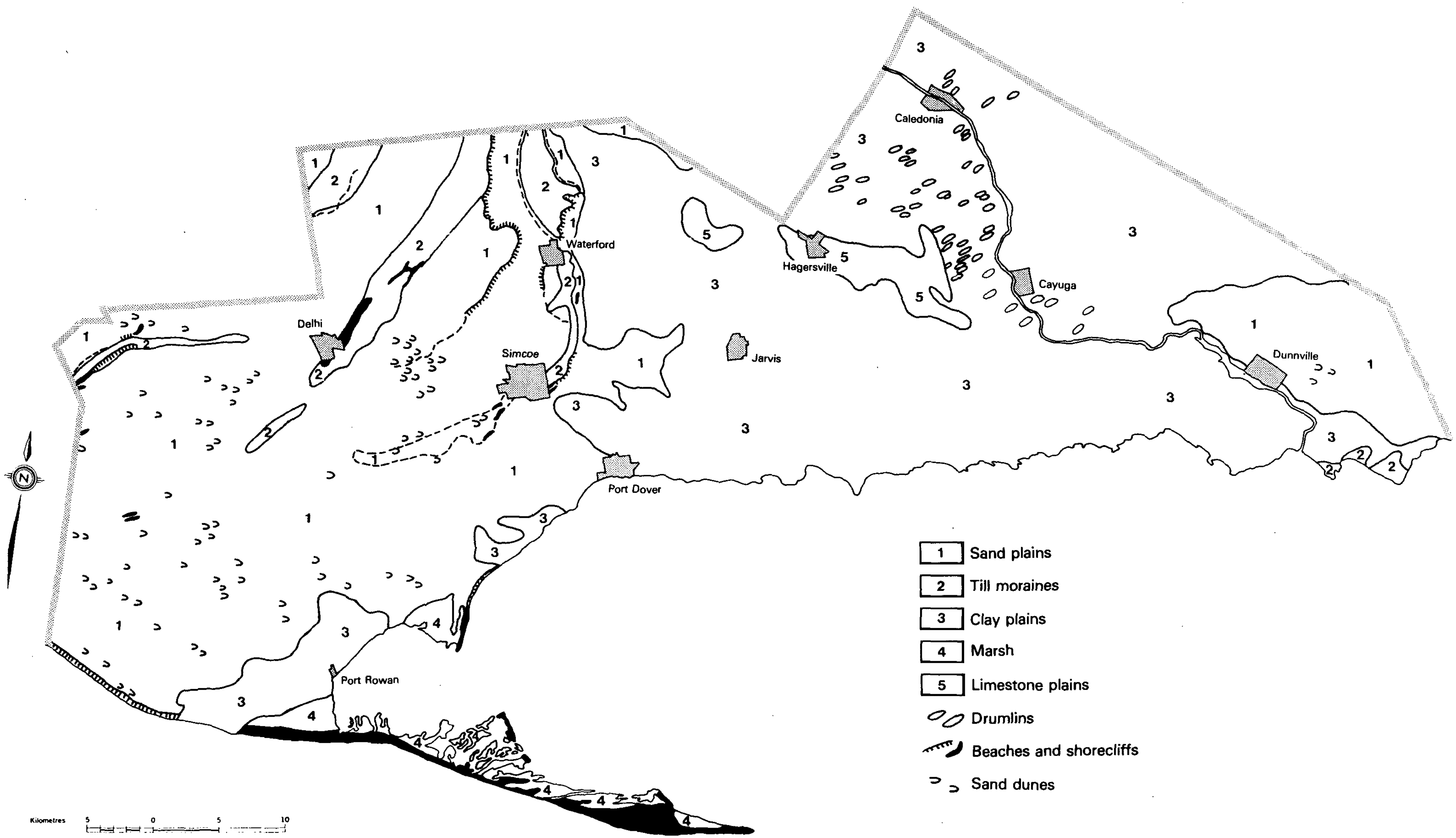


Figure 6. Physiographic features of the Regional Municipality of Haldimand-Norfolk.

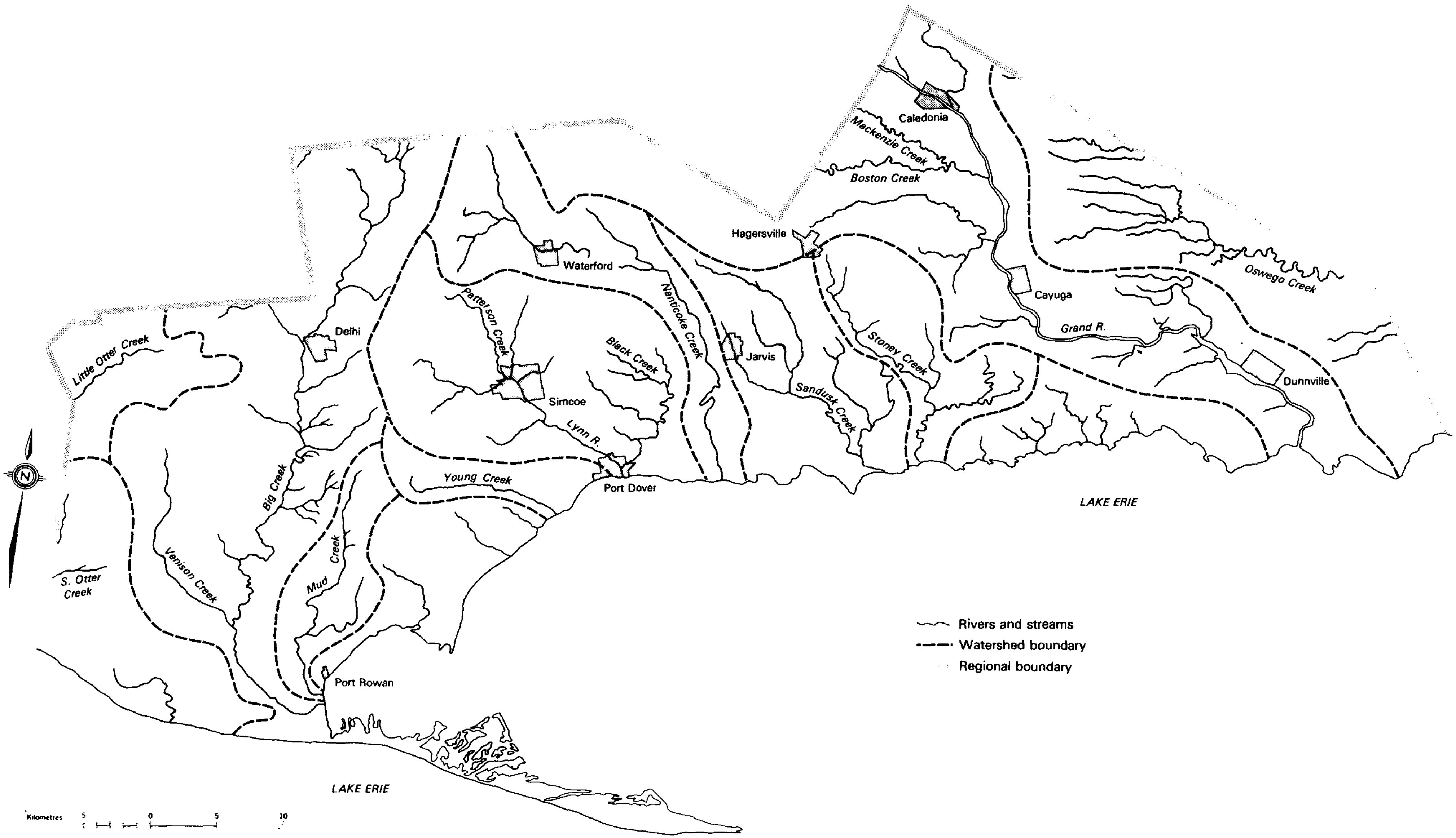


Figure 7. Main streams and watersheds of the Regional Municipality of Haldimand-Norfolk

Table 3. Number and size of farms in the Regional Municipality of Haldimand-Norfolk

Size of farms	No. of farms 1966[1]	1981[1]
All sizes	4 992	3 899
Less than 4 ha (less than 10 ac)	215	199
4 to 28 ha (10 to 70 ac)	1 109	949
28 to 53 ha (70 to 130 ac)	1 919	1 249
53 to 97 ha (130 to 240 ac)	1 354	937
More than 97 ha (more than 240 ac)	395	202

[1]*Data compiled from Census of Canada, 1966, 1981.*

Physiography and Drainage

The two physiographic regions that dominate the Regional Municipality of Haldimand-Norfolk are the Norfolk sand plain and the Haldimand clay plain (3). These are shown in Figure 6 along with smaller physiographic subregions and features.

The Norfolk sand plain blankets most of the former County of Norfolk in the western part of the Region. This plain slopes gently from the northwest to Lake Erie in the southeast. In the north, the low relief of the sand plain is broken by the Horseshoe moraines and the Mount Elgin ridges. The highest elevation in the region, 274 m, is attained on one of these ridges near Kelvin. The drop in elevation from this point to the Lake Erie water level is 102 m.

The sands of the Norfolk sand plain are thought to have been deposited in shallow water stages of glacial lakes Whittlesey and Warren. They range in thickness from less than 1 m to over 20 m, although the average thickness is probably 5 to 10 m. The relief on the sand plain is subdued, except for the moraines and occasional eolian dunes which can range up to 10 m high. Near Lake Erie, the sand plains grade into several small silt and clay plains.

The Horseshoe moraines and Mount Elgin ridges are sometimes partly buried by sands, but usually stand out in bold relief to the surrounding sand plains. The Horseshoe moraines, which include the Galt and Paris moraines, are composed mainly of gravelly sandy till. The Mount Elgin ridges, which include the Tillsonburg moraine, are composed mainly of silty clay loam till.

Most of the drainage of the Norfolk sand plain is by relatively short rivers and streams that cut deeply, sometimes as much as 30 m into the sand plain. The largest streams, Big Creek and Little Otter Creek, are shown in Figure 7. Near the main streams and their tributaries, drainage is good, but in some intermorainal and interfluvial parts of the sand plain, drainage is poor and wet sands or organic soils occur.

The Haldimand clay plain occupies most of the former County of Haldimand, in the eastern part of the region. The topography ranges from rolling and dissected to almost level. The elevation ranges from about 218 m in the northwest near Caledonia to 172 m in the south at Lake Erie. The clays and silts of the clay plain are thought to have been deposited mainly during deep water stages of glacial lakes Whittlesey and Warren. Their thickness ranges from less than 1m near the Onondaga escarpment, to almost 40 m southeast of Dunnville.

Figure 8. An aerial view of the Haldimand plain near Caledonia, showing typical terrain of gentle slopes and potholes

Although much of the relief is related to dissection of the clays, especially near the Grand River, bedrock and older till underlying the clay also strongly influence the topography. One of the major bedrock influences is the Onondaga escarpment, a low escarpment that cuts across the clay plain from west of Hagersville to southeast of Dunnville. The escarpment is partly buried by Pleistocene glacial and lacustrine sediments (4), but near Hagersville it attains heights of 15 m and provides good bedrock exposures.

Some small areas of limestone and dolostone bedrock are exposed at the surface near the Onondaga escarpment. From this escarpment to Lake Erie, bedrock is rarely more than 15 m below ground surface and accounts for the very gentle, south-sloping topography.

North of the Onondaga escarpment where the clays thicken to as much as 40 m over shaley bedrock, the main relief is afforded by dissected clays and partially exhumed drumlins. The drumlins consist of loam till and are mostly concentrated between the Grand River and the escarpment. East of the Grand River and just north of the Onondaga escarpment, where poorly drained clays and silts were ponded, the topography flattens out. In the southeast corner of the region to the south of the escarpment the rolling topography near the Lake Erie shore is due to the presence of some small till moraines.

The Grand River and its tributaries drain a large part of the Haldimand clay plain (Figure 7). The clays are usually more dissected and better drained near the Grand River. There are areas of poorly drained clays on many of the flatter interfluvial plains. East of the Grand River, the Onondaga escarpment and the strike of the bedrock cause the drainage waters to flow eastward to the Welland River and its tributaries, such as Oswego Creek. The low slope and lack of gradient create some very poorly drained sections in this area.

The drainage south of the Onondaga escarpment is

(Continued on page 14)

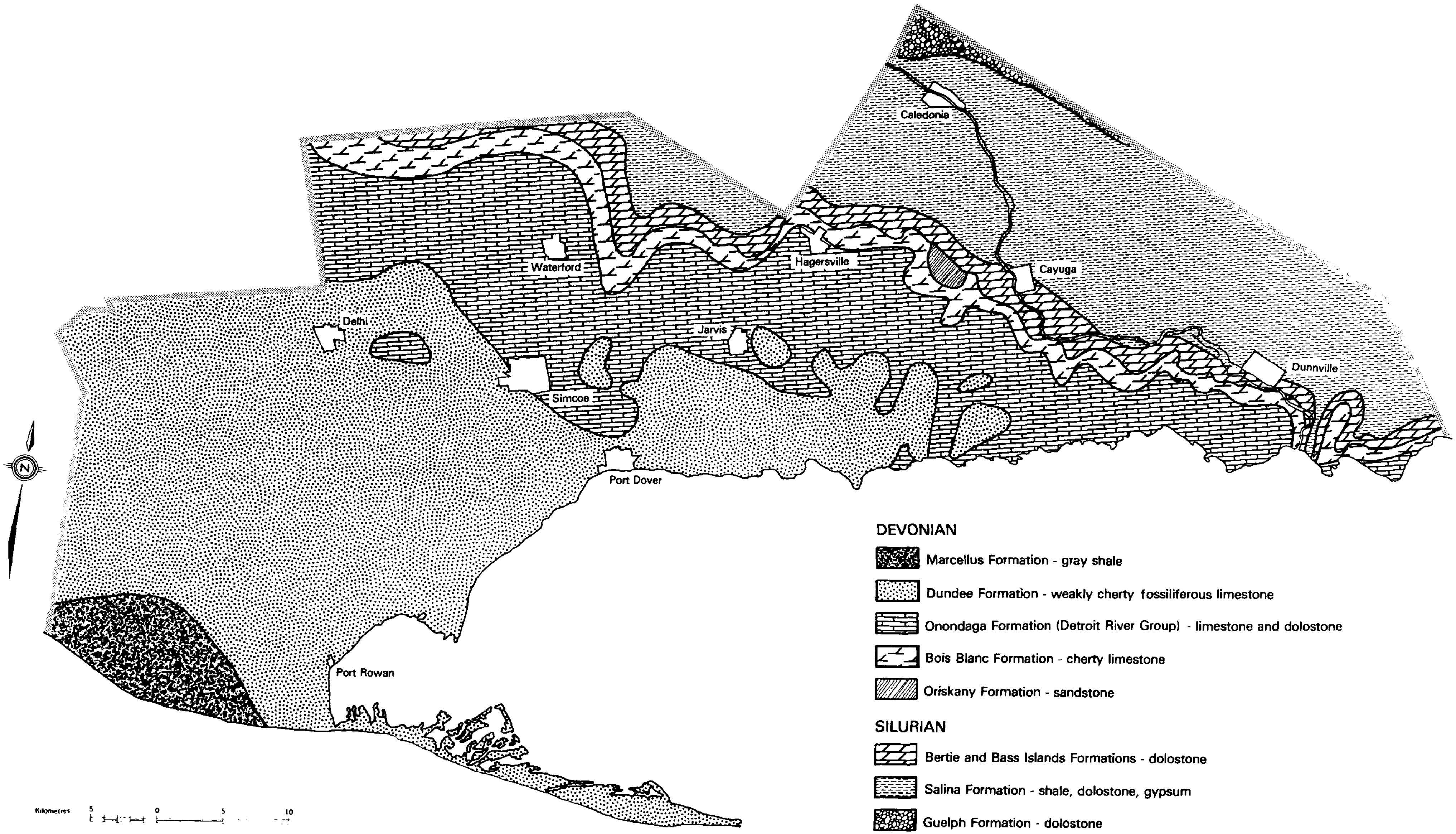


Figure 9. Bedrock geology of the Regional Municipality of Haldimand-Norfolk

mainly bedrock-controlled. Most of the streams, such as the Nanticoke, Sandusk and Stoney, reflect the low gradient of the limestone bedrock (5). There is some dissected moderately well-drained land close to these streams, but most of the land is imperfectly or poorly drained.

Bedrock Geology

The bedrock of the Regional Municipality of Haldimand-Norfolk is shown in Figure 9. It is composed of sedimentary Paleozoic rocks of Silurian and Devonian ages. These rocks occur in flat-lying beds that slope gently in a southerly direction. The main bedrock relief is provided by the Onondaga escarpment, formed by resistant dolostones and limestones over softer shales. Its maximum height is 15 m, but it is usally more subdued and often masked by surficial sediments.

The oldest bedrock in the region is the Guelph formation north of Caledonia, which consists of gray to buff, sugary dolostone. Most of the oil and natural gas, that have been drilled for so extensively in the Region, has come from Silurian sandstones and dolostones that underlie the Guelph formation (7).

The Salina formation, which forms the caprock between the Guelph formation and the Onondaga escarpment, has a greater thickness of surficial deposits than the adjacent dolostones, because of its greater erodibility. It consists of alternating layers of gray shale and dolostone with lenses of anhydrite and gypsum. Outcrops are very scarce; there are a few along the Grand River. The Salina formation has had a strong influence on the course of the Grand River and also, apparently, on the location of the drumlin field north of Hagersville. Gypsum is mined from the Salina formation near Hagersville and Caledonia (8).

The Bertie formation is composed mainly of resistant dolostones, which have produced the Onondaga escarpment (7). These rocks outcrop at the surface in many places on, and adjacent to, the escarpment. They are a major regional source of crushed stone from quarries that extend from Dunnville to Hagersville (7).

The Oriskany formation underlies only one small area near Clanbrasil, east of Hagersville. It consists of quartz sandstone that outcrops at the surface or has only a thin soil cover. A unique assemblage of fossils, flora and fauna are found at this site (9). The sandstone has been used as a source of building stone, silica and glass sand (8), and is presently being quarried for crushed stone.

The Bois Blanc formation extends in a narrow band south and west of the Onondaga escarpment. It consists of moderately to thinly bedded cherty limestone, often with a basal sandstone member (7). Drift thickness is rarely more than 5m over this limestone, and there are numerous surface outcrops. These rocks also are extensively quarried in the region.

The Detroit River group, consisting of limestone and dolostone, only forms a small wedge of the bedrock of the region north of Delhi.

The Onondaga formation underlies part of the region, southwest of the Onondaga escarpment. It consists mainly of variable cherty, fossiliferous limestone (7). Most of this formation occurs near the surface, at depths of 3 to 10 m. Many outcrops are present along stream courses and the Lake Erie shoreline. This limestone has been used, to a limited extent, for building stone and crushed stone.

The Dundee formation occupies most of the bedrock of the region between the Onondaga formation and Lake Erie. It consists of weakly cherty, fossiliferous limestone, containing minor shale (7). There is wide variation in the depth from the ground surface to this formation. It ranges from only 3 m below the ground surface in the Selkirk-Cheapside area, to 115 m near Port Rowan. Numerous outcrops of Dundee limestone occur along stream courses east of Port Dover. There are also several sinkholes in the floodplains of streams flowing over Dundee limestone (5). The Dundee limestone is quarried near Port Dover and Nanticoke.

The youngest bedrock in the region is the Marcellus formation. It underlies the southwest corner of the region along the Lake Erie shore, and consists predominantly of gray shale, with interbeds of gray, crystalline, cherty limestone. It is 80 to 100 m below the ground surface, and no surface outcrops are known.

Surficial Geology and its Relation to the Soils of the Region

The surficial geology of most of the Haldimand-Norfolk region has been described in detail by Cowan (10), Feenstra (12,4,11), and Barnett (5, 13). The major physiographic regions and features are shown in Figure 6.

In Table 4, the surficial deposits are correlated with the soils that developed on them. For example, the Fox, Brady and Granby soils developed mainly in the coarser sands deposited in shallower waters of glacial lakes Warren and Whittlesey, and which blanket much of the western part of the region. The Wattford, Normandale and St. Williams soils developed in the finer, more wind-modified sands, that represent deeper-water deposits of the same glacial lakes.

Virtually all of these lacustrine sands have been eroded and sorted by wind action that created eolian landforms and deposits ranging from a few centimetres thick, to spectacular longitudinal dunes several metres thick. The Plainfield, Walsingham, and Waterin soils have been mapped where eolian fine sand and very fine sand is greater than 1 m thick over the lacustrine sands. A Plainfield dune phase has been mapped wherever larger sand dunes are apparent. The landscape relationship of the Plainfield soils to the lacustrine Fox and Brady soils is shown schematically in Figure 10.

Two other soils of limited extent were mapped on glacial and post-glacial fluvial and lacustrine sediments. Lowbanks soils, the so-called "black sands" of the Dunnville area, are mapped on the poorly drained sands deposited by the ancestral Grand River, and Burford soils occur on the sand and gravel terraces of old river channels.

Three major tills outcrop in the region; the Port Stanley, Wentworth, and Halton tills. The oldest of these, the Port Stanley till, outcrops near the western boundary of the region and is expressed in the Tillsonburg, Courtland and Mabee moraines (Figure 6). The Muriel, Gobles and Kelvin soils have developed on this brown, silty clay loam till. Where sand blankets the till to a depth of 40 to 100 cm, till phases of the Bookton, Berrien and Wauseon soils are mapped. The relationship of these soils on the Tillsonburg moraine, to adjacent eolian and lacustrine sands, is shown in Figure 11.

Table 4. Correlation of surficial geologic and major soil components in the Haldimand-Norfolk Region

SURFICIAL GEOLOGIC COMPONENTS		SOIL MAP COMPONENTS		
Deposits	**Landforms**	**Well drained**	**Imperfectly drained**	**Poorly or Very Poorly Drained**
SANDS				
loamy sand, sand	sand plains	Fox	Brady	Granby
loamy fine sand	sand plains	Wattford	Normandale	St. Williams
fine sand	dunes, sand plains	Plainfield	Walsingham	Waterin
fine sandy loam, "black sands"	shallow sand plain			Lowbanks
GRAVELLY SANDS				
gravelly sand	outwash terraces, plains	Burford		
TILLS				
Port Stanley clay till	Tillsonburg, Courtland, Mabee moraines	Muriel	Gobles	Kelvin
40-100 cm sandy textures over Port Stanley till	Tillsonburg, Courtland, Mabee moraines	Bookton (till phase)	Berrien (till phase)	Wauseon (till phase)
Wentworth loam till	Cayuga-Caledonia drumlin field	Seneca		
Wentworth gravelly sand till	Paris, Galt moraines	Wilsonville		
40-100 cm sandy textures over sandy Wentworth till	Paris, Galt moraines	Scotland	Oakland	Vanessa
Halton clay till	small moraines south of Dunnville	Ontario	Niagara	Welland
LACUSTRINE SILTS				
mostly silt loam	lacustrine plains, sometimes dissected	Brant	Tuscola	Colwood
40-100 cm sandy textures over silts	lacustrine plains, sometimes dissected	Walsher	Vittoria	Silver Hill
LACUSTRINE SILTY CLAYS				
mostly silty clay	lacustrine plains, sometimes dissected	Brantford	Beverly	Toledo
40-100 cm sandy textures over silty clay	lacustrine plains, sometimes dissected	Bookton	Berrien	Wauseon
40-100 cm silty textures over silty clay	lacustrine plains, sometimes dissected		Tavistock	Maplewood
LACUSTRINE HEAVY CLAYS				
mostly heavy clay	lacustrine plains, sometimes dissected	Smithville	Haldimand	Lincoln
40-100 cm sandy textures over heavy clay	lacustrine plains, sometimes dissected		Berrien (heavy clay phase)	
SHALLOW OVER BEDROCK				
less than 20 cm variable textures over bedrock	Onondaga escarpment and adjacent bedrock plains	Farmington		Brooke
FLOODPLAIN ALLUVIUM				
variable textures	active floodplains	Alluvium 1 (variable drainage)		
mainly coarse-textured sandy alluvium	active floodplains	Alluvium 1 (variable drainage)		
mainly medium-textured silty or loamy alluvium	active floodplains	Alluvium 3 (variable drainage)		
mainly fine-textured clayey alluvium	active floodplains	Alluvium 4 (variable drainage)		
ORGANICS				
thicker than 160 cm	poorly drained depressions mainly north of Simcoe			Styx
40-160 cm organics over sands and gravels	poorly drained depressions mainly north of Simcoe			Hampden
40-160 cm organics over loams and silts	poorly drained depressions mainly north of Simcoe			Oakview
40-160 cm organics over clays	poorly drained depressions mainly north of Simcoe			Lonsdale

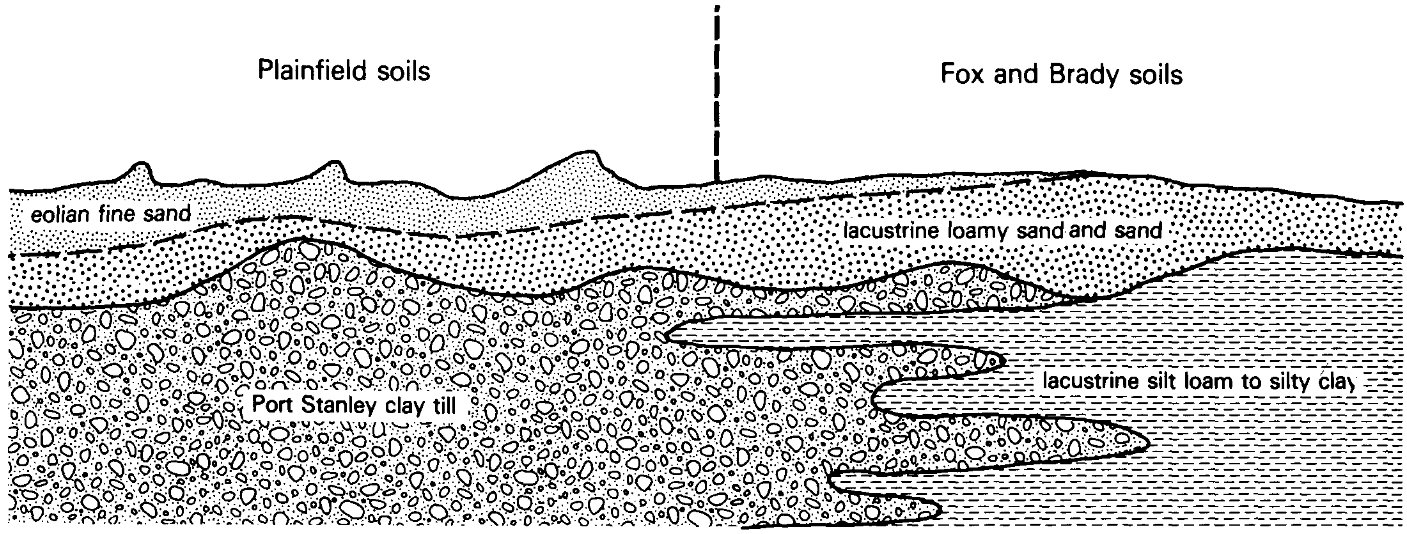


Figure 10. Schematic landscape cross-section showing the relationship of surficial sands to underlying deposits on the Norfolk sand plain.

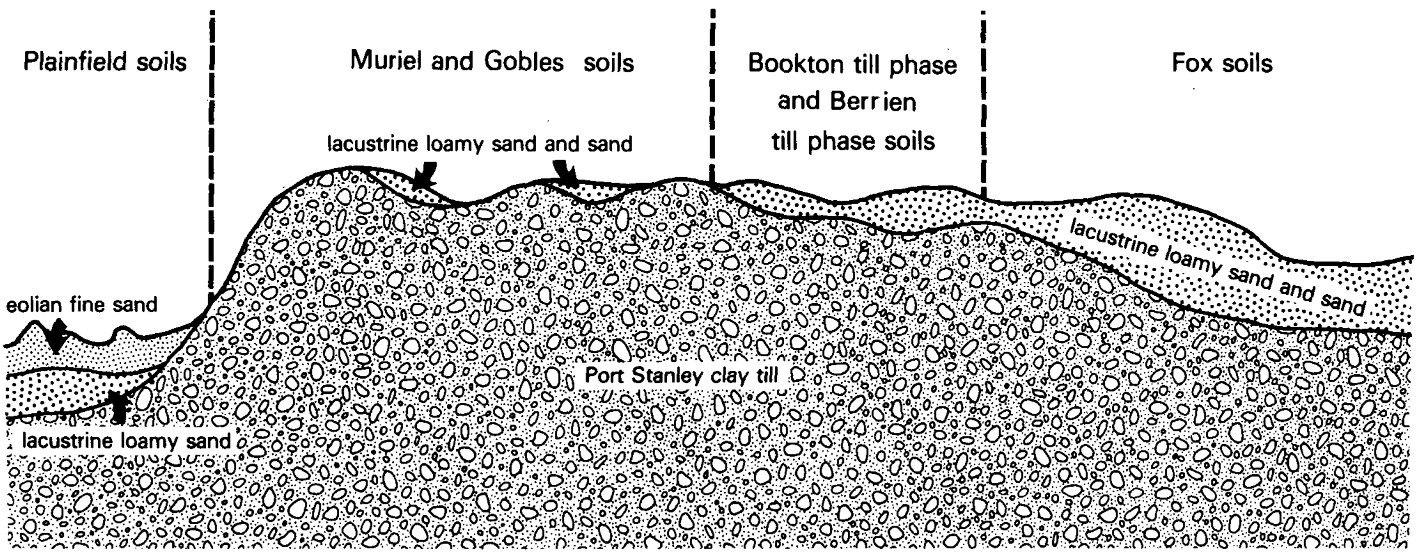


Figure 11. Schematic landscape cross-section showing soil parent materials associated with the Tillsonburg moraine near Teeterville

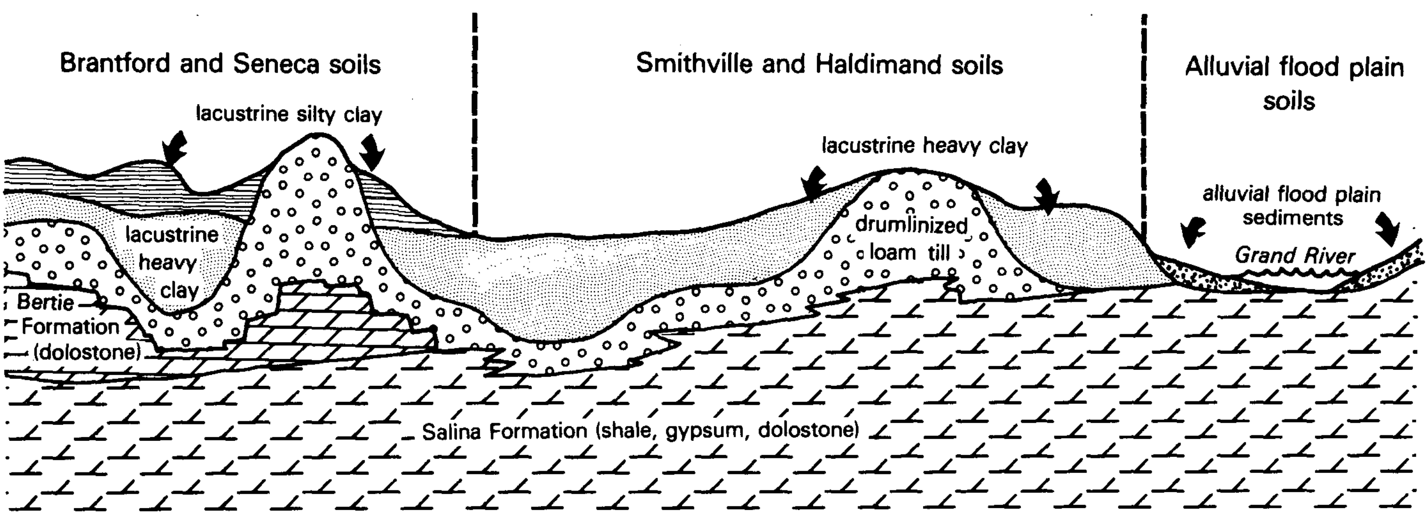


Figure 12. Schematic landscape cross-section showing the relationship of drumlins to the bedrock and overlying deposits near Cayuga.

The Wentworth till occurs on two quite different landforms in the region. It outcrops on the drumlins centred between Caledonia and Cayuga (Figure 6). The Seneca soils developed on this drumlinized loam till are surrounded and often partly covered by glacial Lake Warren clays. This landscape relationship is shown schematically in Figure 12. The other major location of the Wentworth till is in the moraines that extend from the north through Waterford, Simcoe and Delhi (Figure 6). These extensions of the Galt and Paris moraines have been modified considerably by the action of waves and currents within glacial lakes. Consequently, the texture is mainly gravelly sandy loam, often overlain by sand deposits. Where sand deposits are absent to thin, the Wilsonville soils have been mapped, but wherever sand thickness ranges from 40 to 100 cm over till, the Scotland, Oakland and Vanessa soils are mapped. Gravel is being mined from these deposits, mostly in the Waterford and Simcoe areas (Figure 13). Figure 14 depicts a schematic cross-section of the Galt moraine that indicates the relationship of the gravelly till to overlying sands.

The youngest till in the region, the Halton till, is limited to a few small moraines along the Lake Erie shoreline south of Dunnville. These moraines have also undergone considerable modification by glacial lake action. The tills are characterized by reddish hues and variable textures. Clay loam textures are common on well-drained parts of the moraines, mapped as Ontario soils, whereas clay textures predominate on the more poorly drained areas occupied by the Niagara and Welland soils.

Lacustrine silts and clays deposited in glacial lakes Warren and Whittlesey occupy most of the extensive clay plain areas (Figure 6). The Brant, Tuscola and Colwood soils are developed on the siltiest portion of these lacustrine sediments, centred in the Waterford-Simcoe area. Their relationship to the loamy fine sands of the Norfolk sand plain on the west side, and to the lacustrine heavy clays on the east side, is depicted in Figure 15. Thin deposits of sand often overlie these silts. Where the thickness of sand over silt is between 40 and 100 cm the Walsher, Vittoria and Silver Hill soils occur.

The Brantford, Beverly and Toledo soils, developed on lacustrine silty clay loam and silty clay, are found on sections of the clay plains not occupied by the silts and heavy clays. That includes much of the region north and east of the Grand River, and large portions of the clay plains lying north and west of Port Dover. Some of these clay deposits are overlain by sands, especially adjacent to the sand plains. Where these sands attain thicknesses of 40 to 100 cm, the Bookton, Berrien and Wauseon soils have been mapped.

Thin, silty deposits, seldom exceeding 40 cm in thickness, also cover many of these clays. Where these silts are 40 to 100 cm thick over clay the Tavistock and Maplewood soils are mapped.

Lacustrine heavy clays are common throughout most of the central portion of the largest clay plain of the region. The Smithville, Haldimand and Lincoln soils, usually mapped in this area, contain layers with more than 60% clay. Thin deposits of silty clay loam and silty clay, rarely more than 40 cm thick, form a veneer over most heavy clay layers. In a few places, sands 40 to 100 cm thick overlie these clays. A

Figure 13. Gravel mining near Waterford, where high water tables prevent rehabilitation to agriculture

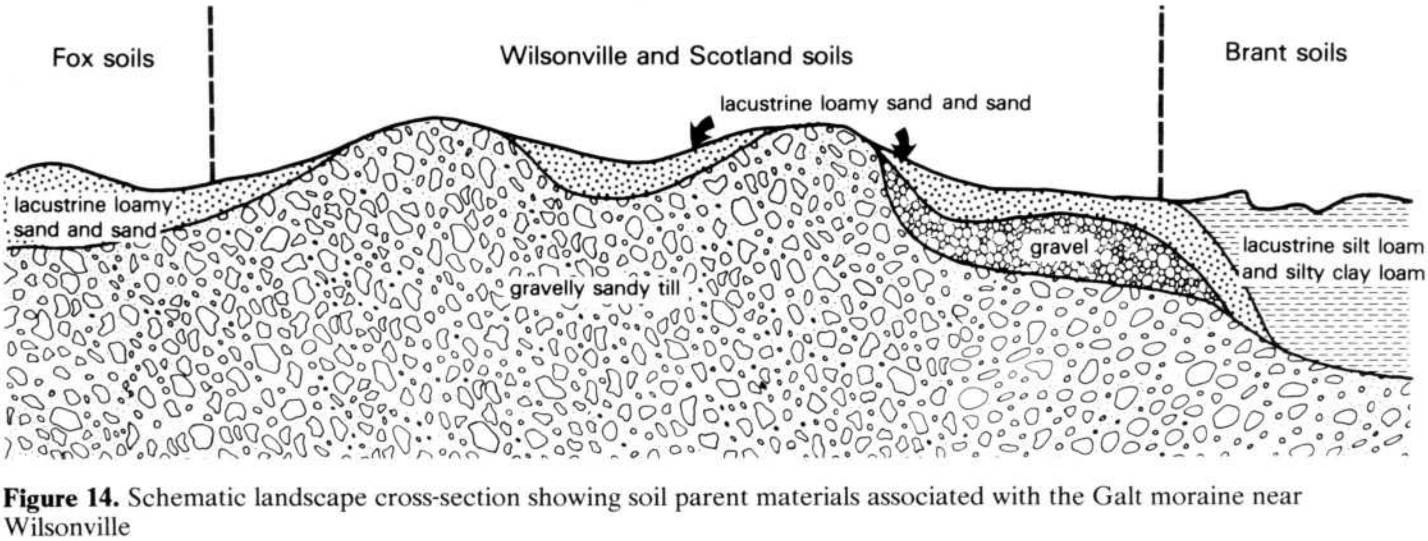


Figure 14. Schematic landscape cross-section showing soil parent materials associated with the Galt moraine near Wilsonville

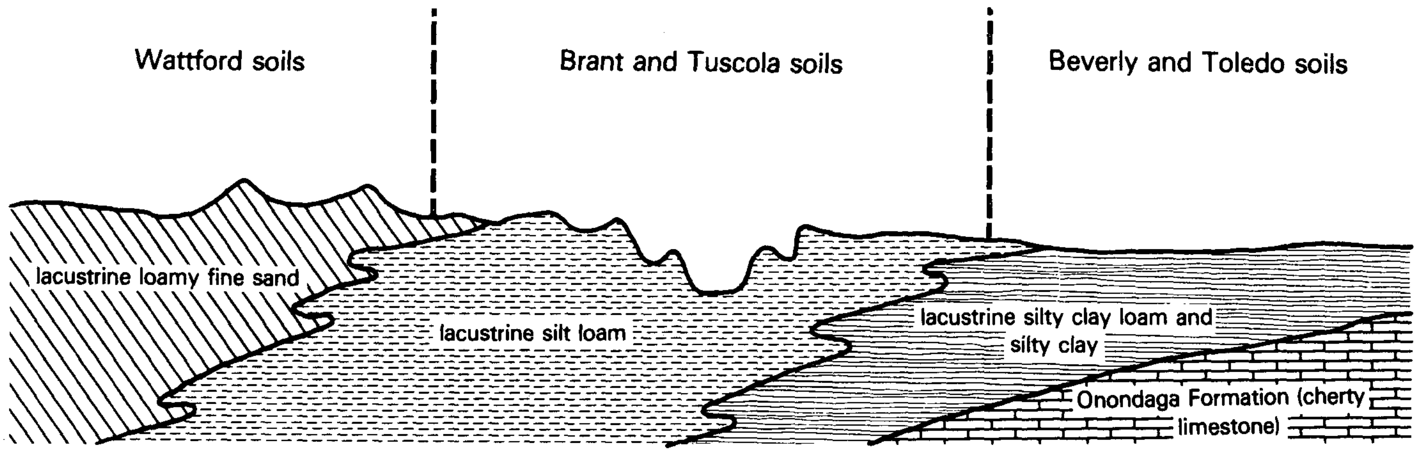


Figure 15. Schematic landscape cross-section near Waterford, showing the relationship of silty deposits to adjacent sands and clays of the Norfolk sand plain and Haldimand clay plain

heavy clay phase of the Berrien soil is mapped at these locations.

Near the Onondaga escarpment, where bedrock is near the surface, shallow and very shallow phases have been mapped for several soils. Where the soil cover is less than 20 cm thick over bedrock, the Farmington and Brooke soils are mapped. The landscape relationship of these shallow soils to the Onondaga escarpment and adjacent clays of the Haldimand clay plain is shown in Figure 16.

Most of the major stream and river channels and their associated active floodplains have been mapped as undifferentiated alluvium (Alluvium 1). Some textural differentiations of these soils have been made on large floodplains of the Grand River and Big Creek (Alluvium 2, 3 and 4).

The Hampden, Oakview, Lonsdale and Styx soils are organic soils, mapped in a few swamps and bogs having organic materials at least 40 cm thick.

Climate

The Haldimand-Norfolk region is situated entirely within the Lake Erie counties climatic region (14). There is a considerable climatic variation within this climatic region, as evidenced by the temperature, precipitation and growing season data shown in Tables 5, 6 and 7. Many of these data were obtained from regional weather stations, located as shown in Figure 17.

The temperature data in Table 5 indicate a general tendency for mean daily temperatures to be higher in a southerly direction, towards Lake Erie. Near the lake where thermal effects and on-shore breezes prevail, there is a noticeable cooling effect during spring and summer. This is reflected by the April and July temperature data for Clear Creek and Long Point.

The highest temperatures occur in a broad zone stretching from Delhi to Brantford (15), caused partly by the heat radiated from the sands of the Norfolk sand plain. For the same reason, cooler night temperatures and increased risk of frost may also occur in this zone.

Both mean annual and May-to-September precipitation seem highest in the central Norfolk County area between Delhi and St. Williams (Table 6). Snowfall values are highest near the Lake Erie shoreline and in the vicinity of Welland. From the growing season and frost data in Table 7, it can be seen that one of the most frost-prone areas in the region is between Delhi and Brantford. Two other frost-prone areas exist (15); one between Hagersville and Caledonia, and the other along the eastern boundary beside the Niagara region. Table 7 also indicates that areas near Lake Erie, in the vicinities of St. Williams, Long Point and Welland, have the longest frost-free periods.

Some of the important local factors that can influence growing conditions and frost incidence are topography,

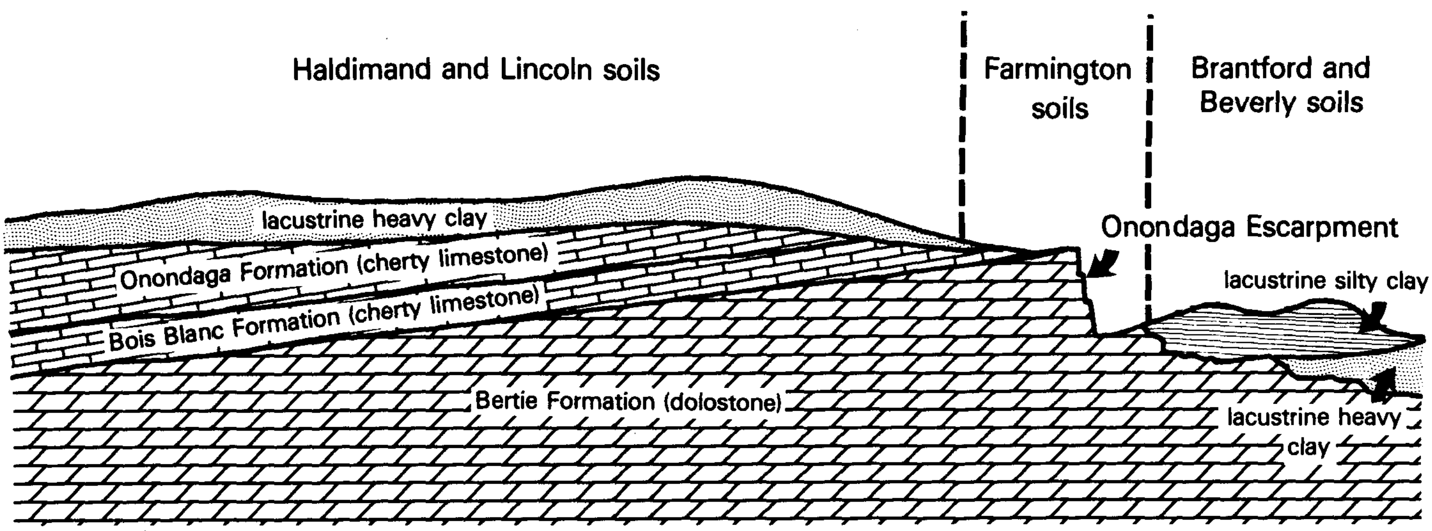


Figure 16. Schematic landscape cross-section showing soil and bedrock relationships in the vicinity of the Onondaga escarpment near Decewsville

Table 5. Temperature data from the Haldimand-Norfolk Region and vicinity[1] (°C)

Location	Mean Annual	Highest Recorded	Lowest Recorded	Mean Daily Maximum Jan.	Apr.	July	Oct.	Mean Daily Minimum Jan.	Apr.	July	Oct.
Brantford	8.1	40.6	−34.4	−1.5	12.3	27.6	16.2	−9.3	1.3	14.7	4.2
Caledonia	7.9	39.4	−36.7	−1.4	12.1	27.3	15.8	−8.9	1.2	14.4	4.7
Hagersville	7.8	35.0	−29.4	−1.8	12.1	26.2	15.4	−8.9	1.5	14.6	4.9
Canboro	7.9	36.1	−30.0	−1.3	12.2	27.1	16.1	−8.8	1.2	14.2	4.6
Welland	8.8	37.8	−32.8	−0.5	12.9	27.4	16.7	−8.2	1.7	15.9	6.1
Kohler	7.8	35.6	−26.1	−1.2	11.6	26.2	16.3	−8.9	1.2	14.7	4.7
Delhi	7.9	40.6	−31.1	−1.8	12.6	27.2	16.1	−9.2	1.2	14.3	4.7
Simcoe	7.8	40.0	−37.8	−1.5	12.7	27.2	16.1	−9.0	1.4	14.0	3.9
Aylmer	8.3	36.7	−23.9	−1.1	13.1	26.8	16.7	−8.9	1.9	14.2	5.0
St. Williams	8.1	34.4	−28.9	−1.7	12.6	26.6	15.7	−9.5	1.6	14.7	5.3
Clear Creek	8.1	33.9	−26.1	−1.1	10.4	25.0	15.3	−7.7	2.3	15.8	6.1
Long Point		32.2			8.8	24.6	15.3		1.8	18.0	9.4

[1]*Compiled from Environment Canada data*

altitude, natural air drainage and proximity to water. In air drainage, for example, cold air has a tendency to flow like water into low-lying areas where it may cause frost damage at the bottom of slopes. Frost-tender crops such as tobacco, cucumbers and peppers, are especially vulnerable to local cold air pockets.

The climate of the Haldimand-Norfolk Region is well suited to a wide variety of agricultural and horticultural crops. This includes all the common Ontario field crops, as well as some that are less common, such as ginseng and peanuts.

The average frost-free period (140 to 150 days) in the Haldimand-Norfolk Region allows commercial production of most common vegetable crops. The first field seeding or planting dates for commercial production of vegetables in Zone C, which includes the Haldimand-Norfolk Region, are shown in Table 8.

The climate of the region also allows commercial production of most of the common tree and small fruits common to southern Ontario, although it is not as suitable for "tender" fruit crops like apricots, sweet cherries, peaches and hybrid grapes, as are the warmer areas in the Niagara Region, Kent County or Essex County.

Table 6. Precipitation data from the Haldimand-Norfolk Region and vicinity.[1]

Location	Mean Annual Precipitation (mm)	Mean Rainfall May to Sept. (mm)	Mean Annual Snowfall (cm)
Brantford	769.9	328.9	112.0
Caledonia	671.8	351.0	111.8
Hagersville	738.9	369.1	121.4
Canboro	735.6	363.5	123.4
Welland	726.2	367.5	177.3
Kohler	736.1	367.3	127.0
Delhi	803.1	396.2	133.1
Simcoe	748.0	375.9	141.5
St. Williams	831.6	399.3	142.2
Clear Creek	745.5	350.8	121.2
Long Point	—	333.8	—

[1]*Compiled from Environment Canada data*

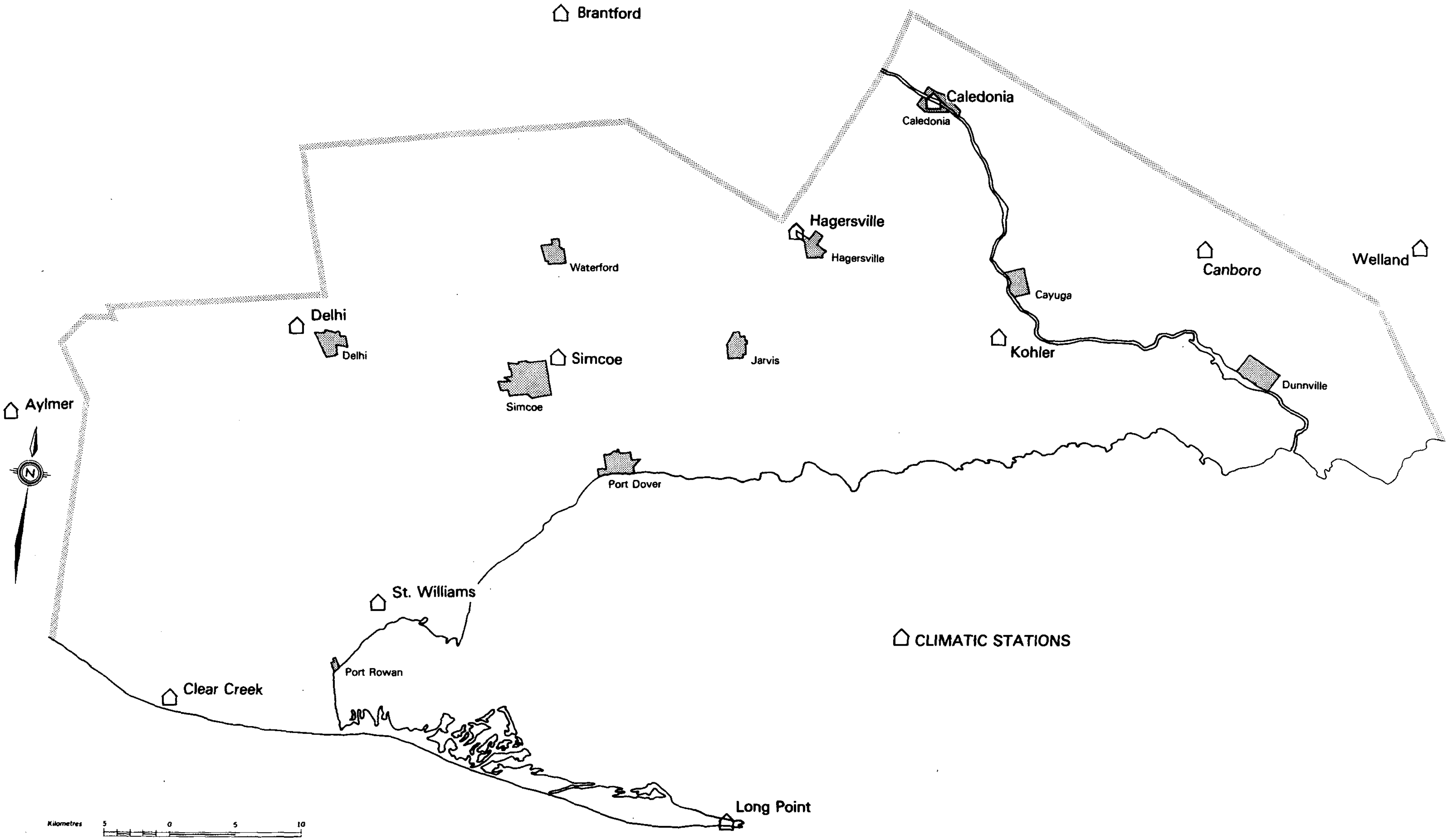


Figure 17. Location of regional weather stations in the Regional Municipality of Haldimand-Norfolk and immediate vicinity

Table 7. Growing season and frost data from the Haldimand-Norfolk Region and vicinity[1]

Location	Growing Season Starts	Growing Season Ends	Mean Length Growing Season (days)	Mean Annual Growing Degree-Days	Mean Annual Corn Heat Units	Mean Date Last Frost	Mean Date First Frost	Mean Annual Frost-Free Period
Brantford	Apr. 12	Nov. 5	205	3600	2900	May 13	Oct. 3	143
Caledonia	Apr. 11	Nov. 7	207	3700	3000	May 12	Oct. 6	147
Hagersville	Apr. 11	Nov. 7	208	3700	3000	May 12	Oct. 6	148
Canboro	Apr. 10	Nov. 8	209	3700	3100	May 11	Oct. 9	150
Welland	Apr. 10	Nov. 10	212	3900	3200	May 11	Oct. 14	162
Kohler	Apr. 10	Nov. 9	210	3700	3000	May 11	Oct. 10	149
Delhi	Apr. 10	Nov. 7	209	3600	2900	May 12	Oct. 6	148
Simcoe	Apr. 10	Nov. 8	210	3700	3000	May 11	Oct. 10	149
Aylmer	Apr. 10	Nov. 8	210	3700	3000	May 11	Oct. 10	149
St. Williams	Apr. 9	Nov. 11	212	3800	3000	May 8	Oct. 14	160
Clear Creek	Apr. 9	Nov. 11	213	3800	3100	May 7	Oct. 15	162
Long Point	Apr. 9	Nov. 12	215	3900	3100	May 3	Oct. 22	165

[1]*Data estimated from Brown et al., 1968 (14)*

Table 8. First field seeding or planting dates for commercial production of vegetables in the Haldimand-Norfolk region[1]

Crops	First Planting Dates
FROST-HARDY	
asparagus, broccoli, brussel sprouts, cabbage, lettuce, onion, radish, rhubarb, pea, spinach, parsnip, early potato	April 15 - April 25
SEMI-FROST-HARDY	
beet, carrot, cauliflower, celery, late potato, early sweet corn	April 25 - May 10
SEMI-FROST-TENDER	
snap bean, sweet corn, tomato	May 15 - May 25
FROST-TENDER	
lima bean, cucumber, eggplant, muskmelon, pepper, pumpkin, squash, watermelon	May 25 - June 5

[1]*Adapted from OMAF Publication 363, 1983 Vegetable Production Recommendations*

Forest Vegetation

Although settlers began clearing forests in the Haldimand-Norfolk Region in the late 1700's, 75% of the land was still forested by 1850 (16). During the next 50 years much of the remaining forest cover was removed; by 1900 only about 20% was still standing. In 1981 woodland occupied 9% of the region.[1]

During this long forest-clearing period, lumbering was the chief industry in the region until the late 1800's, when agriculture became dominant. Many of the logs were floated down Big Creek and the Grand River to lakeside ports from whence they were shipped. Soon after the sand plains were cleared, depleted fertility and wind erosion forced the abandonment of many farms. Some fairly extensive areas of these degraded sands were reforested in the early 1900's to mainly exotic and nonindigenous conifer species, such as Scots pine, red pine and jack pine (16). Many windbreaks of these species were planted in remaining sections of the sand plains, during the 1920's and 1930's, as tobacco became the most important agricultural crop.

[1]*Data compiled from Census of Canada, 1981.*

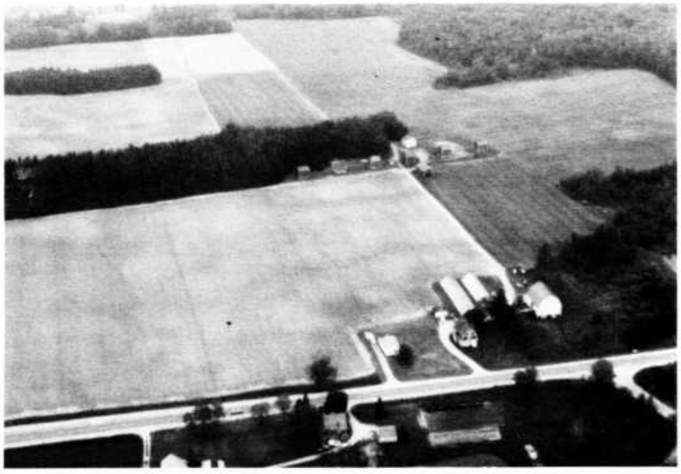


Figure 18. Aerial view of tobacco farm, showing windbreaks and reforestation to reduce wind erosion

Notes and maps from the original surveys completed prior to settlement in the region indicate an extremely diverse original forest due, in part, to variable soil and moisture conditions, but also due to fires set by Indians prior to white settlement (16). Among the dominant forest associations recorded were hard maple — beech — elm — basswood on many of the upland clay and silt areas; almost as widespread on similar upland areas was a butternut — chestnut — white ash — black cherry association. The sand plains were dominated by white pine associations, and oak savannas. Moist lowland areas were often dominated by a single species such as white cedar, willow, alder, tamarack, soft maple or black ash (16).

The Haldimand-Norfolk Region is entirely within the Carolinian zone, a climatic zone that supports native plants and animals having affinities with more southerly areas. Trees of the Carolinian zone that occur in the region include black walnut, shagbark hickory, sweet chestnut, black oak, tulip tree, sassafras and sycamore. Although the original surveys noted some stands dominated by walnut near the mouth of the Grand River, it was estimated that only about 1% of the original forest consisted of such Carolinian species, about the same proportion as in present-day stands (16).

In 1963 Maycock (17) estimated that there were fewer than 25 forest stands of 10 ac or more in the Region that were not being logged severely or grazed. One of the best-conserved stands is the Backus Woods in the Port Rowan — Turkey Point area. It occurs on predominantly moist silty clays and sands, and contains many Carolinian elements. Other unique stands occur on the eolian sands and dunes of Turkey Point Provincial Park, and on Long Point Peninsula. The dune ridges of Long Point contain several interesting savanna and forest communities, dominated by such species as eastern cottonwood, red cedar, red oak, white pine, red maple and red ash (18).

The 1981 Census of Canada indicated that woodland comprised about 9% of the total area of the region. Plantation forests of red pine, white pine, jack pine, Scots pine, Norway spruce and white spruce occupy a significant portion of woodlands on well-drained sands. Elsewhere, the present forest associations are generally similar to those indicated in Figures 19, 20 and 21.

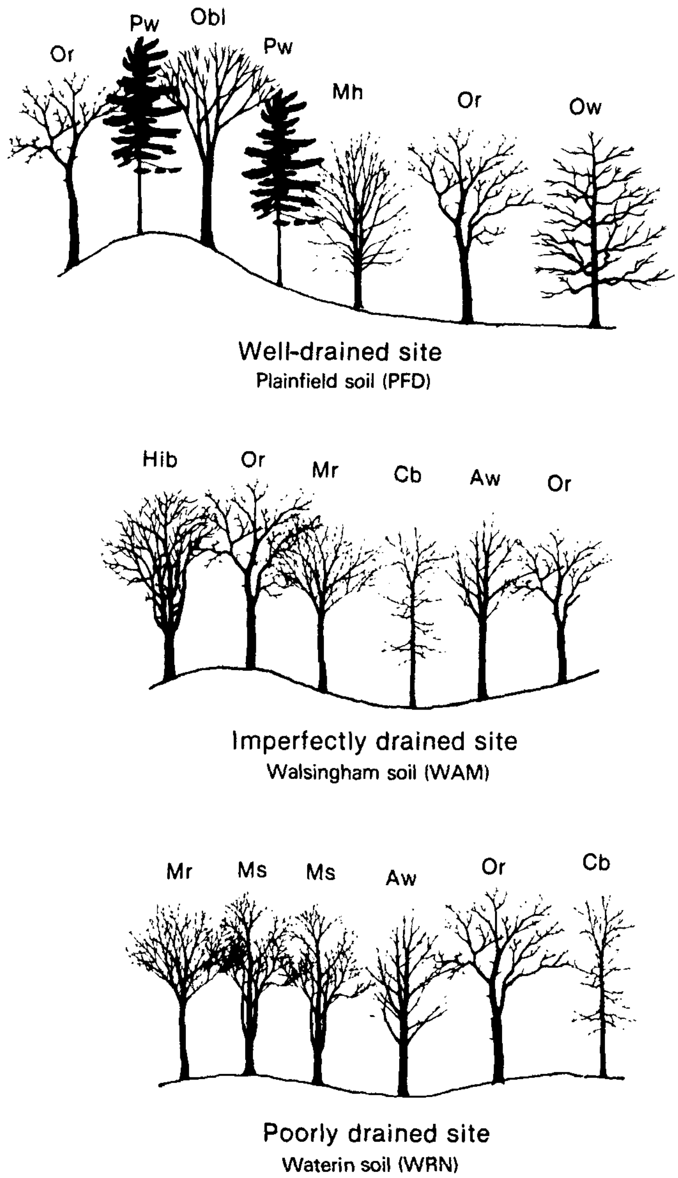


Figure 19. Typical forest tree distribution on a toposequence of sandy soils in the Haldimand-Norfolk Region

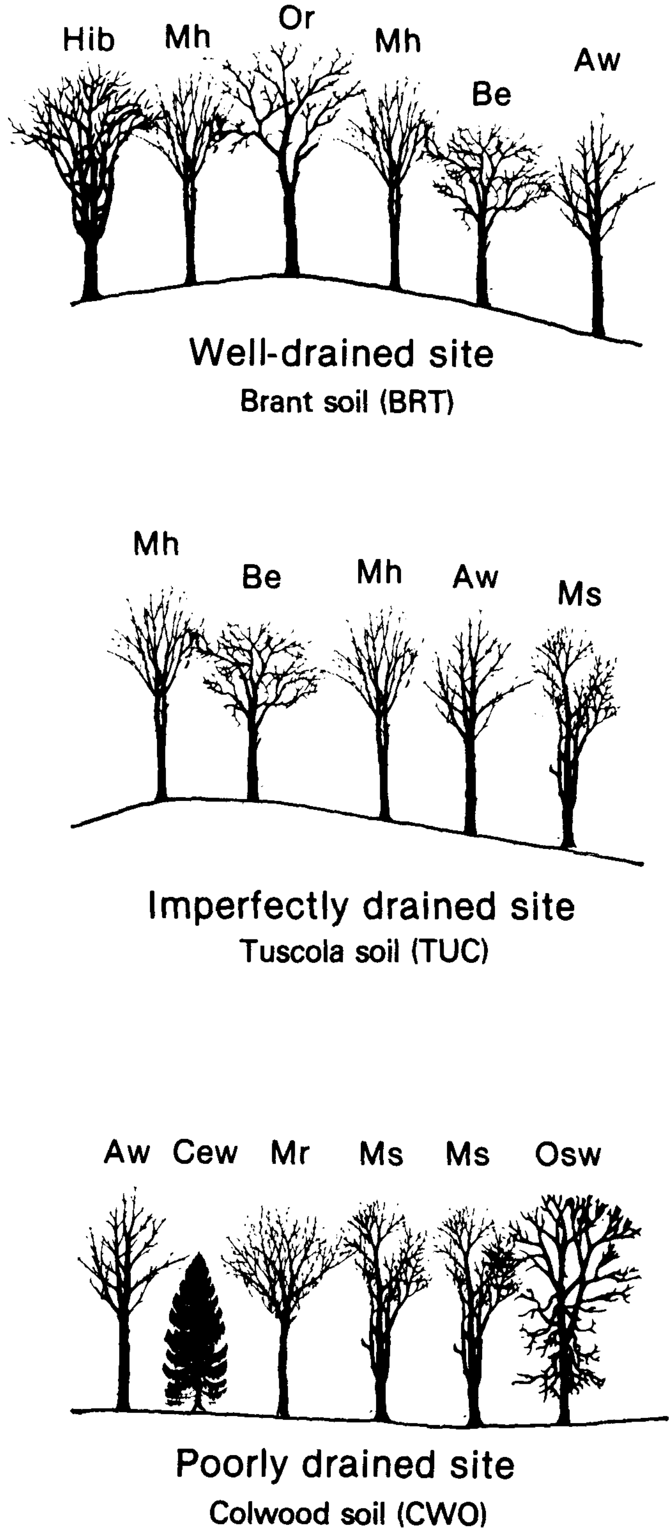
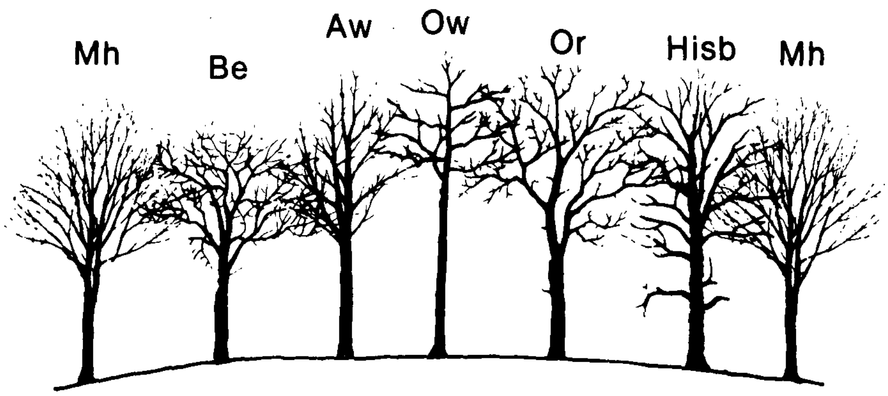


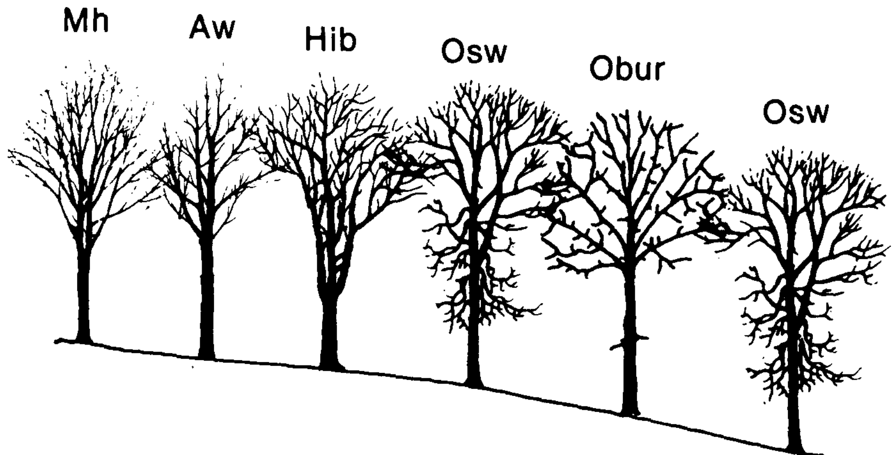
Figure 20. Typical forest tree distribution on a toposequence of loamy soils in the Haldimand-Norfolk Region

During a study of the suitability for major commercial forest tree species of the soils of the Haldimand-Norfolk Region (19), forest tree distributions were determined on a range of soil sites. These distributions are generalized for sandy, loamy, or clayey parent materials and different soil moisture characteristics (Figures 19 to 21). It should be noted that the number of species represented on a specific parent materal site is proportional to the actual frequency distribution at that site. Species symbols are defined in Figure 21.

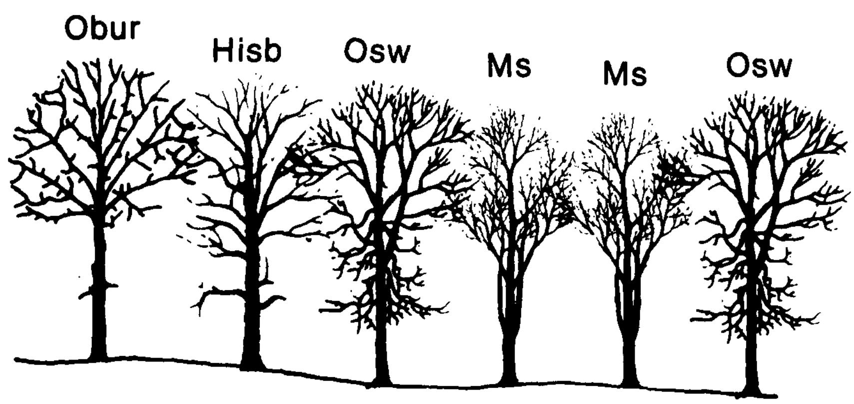
In Figures 19, 20 and 21, each generalized parent material —soil moisture diagram consists of a toposequence and related forest tree distribution. For example on the well drained sandy site (Figure 19), white pine (Pw) and several oaks — red (Or), white (Ow) and black (Obl) — are shown to dominate dry, sandy sites. Downslope on the more level imperfectly drained sand site, the tree distribution includes hardwoods of intermediate shade tolerance such as bitternut hickory (Hib), black cherry (Cb), white ash (Aw) and red maple (Mr). Finally, on the lower topographic positions where poorly drained sandy sites prevail, the forest tree distribution includes mainly soft maples, e.g. silver maple (Ms) and red maple (Mr). Forest tree distributions change similarly with increasing moisture contents and changing topography on clayey and loamy sites (Figures 20, 21).



Well-to moderately well-drained site
Smithville soil (SHV)



Imperfectly drained site
Haldimand soil (HIM)



Poorly drained site
Lincoln soil (LIC)

Tree Species Symbols

Aw = White Ash
Be = Beech
Cb = Black Cherry
Cew = White Cedar
Hib = Bitternut Hickory
Hisb = Shagbark Hickory
Mh = Sugar Maple
Mr = Red Maple
Ms = Silver Maple
Obl = Black Oak
Obur = Bur Oak
Or = Red Oak
Osw = Swamp White Oak
Ow = White Oak
Pw = White Pine

Figure 21. Typical forest tree distribution on a toposequence of clayey soils in the Haldimand-Norfolk Region

HOW THE SOILS WERE MAPPED AND CLASSIFIED

Soil Mapping

First, a legend was developed by compiling information from existing resource publications such as geological reports, conservation area reports, old soil maps, etc., and combining this with preliminary field observations.

Next, with the aid of a stereoscope, tentative soil boundaries were drawn on the most recent aerial photographs (scale 1:15 840). With the legend as a guide, these soil boundaries and the soils were checked in the field.

Field checking of the soils was done along all public roads, where the soil was periodically examined, especially where stereoscopic investigations had indicated major changes. Soils were checked in fields, woodlots, and undisturbed road allowances. Most sites were close to roads, but occasionally it was necessary to traverse some distance into concessions to verify soil boundaries.

Soil probes and Dutch augers were the tools most commonly used to investigate soils. Soils were usually checked and described to a depth of 1 m. Shovels were used occasionally to dig pits and scrape down exposures along roads, ditches and streams. Soil samples were periodically collected for laboratory analyses, to verify or supplement field observations. Between 5 and 10% of all sites were sampled for this purpose.

The next operation was to compile the field and laboratory information in the office onto 1:25 000 scale topographic base maps. Maps compiled in this way were published the year following the field mapping as preliminary soil maps.

The last step was to prepare the final maps. This was done by changing the map unit designations on the preliminary maps to the final unique symbols, and by making any necessary boundary changes. These final maps were prepared for publication and entered into a computerized data file, by the Cartography Section of the Land Resource Research Institute, Agriculture Canada, Ottawa.

Survey Intensity and Map Reliability

The survey intensity level provides an idea of the precision with which the soil survey was done. Survey intensity level 1 indicates the precision of detailed, large scale surveys, e.g. 1:10 000; survey intensity level 5 indicates the precision of small scale surveys, e.g. 1:250 000 (20). The survey intensity level of the Haldimand-Norfolk soil survey is at an intermediate level, between levels 2 and 3.

In this survey there was at least one soil inspection in most map delineations; boundaries of delineations were checked at intervals in the field but mainly extrapolated from air photos. The number of inspections per cm^2 on the Haldimand-Norfolk soil maps was about 0.2 or about one inspection per 29 ha (72 ac).

Soil inspections were done by examinations of vertical soil sections by probe, auger or shovel. Average depth of examination was to about 1 m. Soils were occasionally examined to the 1 to 2 m depth, usually at sites of deep roadcuts or bank cuts.

Considering the survey intensity level and scale of the Haldimand-Norfolk soil maps, the most appropriate uses for these maps are for planning purposes of land areas such as townships, small conservation areas, large urban subdivisions, or large farms. The suitability of the maps for uses of smaller areas such as small farms, small subdivisions, building sites, etc., is less appropriate, because the average area covered by map delineations of the Haldimand-Norfolk soil maps, is about 33 ha (83 ac).

Soil Classification

Soils of the Haldimand-Norfolk Region have developed in soil parent materials ranging in texture from heavy clays to coarse gravels. Most soil differences are related to these textural differences. Variations in drainage also cause differences between soils developed on the same soil parent materials. Other soil forming factors, such as topography, time, climate and vegetation, have also contributed to soil differences.

Most of the soil parent materials in the Haldimand-Norfolk Region are highly calcareous and alkaline. However, the soils developed on such materials are less calcareous because of the leaching action of water on soil bases, especially calcium. This leaching action, along with associated soil weathering, causes the development of soil horizons near the soil surface. These horizons differ from each other in properties such as texture, color, thickness, structure and consistence.

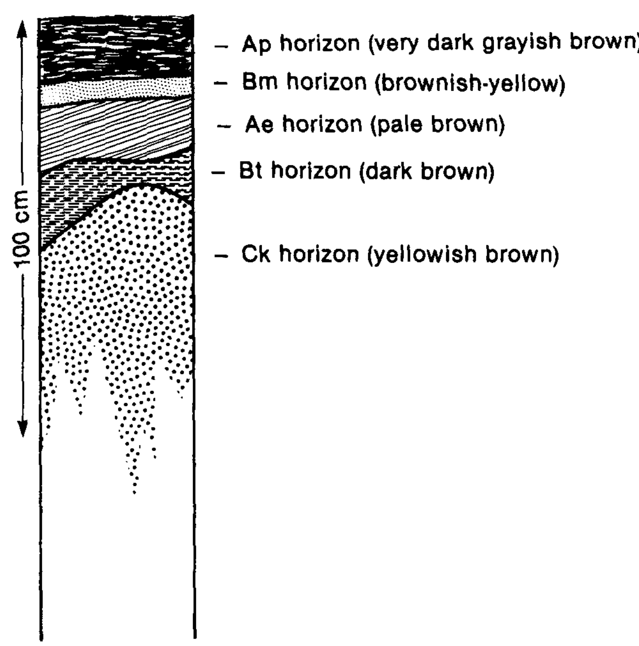


Figure 22. Diagrammatic soil profile of a typical well-drained soil in the Haldimand-Norfolk Region

A vertical section through the exposes a characteristic sequence of soil horizons that is called a soil profile. These soil horizons are usually designated as A, B and C horizons, and subdivided further when more detailed descriptions are required.

Figure 22 shows the soil horizons of a well-drained soil profile typical of many in the Haldimand-Norfolk Region. The A horizon is the surface horizon; it can be further subdivided into an Ap or Ah, and Ae horizons (21). The Ap and Ah horizons are dark colored and usually have high organic matter contents. Ap horizons occur where soils have been cultivated, and usually constitute the topsoil, or plow layer. Ae horizons are leached, light-colored, and have lower organic matter contents than Ap or Ah horizons. Some, or all, of the Ae horizon materials are often incorporated into the plow layer, especially when plowing is deep, or on eroded slopes.

B horizons are usally more reddish, finer-textured, and more compact than A horizons. When they contain significantly more clay than overlying A horizons they are called Bt horizons (21). When they differ from A horizons mainly by color or structure differences, they are called Bm horizons (21). Most well-drained soils in the Haldimand-Norfolk Region have Bt horizons that are overlain by Ae or Bm horizons, as shown in Figure 22. On moderately to severly eroded slopes, B horizons are often exposed at the surface.

C horizons underlie B horizons in normal soil profiles (Figure 22). They are composed of soil parent material that has undergone relatively little weathering compared with the A and B horizons. In the Haldimand-Norfolk region, C horizons are moderately to strongly calcareous because they contain free carbonates. They are called Ck horizons because these carbonates exhibit visible effervescence when contacted with dilute hydrochloric acid (21). If the texture or origin of C horizons is significantly different from that of overlying A or B horizons, e.g. lacustrine sand over clay till, the C horizon is designated as a IIC horizon. C horizons are usually exposed only on roadcuts or on certain severely eroded slopes.

Imperfectly drained soils have the same type and sequence of horizons as well-drained soils, but because they are wetter for longer periods of time, "gley" conditions develop. These conditions are mainly caused by the reduction of iron compounds, and are usually indicated by yellowish-brown mottling in the Ae, Bm or Bt horizons. The horizons are then designated as Aegj, Bmgj and Btgj horizons (21).

Most poorly drained mineral soils in the Haldimand-Norfolk Region have soil horizon sequences similar to that shown in Figure 23. These soils are wet for long periods of time, providing conditions that are especially favorable for "gley" formation. This means that all horizons are gray to grayish-brown in color, and often have yellowish-brown mottles. The B and C horizons of these poorly drained profiles are usually designated as Bg and Ckg horizons.

There are some very poorly drained organic soils in the region that have more than 40 cm of surface organic soil, and contain at least 30% of organic matter. Horizons of organic soils are called O horizons. Different lowercase suffixes are used, e.g. Oh, Om, Of, depending on the degree of decomposition of the organic materials (21).

The highest category of soil classification in the Canadian system of soil classification is the order. Orders are subdivided into great group, great groups into subgroups, subgroups into families, families into series and series into phases (21).

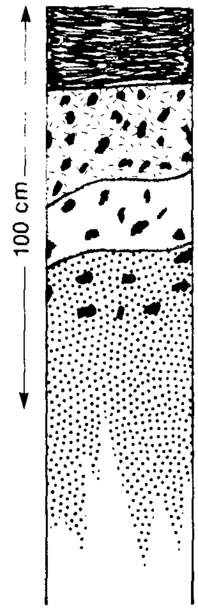


Figure 23. Diagrammatic soil profile of a typical poorly drained soil in the Haldimand-Norfolk Region

Soil Orders

Soil orders that have been noted in the Haldimand-Norfolk Region are the Luvisolic, Brunisolic, Gleysolic, Regosolic and Organic orders.

Most well and imperfectly drained soils in the Region have been classified in the Luvisolic order. They are characterized by light-colored eluvial horizons, and darker colored illuvial B horizons in which clay has accumulated.

Soils of the Brunisolic order, which lack the same degree of horizon development as Luvisols, are fairly common in the Haldimand-Norfolk Region. They seem to be most prevalent in some imperfectly drained soils, and in soils that are relatively young in age, such as alluvial floodplain soils and eolian sands.

Most poorly drained soils in the region were classified in the Gleysolic order. These soils are associated with high groundwater conditions during some period of the year. In the heavier clay soils, groundwater frequently occurs as disconnected lenses. Such groundwater lenses commonly "perch" on relatively impermeable lower horizons. These soils have at least one gray or grayish-brown gley horizon, and usually have prominent mottles within 50 cm of the surface.

Soils belonging to the Regosolic order occur throughout the region on small, localized areas of severely eroded slopes, colluvial depressions and alluvial floodplains. They are characterized by weak or absent soil horizon development.

Soils of the Organic order are saturated by water for prolonged periods of time. They are characterized by high proportions of organic matter and a minimum thickness of 40 cm of organic materials. They were mapped in relatively few depressional areas in the region.

Soil Great Groups and Subgroups

In the Haldimand-Norfolk Region, soils that belong to the Luvisolic order are classified in the Gray Brown Luvisol great group. Well-drained soils of this great group can be classified into the Orthic Gray Brown Luvisol subgroup and the Brunisolic Gray Brown Luvisol subgroup. Imperfectly drained soils are classified in the Gleyed Gray Brown

Luvisol subgroup and the Gleyed Brunisolic Gray Brown Luvisol subgroup.

Brunisolic soils of the region mostly are classified into the Melanic Brunisol great group. These can be further subdivided into the Orthic, Eluviated or Gleyed Melanic Brunisol subgroups. A minority of Brunisolic soils are classified in the Eutric Brunisol great group where they can be further subclassified into Orthic, Eluviated or Gleyed Eutric Brunisol subgroups.

Most Gleysolic order soils in the region are classified into the Humic Gleysol great group. Most of these are subclassified into the Orthic Humic Gleysol subgroup and a few into the Rego Humic Gleysol subgroup. There are also some Gleysolic soils in the Gleysol and Luvic Gleysol great groups.

Soils of the Organic order mapped in the region are classified in either the Mesisol or Humisol great groups. Most of these were subclassified in Terric subgroups because of their relative shallowness over mineral soils.

Soil Families

The soil family is a relatively recent addition to the Canadian system of soil classification that hasn't been used as much as the other categories, such as order, series, etc. Soil subgroups are divided into soil families on the basis of particle size, mineralogy, reaction, depth and soil climate in mineral soils. Somewhat different criteria are used in organic soils.

Soil Series

The soil series is a subdivision of the soil family based on relatively detailed properties, such as soil color, thickness of horizons, etc. On the Haldimand-Norfolk soil maps, the soil map unit names are based on the dominant or codominant soil in the unit, e.g. FOX 3 where the Fox soil constitutes 50 or 75% of the unit. Table 9 is a list, in alphabetical order, of the soils mapped in Haldimand-Norfolk, along with their map symbols. In the other columns are shown all soils developed on similar parent materials, and their drainage relationships.

Soil Phases

In the Haldimand-Norfolk Region the soil phase is used to subdivide soil series on the basis of soil or land properties considered significant for plant growth or soil uses. Most soils in the region have at least one phase designation, e.g. TLD.C is the coarse sandy phase of the Toledo soil, with 15-40 cm of sand over clay. Similarly, PFD.D is the dune phase of the Plainfield soil, mapped on wind-blown dunes. Following is a list of the phase designations and their definitions:

C - 15-40 cm sandy textures over soil with contrasting textures

D - eolian fine sand formed into dunes

H - 40-100 cm sandy textures over lacustrine heavy clay

L - 15-40 cm loamy textures over soil with contrasting textures

P - 15-40 cm organic materials over soil with contrasting textures

S - 50-100 cm soil materials over bedrock

T - 40-100 cm sandy textures over silty clay loam till

V - 20-50 cm soil materials over bedrock

Miscellaneous Land Units

There are a number of land designations too variable or complex to designate as soil series or soil phases that are listed as miscellaneous land units. Some examples are: variable floodplain soils designated as Alluvium 1 (1-ALU); Lake Erie shoreline beach — scarp complexes (CPX 1); and Long Point peninsula marsh — ridge complexes (CPX 4).

Soil Map Units

A soil map unit is the designation given to any area enclosed by a boundary on a soil map. In the Haldimand-Norfolk Region such units are composed of various combinations of one or two soils, or miscellaneous land units, and their respective slopes.

For example, the LIC 1 soil map unit contains only one map unit component, the Lincoln soil, LIC. On the soil map, the slope will also be indicated in the denominator of the map designation, e.g. LIC 1/C, where C indicates a simple slope of 2-5%. Another example, the LIC 2 map unit symbol, contains only the coarse sandy phase, LIC.C. It is designated on the soil map as LIC.C/B, where B indicates slopes of 0-2%. Sometimes in a soil map unit such as LIC 1, that component occurs on two slopes, e.g. LIC 1/B>C.

An example of a soil map unit symbol, with two components, is the unit LIC 5. It is composed of the Lincoln and the Smithville soils in 70:30 or 50:50 proportions. To determine whether the Lincoln soil is dominant (70%) or codominant (50%) in the map unit, it is necessary to scan the slopes in the denominator of the map designation, e.g. LIC 5/B >B, where both components of the unit occupy B slopes (0-2%), but component one, the Lincoln soil, is dominant (70%). In the other case, LIC 5/BB, component one, the Lincoln soil, is codominant (50%) with the Smithville component.

Table 9. Soils mapped in the Haldimand-Norfolk Region and their drainage relationships

Soil Name	Soil Map Symbol	Drainage Conditions of Soils Developed on Similar Parent Materials: Well-Drained	Imperfectly Drained	Poorly Drained	Very Poorly Drained
Berrien	BRR	Bookton	Berrien	Wauseon	
Beverly	BVY	Brantford	Beverly	Toledo	
Bookton	BOO	Bookton	Berrien	Wauseon	
Brady	BAY	Fox	Brady	Granby	
Brant	BRT	Brant	Tuscola	Colwood	
Brantford	BFO	Brantford	Beverly	Toledo	
Brooke	BOK	Farmington		Brooke	
Burford	BUF	Burford			
Colwood	CWO	Brant	Tuscola	Colwood	
Farmington	FRM	Farmington		Brooke	
Fox	FOX	Fox	Brady	Granby	
Gobles	GOB	Muriel	Gobles	Kelvin	
Granby	GNY	Fox	Brady	Granby	
Haldimand	HIM	Smithville	Haldimand	Lincoln	
Hampden	HMP				Hampden
Kelvin	KVN	Muriel	Gobles	Kelvin	
Lincoln	LIC	Smithville	Haldimand	Lincoln	
Lonsdale	LDL				Lonsdale
Lowbanks	LOW				Lowbanks
Maplewood	MPW		Tavistock	Maplewood	
Muriel	MUI	Muriel	Gobles	Kelvin	
Niagara	NGR	Ontario	Niagara	Welland	
Normandale	NDE	Wattford	Normandale	St. Williams	
Oakland	OKL	Scotland	Oakland	Vanessa	
Oakview	OVW				Oakview
Ontario	OTI	Ontario	Niagara	Welland	
Plainfield	PFD	Plainfield	Walsingham	Waterin	
Seneca	SNA	Seneca			
Scotland	STD	Scotland	Oakland	Vanessa	
Silver Hill	SIH	Walsher	Vittoria	Silver Hill	
Smithville	SHV	Smithville	Haldimand	Lincoln	
St. Williams	SLI	Wattford	Normandale	St. Williams	
Styx	SYX				Styx
Tavistock	TVK		Tavistock	Maplewood	
Toledo	TLD	Brantford	Beverly	Toledo	
Tuscola	TUC	Brant	Tuscola	Colwood	
Vanessa	VSS	Scotland	Oakland	Vanessa	
Vittoria	VIT	Walsher	Vittoria	Silver Hill	
Walsher	WSH	Walsher	Vittoria	Silver Hill	
Walsingham	WAM	Plainfield	Walsingham	Waterin	
Waterin	WRN	Plainfield	Walsingham	Waterin	
Wattford	WAT	Wattford	Normandale	St. Williams	
Wauseon	WUS	Bookton	Berrien	Wauseon	
Welland	WLL	Ontario	Niagara	Welland	
Wilsonville	WIL	Wilsonville			

GENERAL DESCRIPTIONS OF THE SOILS

Soil Key

A. Soils Developed on Glacial Till Deposits
- I. Silty clay loam till parent materials
  - (a) Moderately well-drained
    1. Muriel (MUI)
    2. Muriel coarse phase (MUI.C)
    3. Muriel loamy phase (MUI.L)
  - (b) Imperfectly drained
    1. Gobles (GOB)
    2. Gobles coarse phase (GOB.C)
    3. Gobles loamy phase (GOB.L)
  - (c) Poorly drained
    1. Kelvin (KVN)
    2. Kelvin coarse phase (KVN.C)
    3. Kelvin loamy phase (KVN.L)
  - (d) Very poorly drained
    1. Kelvin peaty phase (KVN.P)
- II. Reddish clay loam to clay till parent materials
  - (a) Moderately well-drained
    1. Ontario (OTI)
    2. Ontario coarse phase (OTI.C)
  - (b) Imperfectly drained
    1. Niagara (NGR)
    2. Niagara coarse phase (NGR.C)
    3. Niagara loamy phase (NGR.L)
  - (c) Poorly drained
    1. Welland (WLL)
    2. Welland coarse phase (WLL.C)
    3. Welland loamy phase (WLL.L)
- III. Loam till parent materials
  - (a) Well-drained
    1. Seneca (SNA)
    2. Seneca coarse phase (SNA.C)
    3. Seneca shallow phase (SNA.S)
    4. Seneca very shallow phase (SNA.V)
- IV. Gravelly sandy till parent materials
  - (a) Rapidly to well-drained
    1. Wilsonville (WIL)
    2. Wilsonville coarse phase (WIL.C)
    3. Wilsonville loamy phase (WIL.L)
    4. Wilsonville shallow phase (WIL.S)

B. Soils Developed on 40 to 100 cm of Lacustrine Materials over Glacial Till Deposits
- I. Sandy lacustrine over silty clay loam till parent materials
  - (a) Well-drained
    1. Bookton till phase (BOO.T)
  - (b) Imperfectly drained
    1. Berrien till phase (BRR.T)
  - (c) Poorly drained
    1. Wauseon till phase (WUS.T)
- II. Sandy lacustrine over gravelly sandy till parent materials
  - (a) Rapidly to well-drained
    1. Scotland (STD)
  - (b) Imperfectly drained
    1. Oakland (OKL)
  - (c) Poorly drained
    1. Vanessa (VSS)

C. Soils Developed on Lacustrine Deposits
- I. Loamy sand and sand lacustrine parent materials
  - (a) Rapidly to well-drained
    1. Fox (FOX)
    2. Fox shallow phase (FOX.S)
    3. Fox very shallow phase (FOX.V)
  - (b) Imperfectly drained
    1. Brady (BAY)
    2. Brady loamy phase (BAY.L)
  - (c) Poorly drained
    1. Granby (GNY)
    2. Granby loamy phase (GNY.L)
    3. Granby very shallow phase (GNY.V)
  - (d) Very poorly drained
    1. Granby peaty phase (GNY.P)
- II. Mostly loamy fine sand and fine sandy loam lacustrine parent materials
  - (a) Well-drained
    1. Wattford (WAT)
  - (b) Imperfectly drained
    1. Normandale (NDE)
    2. Normandale coarse phase (NDE.C)
  - (c) Poorly drained
    1. St. Williams (SLI)
- III. Loamy fine sand and fine sand lacustrine parent materials
  - (a) Very poorly drained
    1. Lowbanks (LOW)
- IV. Mostly silt loam lacustrine parent materials
  - (a) Well-drained
    1. Brant (BRT)
    2. Brant coarse phase (BRT.C)
    3. Brant very shallow phase (BRT.V)
  - (b) Imperfectly drained
    1. Tuscola (TUC)
    2. Tuscola coarse phase (TUC.C)
    3. Tuscola shallow phase (TUC.S)
    4. Tuscola very shallow phase (TUC.V)
  - (c) Poorly drained
    1. Colwood (CWO)
    2. Colwood coarse phase (CWO.P)
- V. Silty clay loam and silty clay lacustrine parent materials
  - (a) Moderately well-drained
    1. Brantford (BFO)
    2. Brantford coarse phase (BFO.C)
    3. Brantford loamy phase (BFO.L)
    4. Brantford shallow phase (BFO.S)
    5. Brantford very shallow phase (BFO.V)
  - (b) Imperfectly drained
    1. Beverly (BVY)
    2. Beverly coarse phase (BVY.C)
    3. Beverly loamy phase (BVY.L)
    4. Beverly shallow phase (BVY.S)
    5. Beverly very shallow phase (BVY.V)
  - (c) Poorly drained
    1. Toledo (TLD)
    2. Toledo coarse phase (TLD.C)
    3. Toledo shallow phase (TLD.S)
    4. Toledo very shallow phase (TLD.V)

(d) Very poorly drained
1. Toledo peaty phase (TLD.P)

VI. Heavy clay lacustrine parent materials
(a) Moderately well-drained
1. Smithville (SHV)
2. Smithville coarse phase (SHV.C)
3. Smithville loamy phase (SHV.L)
4. Smithville shallow phase (SHV.S)
5. Smithville very shallow phase (SHV.V)
(b) Imperfecxtly drained
1. Haldimand (HIM)
2. Haldimand coarse phase (HIM.C)
3. Haldimand loamy phase (HIM.L)
4. Haldimand shallow phase (HIM.S)
(c) Poorly drained
1. Lincoln (LIC)
2. Lincoln coarse phase (LIC.C)
3. Lincoln loamy phase (LIC.L)
4. Lincoln shallow phase (LIC.S)
5. Lincoln very shallow phase (LIC.V)
(d) Very poorly drained
1. Lincoln peaty phase (LIC.P)

D. Soils Developed on 40 to 100 cm of Lacustrine and Eolian Materials over Contrasting Lacustrine Deposits

I. Sandy sediments over silt loam lacustrine parent materials
(a) Well-drained
1. Walsher (WSH)
(b) Imperfectly drained
1. Vittoria (VIT)
(c) Poorly drained
1. Silver Hill (SIH)

II. Silty sediments over silty clay loam and silty clay lacustrine parent materials
(a) Imperfectly drained
1. Tavistock (TVK)
(b) Poorly drained
1. Maplewood (MPW)

III. Sandy sediments over silty clay loam and silty clay lacustrine parent materials
(a) Well-drained
1. Bookton (BOO)
(b) Imperfectly drained
1. Berrien (BRR)
(c) Poorly drained
1. Wauseon (WUS)
(d) Very poorly drained
1. Wauseon peaty phase (WUS.P)

IV. Sandy sediments over heavy clay lacustrine parent materials
(a) Imperfectly drained
1. Berrien heavy clay phase (BRR.H)

E. Soils Developed on Glaciofluvial Deposits

I. Gravelly loamy sand on gravelly glaciofluvial parent materials
(a) Rapidly to well-drained
1. Burford (BUF)

F. Soils Developed on Eolian Deposits

I. Fine sand eolian parent materials
(a) Rapidly to well-drained
1. Plainfield (PFD)
2. Plainfield dune phase (PFD.D)
(b) Imperfectly drained
1. Walsingham (WAM)
(c) Poorly drained
1. Waterin (WRN)
(d) Very poorly drained
1. Waterin peaty phase (WRN.P)

G. Shallow Soils Over Bedrock

I. Various parent materials less than 20 cm thick over bedrock
(a) Rapidly drained
1. Farmington (FRM)
(b) Poorly drained
1. Brooke (BOK)

H. Soils Developed on Organic Deposits

I. Organic soils 40 to 160 cm thick over coarse-textured mineral soil
(a) Very poorly drained
1. Hampden (HMP)

II. Organic soils 40 to 160 cm thick over medium-textured mineral soil
(a) Very poorly drained
1. Oakview (OVW)

III. Organic soils 40 to 160 cm thick over fine-textured mineral soil
(a) Very poorly drained
1. Lonsdale (LDL)

IV. Deep organic soils greater than 160 cm thick
(a) Very poorly drained
1. Styx (SYX)

I. Miscellaneous Land Units

I. Soils developed on recent alluvial deposits
(a) Undifferentiated drainage
1. Undifferentiated textures
i) Alluvium 1 (1-ALU)
2. Mainly sand and gravel
i) Alluvium 2 (2-ALU)
3. Mainly silt loam and loam
i) Alluvium 3 (3-ALU)
4. Mainly clay
i) Alluvium 4 (4-ALU)

II. Landscape complexes
1. Beach - scarp complex (CPX 1)
2. Marsh - beach complex (CPX 2)
3. Marsh - dune complex (CPX 3)
4. Marsh - ridge complex (CPX 4)
5. Beach - dune complex (CPX 5)
6. Beach - ridge complex (CPX 6)

III. Miscellaneous units
1. Marsh (MAR)
2. Ridge (RID)
3. Gravel pit (G.P.)
4. Quarry (Q)
5. Urban Land (U.L.)

Soil Descriptions

This section contains generalized descriptions of all the soils, and many of the map units, in the Haldimand-Norfolk Region. The descriptions are arranged in alphabetical sequence and include general information on location, landscape relationships, parent materials, texture, moisture characteristics, profile characteristics, associated soils and land use.

More detailed morphological, chemical and physical descriptions of typical soils, statistical means and engineering test data, are presented in Volume 2 of this soil report.

Many soil names used in this report have been retained from the old Norfolk and Haldimand soil maps (1,2). Although these soils are similar in many respects, they are not identical due to the more detailed mapping of this survey and the necessity for defining more precise limits for soil characteristics. Care should be taken to recognize the differences between soils described on the old soil maps, and soils with similar names in this report, such as the Fox and Haldimand soils.

Alluvial Soils (ALU)

Location and Extent Alluvial soils are mapped on stream and river floodplains. They are most extensive on the floodplains of larger watercourses such as the Grand River, Big Creek and Otter Creek. There are 5533 ha of pure Alluvial map units, and 10620 ha of Alluvial soils in complex map units where they occur in associations with several different soils that occur on the slopes of stream valleys.

Landform and Topography Alluvial soils occur on floodplains that are usually flooded each year, but sometimes, as on higher portions of the Grand River floodplain, flooding is infrequent. The topography is almost always level or nearly level. Local areas near watercourses may be hummocky or dissected from the cut-and-fill action of flood waters.

Parent Materials and Textures Alluvial soils have mostly developed in materials deposited during flood stages of rivers and streams. Sometimes flood erosion exceeds deposition, and soils may develop on older sediments exposed by flood erosion. Textures are variable over short distances; thus some Alluvial soils are undifferentiated texturally and mapped as Alluvium 1 (1-ALU). Between Hagersville and Lake Erie there are many very shallow phase Alluvial soils (1-ALU) having 20-50 cm of soil over bedrock. Textural differentiation of Alluvial soils has been attempted, in a general way, only where floodplains are being cultivated for agricultural crops as, for example, almost entirely along larger watercourses such as the Grand River and Big Creek. On these floodplains, sands and gravels were mapped as Alluvium 2 (2-ALU); loams as Alluvium 3 (3-ALU); and clays as Alluvium 4 (4-ALU).

Soil Moisture Characteristics Alluvial soils have various drainage conditions, but most are imperfectly or poorly drained due to the nearness of the watertable to the surface for long periods each year. Additional soils wetness may be caused by flooding or by seepage of water from adjacent valley slopes. Permeability, water-holding capacity and water runoff vary, depending on soil textures.

General Soil Description Surface horizons are usually between 20 and 30 cm thick. Organic matter contents of Alluvial soils are high, often between 3 and 6%. Textures of both topsoil and subsoil are quite variable, both laterally and with depth. Free carbonates may occur anywhere, and often still remain in the surface horizons of recently flooded soils. Soil reaction may vary from slightly acid to mildly alkaline in the subsoil. Soil classification is also variable, from Regosols to Luvisols in the better-drained soils, and Humic Gleysols or Gleysols in poorly drained soils.

Commonly Associated Soils The soils that most commonly occur with Alluvial soils are moderately well or well-drained soils on the moderate to steep slopes bordering floodplains. These include the Brantford (BFO), Smithville (SHV), Brant (BRT), Fox (FOX), and Plainfield (PFD) soils. The Brantford, Smithville and Brant soils are developed on lacustrine silts and clays, and occur with Alluvial soils in map units ALU 3, ALU 5, ALU 6 and ALU 11. The Fox and Plainfield soils, developed on lacustrine and eolian sands, occur with Alluvial soils in map units ALU 7 and ALU 8.

General Land Use Comments

(1) The greatest limitation of Alluvial soils for agricultural use is flooding. Thus they are not usually suitable for winter wheat, or forage crops that include legumes. If flooding is rare or restricted to early spring, the risks of growing spring grains, corn or vegetable crops are considerably lower. These crops are grown on some floodplain areas, especially along the Grand River and Big Creek. Tile drainage is not recommended on Alluvial soils.

(2) Alluvial soils are highly suited to most forest tree species that are not seriously affected by temporary flooding.

Figure 24. Alluvial soils on the Grand River floodplain near Cayuga

Berrien Soils (BRR)

Location and Extent Berrien soils occur throughout most of the region, being absent only from the northern part of the Town of Haldimand. There are 444 ha of normal Berrien map units, and 5973 ha of Berrien soils in complex map units most often associated with Bookton, Wauseon, Toledo and Kelvin soils. There are also 2617 ha of till phase Berrien, and 2305 ha of heavy clay phase Berrien mapped in the region.

Landform and Topography Most Berrien soils occupy portions of the Haldimand clay plain close to the deep sands of the Norfolk sand plain. Near the western edge of the region, till phase Berrien soils occur on some level areas of sand over clay till. The topography ranges from level to very gently sloping, with slopes usually between 1 and 3%.

Parent Materials and Textures Berrien soils have developed from shallow lacustrine, often wind-modified sands, overlying clayey lacustrine and till deposits. Surface horizons consist of 40-100 cm of fine sand, sand or loamy sand, overlying silty clay loam, silty clay, or heavy clay.

Soil Moisture Characteristics Berrien soils are imperfectly drained. The surface sands are rapidly permeable, but have relatively low water-holding capacities, and a potential for problems of summer droughtiness. The underlying clayey materials are only moderately to slowly permeable, and have groundwater perched on them for variable periods of time each year. Surface runoff from Berrien soils is slow.

General Soil Description The surface Ap horizons usually consist of 20-25 cm of fine sandy loam. They are underlain by 15-80 cm of A and B horizons, with mainly fine sandy loam or loamy fine sand textures. Distinct to prominent yellowish-brown mottles appear in the sands near the underlying clay contact. A weakly cemented layer often occurs at this contact zone. If the clayey materials, that occur at the 40-100 cm depth, consist of lacustrine silty loam or silty clay, the normal Berrien soil (BRR) is mapped. However, if these clayey subsoils consist of lacustrine heavy clay or silty clay loam till, respectively, the Berrien heavy clay phase (BRR.H), or the Berrien till phase (BRR.T) are mapped. Near the sand-clay contact, the C horizon usually begins in the very strongly calcareous, clayey materials (IICk horizon). Soil reaction ranges from slightly acidic or neutral in the surface, to moderately alkaline in the subsoil. The soil classification is usually Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Bookton (BOO) and Wauseon (WUS) soils are most often associated with Berrien soils in map units BRR 4 and BRR 5. Their parent materials are similar to those of Berrien soils but their drainages differ. Coarse phase Bookton and Berrien soils, e.g. BOO.C and BRR.C, are also associated with Berrien soils in map units BRR 6 and BRR 7. Berrien till phase soils (BRR.T) are most commonly associated with Kelvin soils (KVN) in map unit BRR 15.

General Land Use Comments

(1) Berrien soils are important agricultural soils extensively used for grain corn, tobacco, tree fruits, and other specialized horticultural crops. They often require some tile drainage, and may need occasional supplemental irrigation.

(2) Berrien soils are considered to be above average for forest productivity of most plantation and native tree species.

Beverly Soils (BVY)

Location and Extent Beverly soils occur through most of the eastern and central parts of the region but are absent from most of the western part, including theTownships of Delhi and Norfolk. There are 2447 ha of pure Beverly map units, and 22245 ha of Beverly soils mapped in complex map units, most often associated with Brantford, Toledo and Lincoln soils.

Landform and Topography Beverly soils occupy a substantial part of the Haldimand clay plain, especially areas near Townsend, Caledonia and Dunnville. They occur on topography ranging from level or gently sloping to dissected and sometimes hummocky terrain. Slopes are mostly in the 2-4% range.

Parent Materials and Textures Beverly soils have developed mainly on lacustrine silty clay and silty clay loam. With the exception of sandy and silty surfaces on some coarse and loamy phase Beverly soils, most Beverly soils have surface horizons of silty clay loam that grades with depth into predominantly silty clay.

Soil Moisture Characteristics Beverly soils are imperfectly drained. They are moderately to slowly permeable. Groundwater temporarily occupies the surface horizons each year. The saturation period is prolonged, in many cultivated fields where the subsoil has been over-compacted by heavy machines. Water-holding capacity ranges from medium to high and surface runoff is medium to high.

General Soil Description Although the surface horizon usually consists of 15-20 cm of silty clay loam or silty clay, some Beverly soils have an additional overlay of 15-40 cm of fine sandy loam (BVY.C), and a few are capped by 15-40 cm of silt loam (BVY.L). The surface horizons are normally underlain by 30-35 cm of silty clay, or occasionally silty clay loam or clay A and B horizons. These subsoil horizons are frequently compacted. Distinct or prominent yellowish-brown to yellowish-red mottles are usually present in the upper B horizons. The strongly calcareous Ck horizon usually begins at about 50 cm depth. In a few Beverly soils, bedrock occurs within 20-50 cm from the surface (BVY.V); in others, it is somewhat deeper, at 50-100 cm from the surface (BVY.S). Soil reaction ranges from slightly acidic or neutral near the surface to moderately alkaline in the subsoil. Soil classification is usally Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Brantford (BFO), Toledo (TLD) and Lincoln (LIC) soils are most often associated with Beverly soils in the map units BVY 6, BVY 8 and BVY 9. Brantford and Toledo soils differ from Beverly soils by being, respectively, moderately well-drained and poorly drained. Lincoln soils differ by having heavy clay horizons within the soil profile and by being poorly drained. Coarse phase Beverly soils are often associated with coarse phase Brantford soils (BFO.C) in map unit BVY 7, and with normal Toledo and coarse phase Toledo soils in map units BVY 18 and BVY 19.

General Land Use Comments

(1) Beverly soils are important agricultural soils for corn, small grains and forage crops. In the Townsend, Port Dover and Dunnville areas they are often used for specialized crops such as soybeans, tomatoes and peppers. They usually require some tile drainage.

(2) Beverly soils are considered good to fair for production of most commercial tree species.

Bookton Soils (BOO)

Location and Extent Bookton soils are confined to portions of the Norfolk sand plain in the western part of the region. There are 515 ha of normal Bookton map units, and 2544 ha of Bookton soils in complex map units, most often associated with Berrien, Wauseon, and Gobles soils. There are also 874 ha of till phase Bookton soils mapped in the region.

Landform and Topography Bookton soils occupy portions of the Norfolk sand plain and the Port Stanley till moraines, where shallow sands overlie lacustrine clays and clay till.

They occur on topography ranging from nearly level to strongly sloping, but are most prevalent on slopes of 3-6%.

Parent Materials and Textures Bookton soils have developed on shallow lacustrine and eolian sands overlying clayey lacustrine and till deposits. The surface consists of 40-100 cm of fine sand, sand or loamy sand overlying silty clay loam, silty clay or clay.

Soil Moisture Characteristics Bookton soils are well-drained. The surface sands are rapidly permeable, but underlying clays are only moderately to slowly permeable. On flatter sites, groundwater may perch on the clays for brief periods of time. Surface sands have relatively low water-holding capacities and are droughty during dry summers. Surface runoff is slow on level to gently sloping Bookton soils, but increases on moderate and strong slopes.

General Soil Description The surface Ap horizon usually consists of 20-25 cm of fine sandy loam. It is underlaid by 40-70 cm of sandy A and B horizons over clays. The clay content of the sands usually is greatest in the Bt horizon near the clay contact. The clays at this contact zone are sometimes tough and compacted. The clayey materials which comprise the IICk horizon, have silty clay loam or silty clay textures on lacustrine plains (BOO), and silty clay loam or clay textures on till moraines (BOO.T). The IICk horizon is usually very strongly calcareous. Soil reaction ranges from strongly acidic or neutral in the surface horizons, to moderately alkaline in the subsoil. Soil classification is usually Brunisolic Gray Brown Luvisol.

Commonly Associated Soils In lacustrine areas, Berrien (BRR) and Wauseon (WUS) soils are most often associated with Bookton soils in map units BOO 3 and BOO 4. Berrien and Wauseon soils have similar parent materials, but differ from Bookton soils by being imperfectly and poorly drained, respectively. In till areas, Bookton soils are most often associated with imperfectly drained Gobles (GOB) in map unit BOO 15, and till phase Berrien (BRR.T) soils in map unit BOO 13.

General Land Use Comments

(1) Bookton soils are widely used for tobacco, grain corn, winter wheat, sour cherries, and some other horticultural crops. Doughtiness can be a problem and supplemental irrigation may be necessary for some crops.

(2) Bookton soils are suitable foremost upland forest tree species, especially white pine, red pine and black walnut.

Figure 25. Tomatoes growing on a Bookton soil near Boston

Brady Soils (BAY)

Location and Extent Brady soils are mainly confined to the Norfolk sand plain in the western half of the region. They also occupy some small areas near Dunnville at the east end of the region. There are 872 ha of pure Brady map units, and 14669 ha of Brady soils in complex map units, most often associated with Fox and Granby soils.

Landform and Topography Brady soils occur mainly on level areas of the Norfolk sand plain. They are often underlain at a few meters depth by impermeable clays or silts. Brady soils occupy topography ranging from level to very gently sloping, and are most prevalent on slopes of 0.5-2%.

Parent Materials and Textures Brady soils have developed on lacustrine sands, usually modified somewhat at the surface by wind action. Soil textures are most commonly loamy sand or sand, with occasional fine sand at the surface.

Soil Moisture Characteristics Brady soils are imperfectly drained and usually rapidly permeable. Groundwater levels rise into the subsurface horizons of Brady soils during the winter and spring. Brady soils have relatively low water-holding capacities and consequently are droughty during dry summers. They have slow surface runoff.

General Soil Description The surface Ap horizons usually consist of 20-25 cm of loamy sand or sand, underlain by 25-65 cm of loamy sand or sand in subsoil A and B horizons. Distinct to prominent reddish yellow or dark yellowish brown mottles are usually present below the 30 cm depth. The strongly to very strongly calcareous Ck horizon usually begins at 45-85 cm depth and consists of sand. Soil reaction ranges from very strongly acidic to neutral in the surface horizons, and is usually moderately alkaline in the subsoil. Soil classification is typically Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Brady soils are most often associated with Fox (FOX) soils in map unit BAY 4, and with Granby (GNY) soils in map unit BAY 5. Fox and Granby soils differ from the Brady soils by being well drained and poorly drained, respectively.

General Land Use Comments

(1) Brady soils are extensively used for tobacco. To a lesser extent they are used for grain corn, winter wheat, strawberries, and several commercial vegetable crops. Tile drainage is occasionally necessary for wet spots. Brady soils usually suffer from surface droughtiness and require supplemental irrigation for high-value crops like tobacco.

(2) Brady soils are considered to be very good for wood production of most commercial tree species. Droughtiness can be a problem for recent plantings.

Brant Soils (BRT)

Location and Extent Brant soils are confined to the western part of the region, adjacent to the eastern edge of the Norfolk sand plain. They are especially prevalent in the Simcoe-Waterford area and near Langton. There are 3389 ha of pure Brant map units, and 3607 ha of Brant soils in complex map units where they are most frequently associated with Tuscola, Walsher and Alluvium 1 soils.

Landform and Topography Brant soils occur on areas of glaciolacustrine silts that are usually transitional between shallow water sands and deep water clays. Topography ranges from nearly level on the lacustrine plain, to very strongly sloping along some of the dissected valley walls.

Parent Materials and Textures Brant soils have usually developed on silt loam or very fine sandy loam lacustrine sediments, that are often stratified. Coarser sands sometimes occur on the surface, and silty clay loam layers are sometimes present in the subsoil.

Soil Moisture Characteristics Brant soils are well-drained. They are usually moderately permeable, but the permeability decreases where silty clay loam or compacted layers are present. Brant soils have fairly high water-holding capacities. Surface runoff can be high, and increases markedly with slope.

General Soil Description The surface Ap horizons usually consist of about 20 cm of silt loam, loam or very fine sandy loam. Some Brant soils, e.g. (BRT.C), have sandier surface horizons consisting mainly of loamy fine sand, 15-40 cm thick. These surface horizons are normally underlain by about 25 cm of very fine sandy loam or silt loam over a distinctive, dark brown Bt horizon of loam or silty clay loam texture. This Bt horizon is usually closer to the surface on slopes due to erosion of the surficial materials. The strongly to very strongly calcareous Ck horizon occurs, usually, at about the 100 cm depth. Near Springvale there are very shallow phase Brant soils (BRT.V), where the soils are only 20-50 cm deep over bedrock. The texture of the Ck horizon of Brant soils is usually silt loam, but unlike the Bt horizon, may contain thin layers of sandier textures. Soil reaction ranges from strongly acidic to neutral in the surface soil horizons, to moderately alkaline in the subsoil. Soil classification is usually Brunisolic Gray Brown Luvisol.

Commonly Associated Soils The Tuscola (TUC) soils, often associated with Brant soils in map unit BRT 4, differ from the Brant soils only by being imperfectly drained. In the Simcoe-Langton areas, Brant soils are often associated in the BRT 8 map unit with the well-drained Walsher soils that have 40-100 cm of sand over silt loam. Brant soils also border several stream valleys occupied by Alluvium 1 (1-ALU), which has variable textures and drainages. The map unit BRT 13 includes the Brant soils of the valley slopes, and the alluvial soils of the floodplains.

General Land Use Comments

(1) Brant soils are excellent agricultural soils, widely used for grain corn and all other common field crops, as well as for a number of special crops such as apples, lima beans, carrots, peppers and tomatoes. Their main limitation is their susceptibility to water erosion on slopes.

(2) Brant soils are also excellent forestry soils, again limited by potential erosion damage on moderate to steep slopes.

Figure 26. Eroded slopes are common on these rolling Brant soils near Langton

Brantford Soils (BFO)

Location and Extent Brantford soils are widespread in the region and occur everywhere except along the western edge of Norfolk County. There are 6689 ha of pure Brantford map units, and 13747 ha of Brantford soils in complex map units where they are most often associated with Beverly and Toledo soils. There are also relatively large Brantford soil areas associated with Lincoln and Alluvium 1 soils.

Landform and Topography Brantford soils occupy portions of most of the Haldimand clay plain. The topography ranges from nearly level to very strongly sloping. Most slopes range between 3 and 7%, with steeper, dissected slopes near some river and stream valleys.

Parent Materials and Textures Brantford soils have mainly developed on lacustrine silty clay loam and silty clay deposits. Surface textures are most commonly silty clay loam, but sometimes silt loam or silty clay textures also occur. Subsoil textures are usually silty clay loam or silty clay.

Soil Moisture Characteristics Brantford soils are moderately well-drained. They are moderately to slowly permeable, depending upon the incidence of soil cracks and subsoil compaction. Groundwater may perch near the surface of Brantford soils for brief periods. They have relatively high water-holding capacities, but can exhibit summer droughtiness. Surface runoff from Brantford soils is generally rapid.

General Soil Description The surface Ap horizons of Brantford soils usually consist of 10-15 cm of silty clay loam. There are some loamy phase Brantford soils (BFO.L) consisting of 15-40 cm of silt loam or loam at the surface, and some coarse phase Brantford soils (BFO.C) with surfaces of fine sandy loam. Bt horizons usually begin at the 20-25 cm depth, and consist of compact silty clay or clay. The strongly calcareous Ck horizons, which usually commence at the 45-60 cm depth, are most often composed of silty clay with occasional silty clay loam or clay layers. In the Hagersville area, there are some shallow phase (BFO.S) and very shallow phase (BFO.V) Brantford soils. Soil reaction of Brantford soils ranges from very strongly acidic or neutral in the surface horizons, to moderately alkaline in the subsoil. Soil classification is usually Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Beverly (BVY) and Toledo (TLD) soils occur extensively with Brantford soils in map units BFO 6 and BFO 7. They differ from Brantford soils in being imperfectly drained and poorly drained, respectively. There are also major occurrences of Brantford soils with Lincoln (LIC) soils in map unit BFO 10 in the northern part of the Town of Haldimand. Lincoln soils differ in being poorly drained and having heavy clay textures. Alluvium 1 soils (1-ALU) with variable textures and drainages are often associated with Brantford soils in map unit BFO 12, which occupies stream valley-floodplain areas.

General Land Use Comments

(1) Brantford soils are very important for agriculture. They are used for all the common field crops, increasingly so for grain corn and soybeans. They are used to some extent for horticultural crops such as apples or cabbages. Overcompacted subsoils, droughtiness and erosion on slopes can be limi-

tations.

(2) Brantford soils are fair to good for forest productivity, with limitations mainly relating to their high clay content.

Figure 27. Dwarf apples on moderately sloping Brantford soils near Tyrrel

Brooke Soils (BOK)

Location and Extent Brooke soils have a very limited occurrence in the region. They occur on the limestone plain, west of Springvale, in the northern part of the City of Nanticoke. There are no pure Brooke map units, only one complex map unit of Brooke and Granby soils, where Brooke soils occupy 44 ha.

Landform and Topography Brooke soils occupy a level area of the limestone plain, a physiographic region of shallow soil over bedrock. The topography is level because of bedrock control, and slopes are usually 0.5-1%.

Parent Materials, and Textures Brooke soils have usually developed on variable soil parent materials less than 20 cm thick over bedrock. They are composed mostly of sandy surface materials that grade into loamy materials just above the bedrock.

Soil Moisture Characteristics Brooke soils are poorly drained. They range from rapidly to moderately permeable. They are usually saturated for lengthy periods every year by groundwater ponded on the relatively impermeable bedrock. The water-holding capacity of Brooke soils is variable, and surface runoff is slow.

General Soil Description The surface Ap horizon consists of 10-15 cm of variably textured materials, usually sandy, over somewhat loamier soil materials in the Bg horizon. Prominent, strong brown mottles occur in the Bg horizon. Limestone bedrock usually appears at depths shallower than 20 cm. Soil classification is Orthic Humic Gleysol.

Commonly Associated Soils Brooke soils are associated with very shallow phase Granby soils (GNY.V) in map unit BOK 1. Like Brooke soils these Granby soils are poorly drained, shallow (20-50 cm) to bedrock, but they have dominantly loamy sand textures.

General Land Use Comments

(1) Brooke soils have virtually no agricultural importance because they are so shallow over bedrock. They may have some very limited use for perennial forages.

(2) Brooke soils are also of little value for forestry because of shallowness over bedrock.

Burford Soils (BUF)

Location and Extent Burford soils are of limited extent in the region, and are only mapped at several locations between Simcoe and Tillsonburg, and north of Delhi. There are 99 ha of pure Burford map units, and 84 ha of Burford soils in complex map units where they are most often associated with Fox or Walsingham soils.

Landform and Topography Burford soils are mapped on old terraces of Big Creek and some neighboring outwash areas in the Norfolk sand plain. Burford soils are found on topography ranging from nearly level to strongly sloping.

Parent Materials and Textures Burford soils have mostly developed on glaciofluvial deposits of gravelly loamy coarse sand. These gravelly materials may be overlain by as much as 40 cm of sandy loam or loamy sand that contains up to 20% gravel.

Soil Moisture Characteristics Burford soils are rapidly to well drained. They are rapidly permeable. They generally have low water-holding capacities and definite droughtiness limitations. They have slow surface runoff except on steeper slopes.

General Soil Description The surface Ap horizons usually consist of 20-25 cm of sandy loam or loamy sand, with various amounts of gravel. They are underlain by thin B horizon layers that terminate in the Ck horizons, usually at the 20-50 cm depth. The gravel content of the Ck horizon is at least 20%, and the texture is usually gravelly loamy coarse sand. Calcareousness of the Ck horizons ranges from moderately to extremely calcareous. Soil reaction is slightly acidic or neutral in the upper horizons, and mildly to moderately alkaline in the subsoil. Soil classification is usually Orthic Gray Brown Luvisol.

Commonly Associated Soils Burford soils occur with Fox (FOX) soils in map unit BUF 2, and with Walsingham (WAM) soils in map unit BUF 3. Fox soils differ in having loamy sand or sand textures, greater than one m thick. Walsingham soils differ by being imperfectly drained, and having mainly fine sand textures.

General Land Use Comments

(1) The Burford soils on nearly level to gently sloping terrain have limited agricultural value because of their droughtiness limitations. They are mostly used for winter wheat and grain corn. When used for higher value crops such as tobacco, supplemental irrigation is necessary.

(2) Burford soils are generally fair to poor for most commercial forest species because of their droughtiness and high carbonate contents.

Colwood Soils (CWO)

Location and Extent Colwood soils are found on areas where lacustrine silts form important components of clay plains, e.g. north and west of Port Rowan, north of Simcoe, and in the Dunnville area. There are 1558 ha of pure Colwood map units, and 4486 ha of Colwood soils in complex map units where they are most often associated with Tuscola, Maplewood and Walsingham soils.

Landform and Topography Colwood soils occupy relatively level areas on the Haldimand clay plain, and on smaller lake plains in the Port Rowan-Langton areas. Their topography ranges from level to very gently sloping with the average slope about 1%.

Parent Materials and Textures Colwood soils have developed on glaciolacustrine silt deposits. Textures are usually silt loam, loam or very fine sandy loam. Sandy phase Colwood soils (CWO.C) have sandy loam surface horizons, whereas peaty phase Colwood soils (CWO.P) have surface horizons composed of organic soil materials.

Soil Moisture Characteristics Colwood soils are poorly drained, except for peaty phase Colwood soils which are very poorly drained. They are moderately to slowly permeable. They usually remain saturated for relatively long periods each year. Colwood soils have high water-holding capacities. Surface runoff is slow to moderate, depending on slope.

General Soil Description Surface Ap horizons range between 15 and 30 cm in thickness. The textures of these, and underlying B horizons, range between silt loam, loam and very fine sandy loam. Distinct and prominent yellowish brown mottles are common in the B and C horizons. The Ck horizon, which usually begins between 40 and 60 cm, is generally silt loam and strongly to very strongly calcareous. Soil reaction ranges from slightly acidic or neutral in the surface horizons, to moderately alkaline in the subsoil. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils Tuscola (TUC), Maplewood (MPW) and Walsingham (WAM) soils are those most extensively associated with Colwood soils. Tuscola soils, which are included with Colwood soils in map unit CWO 4, differ by being imperfectly drained. Walsingham soils, associated with Colwood soils in map unit CWO 12, are also imperfectly drained, but consist of fine sand. The poorly drained Maplewood soils, consisting of 40-100 cm of loam over clay, are mapped with Colwood soils in map unit CWO 11.

General Land Use Comments

(1) Colwood soils are good agricultural soils if drainage is artificially improved. Grain corn, silage corn, and spring grains are the crops most improved. Colwood soils have potential for commercial vegetable production.

(2) Colwood soils are very productive for most commercial tree species, in spite of having limitations caused by excess moisture.

Farmington Soils (FRM)

Location and Extent Farmington soils are limited to small areas of the limestone bedrock plain and Onondaga escarpment between Cayuga, Hagersville, and Springvale. There are 100 ha of pure Farmington map units, and 308 ha of Farmington soils in complex map units where they are most often associated with Normandale soils, shallow phase Fox soils, and very shallow phase Brant soils.

Landform and Topography Farmington soils occur on the Onondaga escarpment, and on nearly bedrock plains that contain thin soil deposits. The topography is moderately sloping on the Onondaga escarpment and nearly level on the bedrock plain.

Parent Materials and Textures Farmington soils in the region have usually developed on loam or clay loam deposits less than 20 cm thick over bedrock.

Soil Moisture Characteristics Farmington soils are rapidly drained. They are usually rapidly permeable. Their water-holding capacities vary depending on textures, but because of their proximity to bedrock they suffer from droughtiness. Surface runoff varies, according to texture and slope.

General Soil Description Surface Ap horizons of Farmington soils range from 10-20 cm thick. Bm horizons may or may not be present, and range from 0-10 cm thick. Soil textures vary but are usually loam or clay loam, sometimes with a thin cap of sandy loam. They range from weakly to moderately calcareous, and soil reaction is usually neutral to mildly alkaline. Soil classification is usually Orthic Melanic Brunisol.

Commonly Associated Soils Farmington soils are associated, to a limited extent, with very shallow phase Brant (BRT.V) and shallow phase Fox (FOX.S) soils. Shallow phase Fox soils, which occur with Farmington soils in map unit FRM 3, have 50-100 cm of loamy sand or sand over bedrock. Very shallow phase Brant soils, which occur with Farmington soils in map unit BRT 24, have 20-50 cm of loam over bedrock.

General Land Use Comments

(1) Being so shallow to bedrock, Farmington soils have very little agricultural importance, except for some limited production of forages.

(2) For the same reason, they have very limited potential for forestry.

Figure 28. Farmington soils occur on some stream valley slopes on the Haldimand clay plain

Fox Soils (FOX)

Location and Extent Fox soils are widely distributed on the Norfolk sand plain, in the City of Nanticoke, and in the Townships of Delhi and Norfolk. There are 9535 ha of pure Fox map units, and 15700 ha of Fox soils in complex map units where they are most often associated with Brady soils, but Grimsby, Plainfield and Scotland soils are fairly common soil associates as well.

Landform and Topography Fox soils have developed on the nearshore glaciolacustrine sand deposits of the Norfolk sand plain. Surface materials and topography of these deposits have usually been somewhat modified by wind action. The topography ranges from level to moderately sloping on most of the areas, but can be strongly to very strongly sloping on dissected stream valley slopes. Slopes of most Fox soils range from 2-5%.

Parent Materials and Textures The parent materials of Fox soils are mainly glaciolacustrine loamy sands and sands, usually modified somewhat at the surface by wind action. The wind-graded surface sand and fine sand can range up to one m thick in Fox soils, but are usually less than 50 cm thick. Occasional thin bands of fluvial coarse sands or gravels occur in some Fox soils.

Soil Moisture Characteristics Fox soils are rapidly to well drained and rapidly permeable. They have relatively low water-holding capacities, and almost always have droughtiness limitations. Surface runoff is slow, except on steeper slopes.

General Soil Description The surface Ap horizons typically consist of 20-25 cm of sand, loamy sand or loamy fine sand. They are underlain by 20-80 cm of other A and B horizons, composed of sands or loamy sands. There are some very shallow phase fox soils (FOX.V), in the vicinity of Hagersville, in which the B horizon-bedrock contacts occur at 20-50 cm. In most Fox soils, the Bt horizon typically has a very wavy or tongueing contact with the calcareous Ck horizon, and so the mean depth to the top of the Ck horizon is about 70 cm, but the range varies from 40-100 cm. The Ck horizons are usually strongly or very strongly calcareous sand. Soil reaction varies from very strongly acidic or neutral in the surface horizons, to mildly alkaline in the Ck horizons. Soil classification is usually Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Fox soils are associated with many others. Their most common associate, in map unit Fox 4, is the imperfectly drained, but otherwise similar Brady (BAY) soil. Other fairly common associates include Granby (GNY) soils, similar in texture to Fox soils but poorly drained, in map unit FOX 3; Plainfield (PFD) soils in map unit FOX 14, that differ from Fox soils in texture; and Scotland (STD) soils in map unit FOX 9, which have 40-100 cm of sand over gravelly sandy till.

General Land Use Comments

(1) Fox soils are extensively used for growing flu-cured tobacco. Rye and winter wheat are also widely grown on Fox soils, usually in tobacco rotations. Increasing use is being made of Fox soils for peanuts and horticultural crops such as asparagus, onions, potatoes, apples and cherries. Supplemental sprinkler irrigation is necessary for tobacco and most other high value crops.

(2) Fox soils have only fair potential for most tree species, except red pine or white pine which seem to do well.

Figure 29. Harvesting potatoes on Fox sands near Round Plains

Gobles Soils (GOB)

Location and Extent Gobles soils are found on the clay till moraines and till plains that occupy portions of the west side of the region. There are 55 ha of pure Gobles map units, and 4735 ha of Gobles soils in complex map units where they are most often associated with Kelvin soils.

Landform and Topography Gobles soils are located on relatively level areas of till moraines and till plains composed of Port Stanley till. They are sometimes overlain by shallow caps of lacustrine or eolian silts and sands. Gobles soils occupy topography that ranges from nearly level to very gently sloping.

Parent Materials and Textures Gobles soils have developed on mainly silty clay loam till that has thin caps of loams and sands. Textures range from fine sandy loam to loam or clay loam in the surface horizons, grading into silty clay loam or, occasionally, silty clay in the subsoil.

Soil Moisture Characteristics Gobles soils are imperfectly drained. They are moderately to slowly permeable. Groundwater occupies the surface horizons for temporary periods each year. Gobles soils have relatively high water-holding capacities, and moderate to rapid surface runoff.

General Soil Description Surface Ap horizons usually consist of about 20 cm of clay loam. Loamy phase Gobles soils (GOB.L) are mapped where 15-40 cm of loam or silt loam overlie the clayey till. Sandy phase Gobles soils (GOB.C) are mapped where 15-40 cm of fine sandy loam makes up the surface horizons. The texture of the subsoil horizons is usually silty clay loam, occasionally silty clay. Distinct to prominent yellowish-brown mottles occur in the subsoil A and B horizons. The strongly to very strongly calcareous Ck horizons usually begin at 40-50 cm. Soil reaction ranges from slightly acidic to mildly alkaline in the surface horizons to moderately alkaline in the subsoil. Soil classification is usually Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Gobles soils are most commonly associated with the poorly drained Kelvin (KVN) soils in map unit GOB 3. Kelvin soils are composed of parent materials that are similar to Gobles soils. Coarse phase Gobles soils also are associated with Kelvin soils in map unit GOB 7.

General Land Use Comments

(1) Gobles soils are good agricultural soils that are being used for general field crops, especially grain corn and spring grains. They usually require some tile drainage.

(2) Gobles soils are better than average for forest productivity. Hard maple, white cedar and European larch do particularly well.

Figure 30. These Gobles coarse phase soils near Port Rowan are often used for vegetable crops such as cucumbers

Granby Soils (GNY)

Location and Extent Granby soils are distributed over the Norfolk sand plain, in the City of Nanticoke and in the Townships of Delhi and Norfolk. There are 5087 ha of pure Granby map units, and 11842 ha of Granby soils in complex map units where they are most commonly associated with Brady and Walsingham soils, and to a lesser extent with Plainfield and peaty phase Granby soils.

Landform and Topography Granby soils are located on level to depressional areas of the nearshore lacustrine sand deposits of the Norfolk sand plain. Topography ranges from depressional to nearly level. The slopes of Granby soils are mostly 0.5-1%.

Parent Materials and Textures Granby soils have developed on glaciolacustrine deposits, with mainly sand and loamy sand ,textures. Surface textures are typically loamy sand or sandy loam. Subsoil textures are loamy sand, sand, or occasionally, fine sand.

Soil Moisture Characteristics Most Granby soils, except for some very poorly drained peaty phase Granby soils, are poorly drained. They are usually rapidly permeable. Most horizons are saturated by groundwater for long periods each year unless artificially drained. Granby soils have relatively low water-holding capacities and slow surface runoff.

General Soil Description Granby soils have surface Ap horizons that usually consist of 20-30 cm of loamy sand or sandy loam. Peaty phase Granby soils (GNY.P) having 15-40 cm of surface organic soil overlying sands, occur in some low, swampy parts of the region. North of Delhi there are some loamy phase Granby soils (GNY.L) having 15-40 cm of loamy surface materials. Bg horizons with prominent, dark yellowish-brown mottles, and sand or loamy sand textures, occur under the Granby surface horizons. Near Springvale, there are some very shallow phase Granby soils (GNY.V), only 20-50 cm thick over bedrock. Granby Ck horizons begin at variable depths, ranging from 30-160 cm. They are usually strongly to very strongly calcareous and have sand textures. The usual range of soil reaction is from strongly acidic or neutral in the surface horizons to mildly alkaline in the subsoil. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils Soils most extensively associated with Granby soils are Brady (BAY) and Walsingham (WAM) in map units GNY 4 and GNY 8 respectively. Both differ from Granby soils by being imperfectly drained, and Walsingham soils consist of eolian fine sand. Fox (FOX) soils, a common associate of Granby soils in map unit GNY 6, are rapidly to well-drained. Another common associated soil is the peaty phase Granby soil (GNY.P) in map unit GNY 11; it has a surface layer of 15-40 cm of organic soil.

General Land Use Comments

(1) Artificially drained Granby soils are fairly useful for grain corn, soybeans, tobacco and some commercial vegetable crops.

(2) Granby soils are fair to average for commercial forestry, limited mainly by their high water tables.

Figure 31. Granby peaty phase soils are sometimes drained and used for vegetable or cash crops

Haldimand Soils (HIM)

Location and Extent Haldimand soils are widely distributed over the eastern part of the region on the Haldimand clay plain. There are 10236 ha of pure Haldimand map units, and 44272 ha of Haldimand soils in complex map units where they usually occur with Smithville and Lincoln soils.

Landform and Topography Haldimand soils are located on level or gently dissected glaciolacustrine clay deposits. The topography ranges from level to gently sloping, and somewhat hummocky. Surface slopes are most commonly between 1 and 3%.

Parent Materials and Textures Haldimand soils have developed on glaciolacustrine clay deposits. Surface textures are usually silty clay or silty clay loam, but some areas may have shallow silty or sandy loam surfaces. Subsoil textures are usually heavy clay, with occasional layers of silty clay or clay.

Soil Moisture Characteristics Haldimand soils are imperfectly drained, and slowly permeable. Groundwater perches for temporary periods each year in the upper horizons of these soils. Haldimand soils have medium to high water-holding capacities, but can be droughty during dry periods because of slow release of water by the clays. Surface runoff is rapid.

General Soil Description The surface horizons of Haldimand soils usually consist of 10-15 cm of silty clay loam or silty clay. In sandy phase Haldimand soils (HIM.C), the surface horizons usually consist of 15-40 cm of fine sandy loam. In loamy phase Haldimand soils (HIM.L), surface horizons consist of 15-40 cm of silt loam or clay loam. The A and B horizons, underlying the surface Ap horizons in Haldimand soils, usually consist of silty clay, grading into heavy clay with depth. The mottles in these horizons are distinct to prominent, and range from dark yellowish-brown to strong brown. B and C horizons normally have angular blocky to prismatic structures, but in cultivated fields B horizons are often compacted with almost amorphous structures. The Ck horizon usually begins at 40-50 cm, and can be moderately or strongly calcareous. Shallow phase Haldimand soils (HIM.S) are mapped in a few areas where bedrock occurs at the 40-100 cm depth. Soil reaction ranges from strongly acidic or neutral in the surface horizons to moderately alkaline in the subsoil. Soil classification is usually Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Haldimand soils are most commonly associated with Smithville (SHV) and Lincoln (LIC) soils in map units HIM 5 and HIM 3, respectively. These have textures similar to Haldimand soils, but Smithville soils are moderately well-drained and Lincoln soils are poorly drained. Both coarse phase Haldimand (HIM.C) and loamy phase Haldimand (HIM.L) soils are frequently associated with poorly drained Lincoln soils.

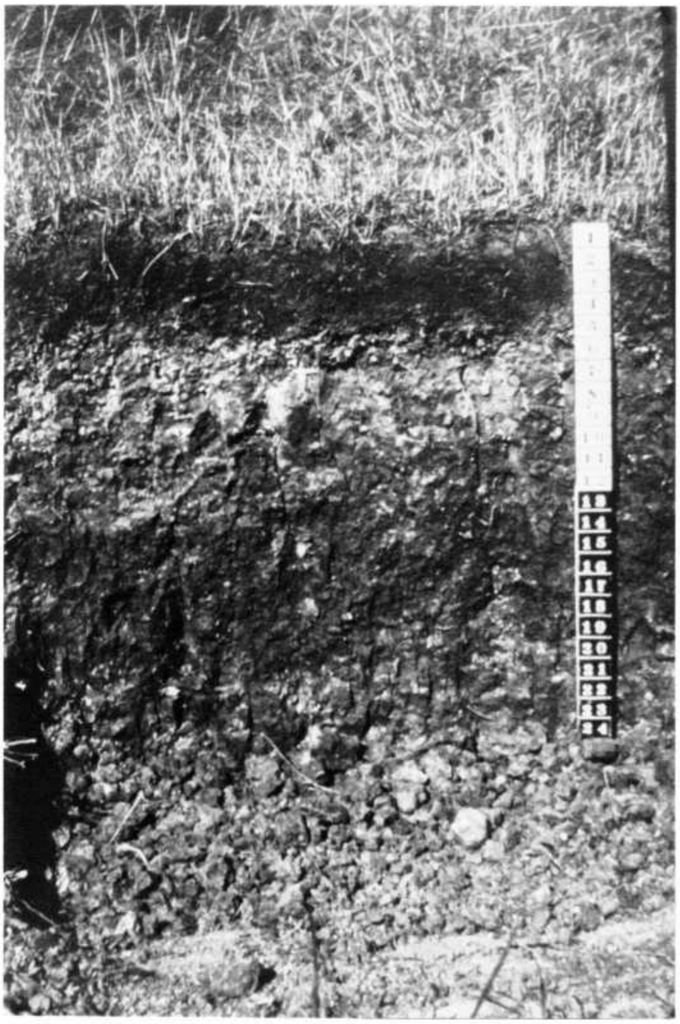


Figure 32. Typical Haldimand soil profile, showing blocky and prismatic structures in the lower part of the profile

General Land Use Comments

(1) Haldimand soils are fair agricultural soils, limited mainly by their high clay contents and attendant tillage problems. Excess moisture can also be a problem, and some tile drainage may be necessary. Grain and silage corn, spring grains, winter wheat, and forages, are the most common crops on these soils.

(2) Haldimand soils are fair to poor for forest productivity because of limitations related to the high clay contents.

Hampden Soils (HMP)

Location and Extent Hampden soils have limited occurrences in a few places on the Norfolk sand plain, and on gravelly till moraines north of Waterford. There are 371 ha of pure Hampden map units, and 605 ha of Hampden soils in complex map units where they are most often associated with Granby soils.

Landform and Topography Hampden soils are located in relatively closed depressional areas over lacustrine and fluvial sands and gravels, and gravelly sandy till. Topography ranges from depressional to level.

Parent Materials and Textures Hampden soils have developed on organic materials, 40-160 cm thick, over sands and gravels of lacustrine, fluvial or till origin. Humic or mesic organic soil materials usually dominate. Mineral soil textures range from fine sandy loam to gravelly sand.

Soil Moisture Characteristics Hampden soils are very poorly drained. They are rapidly permeable but saturated by groundwater most of the time. They have high water-holding capacities and very slow surface runoff.

General Soil Description Hampden soils consist of 40-160 cm of highly or moderately decomposed organic materials over mineral soils. The mineral soils are predominantly sands and gravels, with specific textures ranging from sandy loams to very gravelly sands. Soil classification is usually Terric Humisol.

Commonly Associated Soils Granby (GNY) and peaty phase Granby (GNY.P) are the soils most often associated with Hampden soils in the Region. They occur in map units HMP 2 and HMP 3, respectively. peaty phase Granby soils differ from Hampden soils in having only 15-40 cm of organic soil over mineral soil. Granby soils are poorly drained sandy soils.

General Land Use Comments

(1) Most Hampden soils would require extensive clearing and draining to be of any agricultural use, and the advisability of this is questionable.

(2) The continual high watertables of Hampden soils preclude their use for commercial forestry.

Kelvin Soils (KVN)

Location and Extent Kelvin soils are mapped in the western part of the region, on the clay till moraines and till plains. There are 243 ha of pure Kelvin map units, and 508 ha of Kelvin soils in complex map units where they are most often associated with till phase Berrien and Wauseon soils.

Landform and Topography Kelvin soils are located on level areas of moraines and till plains, that are composed of Port Stanley clay till. The topography of Kelvin soils ranges from depressional to nearly level. Slopes usually range between 0.5 and 1.5%.

Parent Materials and Textures Kelvin soils have developed on till that usually has silty clay loam textures. They are often modified at the surface by wind or water action that causes fine sandy loam, or loam surface textures.

Soil Moisture Characteristics With the exception of some very poorly drained peaty phase Kelvin soils, Kelvin soils are poorly drained and moderately to slowly permeable. Groundwater occupies most horizons of Kelvin soils for long periods each year. Kelvin soils have relatively high water-holding capacities and slow surface runoff.

General Soil Description The surface Ap horizons usually consist of about 20 cm of clay loam or loam. In the Township of Norfolk, there are some coarse phase Kelvin soils (KVN.C) that have 15-40 cm of fine sandy loam at the surface. West of Teeterville, there are some relatively small areas of peaty phase Kelvin soils (KVN.P) having 15-40 cm of organic materials on the surface. The underlying Bg horizons usually consist of silty clay loam till, with prominent mottles ranging from reddish to dark yellowish-brown. The mean depth at which the Ck horizon begins is about 65 cm. The texture of this horizon varies, but is usually silty clay loam. It ranges from strongly to very strongly calcareous. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils The soils that are most commonly associated with Kelvin soils are till phase Berrien (BRR.T) and till phase Wauseon (WUS.T) soils, in map units KVN 4 and KVN 13, respectively. They differ from Kelvin soils by having 40-100 cm of sand over clayey till. In addition, till phase Wauseon soils are poorly drained. Coarse phase Kelvin soils (KVN.C) are most common in map unit KVN 14, where they occur with imperfectly drained Gobles (GOB)soils.

General Land Use Comments

(1) Kelvin soils are presently used for most general field crops including grain corn. They require artificial drainage for maximum production.

(2) Kelvin soils, because of their wetness, are only fair for most commercial tree species, although some species, such as hard maple and white ash, do very well.

Lincoln Soils (LIC)

Location and Extent Lincoln soils occupy the greatest area on the Haldimand clay plain. There are 9348 ha of pure Lincoln map units, and 49569 ha of Lincoln soils in complex map units, where they are most often associated with Smithville and Haldimand soils.

Landform and Topography Lincoln soils occupy depressional to very gently sloping areas of the Haldimand clay plain. They consist of lacustrine clays, sometimes with thin loamy or sandy caps. The topography ranges from level to very gently sloping, with most slopes in the 0.5-2% range.

Parent Materials and Textures Lincoln soils have developed on deep-water glaciolacustrine clays. Surface soil textures are usually silty clay, but occasionally clay loam, silty clay loam or fine sandy loam. Subsoil textures are silty clay with various thicknesses of heavy clay.

Soil Moisture Characteristics Lincoln soils are mainly poorly drained. There are a few areas of very poorly drained peaty phase Lincoln soils. They are usually slowly permeable. Groundwater occupies the surface and upper subsoil horizons for long periods each year. Lincoln soils have medium to high water-holding capacities, but can be droughty during dry periods because of insufficient moisture release for plant use. Surface runoff can be slow to rapid, depending on the incidence of surface cracks.

General Soil Description The surface horizons of Lincoln soils usually range from 15-25 cm in thickness. Textures are usually silty clay. Loamy phase Lincoln soils (LIC.L) have 15-40 cm of surface clay loam or silty clay loam. Coarse phase Lincoln soils (LIC.C) have 15-40 cm of fine sandy loam on the surface. Peaty phase Lincoln soils (LIC.P) have 15-40 cm of surface organic soil. The B horizons usually have heavy clay or silty clay textures and prominent yellowish-brown mottles. Both B and C horizons have angular blocky or prismatic structures. The calcareous Ck horizons usually begin at 40-65 cm depth, but in some very shallow phase (LIC.V) and shallow phase (LIC.S) Lincoln soils, bedrock occurs at 20-50 or 50-100 cm, respectively. Ck horizons are mostly strongly calcareous. Soil reaction ranges from strongly acidic to neutral in the surface horizons, and is moderately alkaline in the subsoil. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils Lincoln soils are very often associated with Smithville (SHV) or Haldimand (HIM) soils in the LIC 5 and LIC 6 map units. They all have similar parent materials, but the Smithville and Haldimand soils are, respectively, moderately well-drained and imperfectly drained. Coarse phase Lincoln soils (LIC.C) often occur in associations with coarse phase Haldimand soils (HIM.C) and heavy clay phase Berrien soils (BRR.H), in map units LIC 15 and LIC 19, respectively.

General Land Use Comments

(1) Because of their poor drainage and high clay contents, Lincoln soils are not highly valued for agriculture. They are presently used for general field crops.

(2) The wetness and clay limitations of Lincoln soils keep productivity of most forest species low, but some species such as white spruce, silver maple, red maple and swamp white oak seem to do quite well.

Figure 33. Shrinkage cracks are common in Lincoln soils during dry periods

Lonsdale Soils (LDL)

Location and Extent Lonsdale soils are only mapped in a few locations in the Township of Delhi, northwest of Teeterville. There are 38 ha of pure Lonsdale map units, and 81 ha of Lonsdale soils in complex map units where they are associated with Granby soils.

Landform and Topography Lonsdale soils occupy depressional areas in the clay till moraines that cut across the northwest corner of the Township of Delhi. Topography is usually level.

Parent Materials and Textures Lonsdale soils consist of 40-160 cm of organic soil over fine-textured soil materials, mainly clays. The surface organic soil is mainly highly decomposed humic material, and the underlying mineral soil is usually Port Stanley till with silty clay loam or silty clay textures.

Soil Moisture Characteristics Lonsdale soils are very poorly drained. They are rapidly permeable, but groundwater is close to or above the ground surface most of the year. They have high water-holding capacities and very slow surface runoff.

General Soil Description Lonsdale soils consist of 40-160 cm of highly decomposed organic material overlying mineral soils. The mineral soils are predominantly silty clay loam till in the Haldimand-Norfolk Region. Soil classification is usually Terric Humisol.

Commonly Associated Soils Lonsdale soils may be associated with Granby (GNY) soils. Granby soils are poorly drained with loamy sand or sand textures.

General Land Use Comments

(1) Most Lonsdale soils would require extensive clearing and draining to be capable of agricultural use, and the advisability of this is questionable.

(2) Because of their wetness, Lonsdale soils are of little use for commercial forestry.

Lowbanks Soils (LOW)

Location and Extent Lowbanks soils are confined to the shallow sand plain at the eastern end of the region near Dunnville. There are 475 ha of pure Lowbanks map units, and 2108 ha of Lowbanks soils in complex map units in which the main associated soils are Walsingham or coarse phase Toledo soils.

Landform and Topography Lowbanks soils occupy the plain east of Dunnville where lacustrine sands overlie lacustrine silts and clays. The topography is usually level, but there are some very gently sloping and hummocky areas.

Parent Materials and Textures The parent materials of Lowbanks soils consist mainly of fine sand and loamy fine sand deposited in lacustrine environments, and later modified by wind action. These sands were deposited over lacustrine silty clay loam and silty clay, usually at depths ranging between one and two m.

Soil Moisture Characteristics Lowbanks soils are very poorly drained. They are moderately to rapidly permeable, but the groundwater surface is near the soil surface for much of the year. Lowbanks soils have moderate water-holding capacity and slow surface runoff.

General Soil Description The cultivated surface horizons of Lowbanks soils usually consist of loamy fine sand or fine sand, about 20 cm thick. Their black color reflects high organic matter contents ranging between 8 and 17%. The subsurface B horizons are usually composed of light gray, fine sand having distinct or prominent yellowish-brown mottles. The depth to the calcareous C horizon is quite variable, usually 40-50 cm, but sometimes much less. The C horizon is usually fine sand, sometimes loamy very fine sand. Thin layers of silt loam or silty clay loam are more numerous with depth, eventually grading into continuous lacustrine clays and silts. C horizons are usually strongly or very strongly calcareous. Soil reaction varies from medium acidic to mildly alkaline in all but the C horizons, where it is mildly to moderately alkaline. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils Lowbanks soils are usually associated with Walsingham (WAM) in map unit LOW 3, or with coarse phase Toledo (TLD.C) soils in LOW 4. Walsingham soils differ from Lowbanks soils by being imperfectly drained and by having considerably less organic matter in the surface horizons. Coarse phase Toledo soils have only 15-40 cm sand over poorly drained lacustrine silty clay.

General Land Use Comments

(1) Lowbanks soils are used for grain corn, soybeans, several horticultural crops and sod crops. The high watertables tend to recede during the growing season, but artificial drainage is definitely beneficial.

(2) Lowbanks soils are generally not suitable for commercial wood production because of their wetness.

Figure 34. Aerial view of Lowbanks and Walsingham soils near Dunnville, showing patchy drainage pattern. Darker areas are Lowbanks soils

Maplewood Soils (MPW)

Location and Extent Maplewood soils occur in a few places north of Simcoe, and in the area between Port Dover and Port Burwell near Lake Erie. There are 195 ha of pure Maplewood map units, and 1008 ha of Maplewood soils in complex map units where they are often associated with Tavistock soils.

Landform and Topography Maplewood soils occupy portions of lacustrine plains, such as the Haldimand clay plain, where silt loam has accumulated over clayey sediments. The topography is level or nearly level, and slopes rarely exceed 1.5%.

Parent Materials and Textures Maplewood soils are developed on deep-water glaciolacustrine silts and clays. Textures usually consist of 40-100 cm of silt loam over silty clay or silty clay loam.

Soil Moisture Characteristics Maplewood soils are poorly drained and are moderately to slowly permeable. Groundwater perches on the relatively dense clays for long periods each year. Maplewood soils have high water-holding capacities and moderate surface runoff.

General Soil Description The surface Ap horizons of Maplewood soils are usually about 20 cm thick with textures of silt loam, loam or very fine sandy loam. The underlying Bg horizons, which can attain thicknesses of as much as 100 cm, usually have textures similar to the surface horizons. Subsoil horizons have distinct to prominent reddish-yellow or yellowish-brown mottles. Clays are often more compacted at the silt-clay contact, which can occur at depths between 40 and 100 cm. The C horizon, which may also begin within this depth range, is usually very strongly calcareous. Soil reaction usually ranges from slightly acidic to neutral in the surface horizons, and mildly to moderately alkaline in the subsoil. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils Tavistock (TVK) soils are most often associated with Maplewood (MPW) soils in map unit MPW 2. They have textures similar to Maplewood soils, but are imperfectly drained.

General Land Use Comments

(1) Maplewood soils require artifical drainage to improve their suitability for agricultural uses. Those that have been drained are used for grain corn, soybeans, spring grains, sweet corn and tomatoes.

(2) Maplewood soils, despite their wetness, are capable of producing good yields of white spruce, European larch, silver maple and red maple.

Muriel Soils (MUI)

Location and Extent Muriel soils are mapped on the clay till moraines and plains that occupy portions of the west side of the region. There are 836 ha of pure Muriel map units, and 3654 ha of Muriel soils in complex map units in which they are most commonly associated with Gobles and Kelvin soils.

Landform and Topography Muriel soils are located on sloping areas of till moraines and till plains consisting of Port Stanley till. They are sometimes overlain by shallow caps of lacustrine sands or eolian silts. The topography ranges from very gently sloping to very strongly sloping.

Parent Materials and Textures Muriel soils have developed on mainly silty clay loam till, often with thin surface caps of lighter-textured loams or sands. Surface textures are usually clay loam. Silty clay textures sometimes occur in the subsoil.

Soil Moisture Characteristics Muriel soils are moderately well-drained, and moderately to slowly permeable. Groundwater derived from seepage or runoff may occupy the surface horizons for brief periods during the growing season. Muriel soils have relatively high water-holding capacities but fairly rapid surface runoff, so droughty conditions can develop on the steeper slopes.

General Soil Description The surface Ap horizons are usually composed of 20-30 cm of clay loam. Loamy phase Muriel soils (MUI.L) are mapped when 15 to 40 cm of loam or silt loam overlie clayey till. Coarse phase Muriel soils (MUI.C) are usually mapped when 15 to 40 cm of fine sandy loam overlies clayey till. The texture of the lower B and C horizons is usually silty clay loam, but sometimes silty clay or less commonly, clay loam. Bt horizons are sometimes compacted to a semi-hardpan consistence. The calcareous C horizons usually commence somewhere between 40 and 80 cm depth. They are usually strongly or very strongly calcareous. Soil reaction usually ranges from medium acidic to neutral in the surface horizons, and can be mildly or moderately alkaline in the subsoil. Soil classification is usually Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Muriel soils are most commonly associated with Gobles (GOB) soils in the MUI 2 map unit, and with Kelvin (KVN) soils in the MUI 4 map unit. These soils have parent materials and textures similar to Muriel soils, but differ by being, respectively, imperfectly and poorly drained.

General Land Use Comments

(1) Muriel soils are good agricultural soils, except on steeper slopes where erosion and topographic limitations prevail. Grain corn and soybeans are increasingly important on these soils, which have traditionally been used mainly for small grain and forage crops. Tile drainage may be necessary where wet spots or seepage areas occur.

(2) Muriel soils have some limitations for forest production related to high clay contents, but are capable of better-than-average production of white pine, hard maple and black cherry.

Niagara Soils (NGR)

Location and Extent Niagara soils are only found in a few areas in the Town of Dunnville near Lake Erie. There are 62 ha of pure Niagara map units, and 1195 ha of Niagara soils in complex map units where they are usually associated with Welland soils.

Landform and Topography Niagara soils occupy relatively level areas of till moraines, which are composed of reddish Halton clay till. Topography is level or very gently sloping.

Parent Materials and Textures Niagara soils have developed on reddish Halton clay till, which is sometimes overlain by a thin veneer of lacustrine sediments. Textures range from silt loam to clay in the surface horizons, and from silty clay loam to clay in the subsoil horizons.

Soil Moisture Characteristics Niagara soils are imperfectly drained. They are moderately to slowly permeable. Groundwater usually occupies the surface and upper subsoil horizons during the winter and early spring; it may persist longer, depending on weather conditions. Niagara soils have moderate to high water-holding capacities. Surface runoff ranges from slow on level topography, to rapid on some gentle slopes.

General Soil Description The surface Ap horizons, which are usually 15-20 cm thick, range in texture from silt loam to clay but are mainly silty clay loam. In a few areas there are coarse phase Niagara soils (NGR.C) having 15-40 cm of sandy loam on the surface. The subsoil B horizons of Niagara soils range from silty clay loam to clay, and have distinct or prominent strong brown mottles. The C horizons that usually begin around 50 cm also have various textures, most often clay. They are usually strongly to very strongly calcareous. Soil reaction varies from slightly acidic to neutral in the surface horizons and from mildly to moderately alkaline in the subsoil. Soil classification is usually Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Welland (WLL) soils in map unit NGR 3 are the most common associate of Niagara soils. Welland soils are composed of soil materials similar to Niagara soils, but differ by being poorly drained.

General Land Use Comments

(1) Wetness can be a limitation for the agricultural use of Niagara soils, and some tile drainage may be necessary; otherwise, they are good agricultural soils used for general field crops such as grain corn, soybeans, and winter wheat.

(2) Forest production on Niagara soils is fair to moderately good, being somewhat limited by factors associated with the high clay contents of many of the soils.

Normandale Soils (NDE)

Location and Extent Normandale soils are located on relatively level sand plains in the region, especially in the Waterford and Turkey Point areas. There are 182 ha of pure Normandale map units, and 2155 ha of Normandale soils in complex map units in which they are most extensively associated with St. Williams and Wauseon soils.

Landform and Topography Normandale soils are located on lacustrine sand plains having wind-modified and wind-sorted surfaces, sometimes formed into low dunes. These sands often merge into lacustrine silt deposits. The topography ranges from level to very gently sloping.

Parent Materials and Textures Normandale soils have developed on wind-modified glaciolacustrine sediments ranging from very fine sandy loam to very fine sand. Surface textures are most often loamy fine sand, very fine sand or very fine sandy loam, whereas in the subsoil, very fine sandy loam and fine sandy loam textures predominate.

Soil Moisture Characteristics Normandale soils are imperfectly drained and rapidly to moderately permeable. Groundwater levels may be near the surface during the early part of the growing season. Normandale soils have low to moderate water-holding capacities, so that the surface horizons can be droughty during summer. Surface runoff is slow to moderate depending on slopes and textures.

General Soil Description The surface Ap horizons of Normandale soils usually range between 20 and 30 cm in thickness, and textures consist, most commonly, of loamy fine sand, very fine sandy loam or very fine sand. Similar textures are found in the subsoil, but occasional layers of loamy very fine sand, fine sand and fine sandy loam also occur. Subsoil horizons have distinct or prominent mottles, usually reddish-yellow or yellowish-brown. A distinct Bt horizon is usually present just above the calcareous C horizon. The Ck horizons usually begin at depths between 50 and 110 cm, and tend to be strongly calcareous. Soil reaction in the surface and upper subsoil horizons ranges from very strongly acidic to neutral, but in the Ck horizons it is usually mildly alkaline. Soil classification is usually Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils St. Williams (SLI) and Wauseon (WUS) soils are those most often associated with Normandale soils, in map units NDE 3 and NDE 8, respectively. St. Williams soils are composed of soil materials similar to Normandale soils, but are poorly drained. Wauseon soils are also poorly drained, but have clays underlying 40 to 100 cm of sandy surface deposits.

General Land Use Comments

(1) Normandale soils are very good agricultural soils, used for common crops like grain corn and winter wheat, and special crops like tobacco, sweet corn, strawberries, lima beans and onions. Supplemental irrigation is necessary during the summer for certain special crops like tobacco.

(2) Normandale soils are very suitable for most forest tree species. Wind erosion could be a problem for seedlings.

Oakland Soils (OKL)

Location and Extent Oakland soils are found on the Norfolk sand plain where shallow sands overlie gravelly sand materials, in the northwest part of the region. There are 225 ha of pure Oakland map units, and 1959 ha of Oakland soils in complex map units where they are associated most commonly with Scotland and Vanessa soils.

Landform and Topography Oakland soils occur on relatively shallow lacustrine and eolian sands overlying gravelly, sandy Wentworth till and outwash gravels associated with the Galt and Paris moraines. The topography is level to very gently sloping.

Parent Materials and Textures Oakland soils have developed on 40 to 100 cm of nearshore, glaciolacustrine sand, modified by wind action, over Wentworth till. The texture of the surface horizons is usually fine sandy loam, sometimes grading into fine sand or loamy sand, with depth. The Wentworth Till ranges from somewhat gravelly loam to gravelly fine sandy loam.

Soil Moisture Characteristics Oakland soils are imperfectly drained and are rapidly permeable. The groundwater table is near the soil surface during the winter and early spring but recedes during the summer. Seepage along the sand-till contact, emanating from adjacent moraines, is fairly common. They have low water-holding capacity and slow surface runoff.

General Soil Description The surface layers usually consist of 20-30 cm of fine sandy loam. Underlying them is a zone, usually 30-40 cm thick, of fine sandy loam or fine sand that contains distinct or prominent strong brown to dark yellowish-brown mottles. The underlying till, which is usually very strongly calcareous, begins at 50 to 70 cm depth, and ranges in texture from loam, containing 10-20% gravel, to a gravelly fine sandy loam. Soil reaction is usually neutral in the surface horizons, and ranges from mildly to moderately alkaline in the gravelly subsoil. Soil classification is usually Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Scotland (STD) and Vanessa (VSS) soils often occur in close association with Oakland soils. Such associations occur in map units OKL 2 and OKL 3, respectively. They have developed on parent materials similar to Oakland soils, but have different drainage conditions. Scotland soils are rapidly to well-drained, and Vanessa soils are poorly drained.

General Land Use Comments

(1) Oakland soils are good agricultural soils, widely used for tobacco, grain corn and winter wheat. They are also used, to some extent, for tomatoes, peppers, and some tree fruits such as apples. Some tile drainage may be necessary for certain tree fruits. Supplemental irrigation is necessary for tobacco and certain other vegetable crops.

(2) Oakland soils, because of properties related to coarse textures, are just average to fair for commercial forest production. Reasonable yields of white pine, red pine, white ash and red oak can be expected.

Oakview Soils (OVW)

Location and Extent Oakview soils are mapped in some poorly drained depressional areas in the northern parts of the Township of Delhi and the City of Nanticoke. There are 16 ha of pure Oakview map units, and 225 ha of Oakview soils in complex map units. Kelvin soils are associated with Oakview soils northwest of Teeterville.

Landform and Topography Oakview soils are found in depresstions on the Tillsonburg moraine, Norfolk sand plain and Haldimand clay plain. The topography of these areas is depressional to nearly level.

Parent Materials and Textures Oakview soils consist of relatively shallow organic materials over silty and loamy materials. The surface organic soil is moderately to well-decomposed. The underlying mineral soil may be loamy Port Stanley Till, or deep-water glaciolacustrine loam or silt loam.

Soil Moisture Characteristics Oakview soils are very poorly drained and rapidly permeable, with the groundwater level above or near the ground surface most of the year. Oakview soils have high water-holding capacities and very slow surface runoff.

General Soil Description Oakview soils consist of 40-160 cm of dominantly humic or mesic organic soils overlying mineral soils. The mineral soils are loamy Port Stanley till, or lacustrine loam or silt loam. Soil classification is usually Terric Humisol.

Commonly Associated Soils Oakview soils, northwest of Teeterville, are sometimes associated with Kelvin (KVN) soils in map unit OVW 2. Kelvin soils differ from Oakview soils by consisting of poorly drained silty clay and silty clay loam till.

General Land Use Comments

(1) Because of their wetness and vegetative cover, most Oakview soils would require extensive draining and clearing in order to be useful for agriculture; the advisability of this is questionable.

(2) Oakview soils are of little value for commercial forestry because of their wetness.

Ontario Soils (OTI)

Location and Extent Ontario soils are restricted to a few areas in the Town of Dunnville near Lake Erie. There are 189 ha of Ontario soils in complex map units in which they are most extensively associated with Welland soils.

Landform and Topography Ontario soils occur on moraines composed of reddish Halton till. The topography ranges from level to gently sloping.

Parent Materials and Textures The original parent material of Ontario soils was reddish Halton clay till. Due to subsequent modification by wave action in glacial lakes, surface textures can be quite variable. Silt loam, sandy loam and clay loam, sometimes with significant gravel concentrations, are the surface textures most often encountered. Subsoil textures are usually clay loam or clay.

Soil Moisture Characteristics Ontario soils are moderately well-drained, and moderately to slowly permeable. Seepage spots sometimes occur on slopes in the spring and after heavy rains. Ontario soils have moderate to high water-holding capacities. Surface runoff ranges from slow on level terrain, to rapid on steeper slopes.

General Soil Description Surface Ap horizons are usually 15-20 cm thick. They have various textures ranging from clay loam, through silt loam, to gravelly sandy loam. Where these surface sands and gravels are 15-40 cm thick, coarse phase Ontario soils (OTI.C) are mapped. Subsoil textures are usually clay loam, silty clay loam, or clay. The strongly calcareous Ck horizons usually begin at around 50 cm depth. Soil reaction ranges from slightly acidic or neutral in the surface and upper subsoil, to mildly alkaline in the C horizons. Soil classification is usually Orthic Gray Brown Luvisol.

Commonly Associated Soils Welland soils are the most significant associates of Ontario soils in the region. They are composed of similar materials but are poorly drained. This soil association occurs in map unit OTI 3.

General Land Use Comments

(1) Ontario soils are considered as good agricultural soils, although erosion is a limitation on most slopes. Winter wheat, forage crops, spring grains, and corn are the most common agricultural crops grown on Ontario soils.

(2) Ontario soils are considered to have only fair to mediocre potential for production of most major tree species.

Plainfield Soils (PFD)

Location and Extent Plainfield soils are among the most widespread soils in the Haldimand-Norfolk Region. They are found throughout the Norfolk sand plain, and on the sand plain east of Dunnville. There are 14204 ha of pure Plainfield map units, and 16264 ha of Plainfield soils in complex map units, in which their most extensive association is with the Walsingham soils.

Landform and Topography Plainfield soils occur on wind-worked sands, expressed by a variety of landforms, ranging from level plains to large dunes. The dunes range from less than one m to tens of metres in height. Dune phase Plainfield soils (PFD.D), which are mapped on these landforms, are most extensive in the Township of Norfolk, and southeast of Delhi.

Parent Materials and Textures Plainfield soils have developed on a metre or more of wind-blown eolian sands. Textures are predominantly fine sand throughout, although loamy fine sand and sand occur fairly often in the surface A horizons, and loamy fine sand may occur in the lower B horizons.

Soil Moisture Characteristics Plainfield soils are rapidly to well-drained and rapidly permeable. They have low water-holding capacities and, consequently, droughtiness limitations for plant growth are normal. Surface runoff is slow on level to very gently sloping Plainfield terrain, but increases as slopes become steeper.

General Soil Description The surface horizons of Plainfield soils usually range from 15-30 cm in thickness. They are dominantly composed of fine sand, although loamy fine sand and sand textures also occur. The mean organic matter content of the surface horizons is low, being slightly less than 2%. The A and B horizons that underlie the surface horizons also have dominantly fine sand textures, although loamy fine sand may occur in the lower B horizons. The Ck horizons, which usually begin at the 100-105 cm depth, have fine sand textures, and are usually moderately or strongly calcareous. The soil reaction of Plainfield soils is relatively acidic, usually medium to slightly acid in the surface and upper subsoil, and neutral to mildly alkaline in the lower subsoil. The properties of dune phase Plainfield soils (PFD.D) are very similar to normal Plainfield soils, except for a slightly higher propertion of fine sand in all horizons. Soil classification is usually Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Walsingham (WAM) soils are most frequently associated with Plainfield soils in map unit PFD 3. They are composed of similar soil materials, but differ by being imperfectly drained. Dune phase Plainfield (PFD.D) soils are associated with Walsingham soils in map unit PFD 24. They also are extensively associated with normal Plainfield soils in map unit PFD 23.

General Land Use Comments

(1) Plainfield soils have droughtiness limitations for most crops, but are extensively used for tobacco, with the help of supplemental sprinkler irrigation. Asparagus, peanuts and some other horticultural crops are also feasible on Plainfield soils, usually with supplementary irrigation.

(2) Growth of most forest tree species is limited by the low nutrient and moisture status of the Plainfield soils, except for black walnut and beech which seem to do reasonably well on some level sand plains.

Figure 35. Tobacco is the most common crop on Plainfield soils

Figure 36. Typical soil tongue in a Plainfield dune phase soil

Scotland Soils (STD)

Location and Extent Scotland soils occur in the western part of the region, where shallow sands of the Norfolk sand plain overlie gravelly sand materials. There are 2479 ha of pure Scotland map units, and 3315 ha of Scotland soils in complex map units in which they are often associated with Oakland, Wilsonville or Fox soils.

Landform and Topography Scotland soils are found on relatively shallow lacustrine and eolian sands that overlie gravelly, sandy Wentworth till or outwash gravels. They are mostly located on the Galt and Paris moraines. The topography ranges from level to moderately sloping.

Parent Materials and Textures Scotland soils have developed on 40-100 cm of wind-modified lacustrine sand, over gravelly Wentworth till or outwash gravels. Textures of the cap sands range from fine sandy loam to sand. Gravel contents of the underlying sandy till or outwash usually increase with depth, and exceed 20% in the C horizon parent material.

Soil Moisture Characteristics Scotland soils are rapidly to well-drained and rapidly permeable. Wet spots occasionally occur on slopes where groundwater discharges. They have low water-holding capacities and slow surface runoff, except on slopes greater than 5% where runoff may be moderate.

General Soil Description The surface Ap horizons of Scotland soils usually range from 15-30 cm thick, with textures of fine sandy loam, loamy sand, loamy fine sand, fine sand or sand. Up to 8% of gravel may also be present. Similar textures and gravel proportions occur in the underlying A and B horizons, to a depth of 40-80 cm where the gravel contact usually begins. The brown, wavy Bt horizon occurs at or near the gravel contact. The calcareous Ck horizon underlies the Bt horizon at depths that usually range between 55 and 90 cm. Textures of the Bt and C horizons range from loam to coarse sand, usually with 10-35% of gravel. C horizons are usually strongly or very strongly calcareous. Soil reaction ranges from strongly acidic to neutral in the surface horizons, to mildly alkaline in the subsoil. Soil classification is usually Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Oakland (OKL), Wilsonville (WIL) and Fox (FOX) soils are often associates of Scotland soils in map units STD 2, STD 4 and STD 6, respectively. Oakland soils have similar textures, but are imperfectly drained. Wilsonville and Fox soils are both rapidly to well-drained, like Scotland soils, but Wilsonville soils have less than 40 cm of sands over gravels, and Fox soils are developed in deep loamy sands or sands.

General Land Use Comments

(1) Scotland soils are valuable agricultural soils. They usually tend to be droughty, which poses limitations for some general field crops. With supplemental irrigation they are good tobacco soils. Asparagus, apples, cherries, peppers, potatoes and ginseng are being commercially grown on Scotland soils at the present time.

(2) Forest productivity is average for most species, but limited by the coarse textures and droughtiness.

Figure 37. Vegetable crops, such as peppers, are replacing tobacco on some Scotland soils

Seneca Soils (SNA)

Location and Extent Almost all Seneca soils are found in the northern part of the Town of Haldimand, north of an imaginary line joining Hagersville and Cayuga. There are 881 ha of pure Seneca map units, and 495 ha of Seneca soils in complex map units in which they are sometimes associated with Haldimand or Brantford soils. Some very shallow Seneca soils are commonly associated with Farmington soils.

Landform and Topography Seneca soils are mostly found on the exposed parts of drumlins, surrounded by lacustrine clays of the Haldimand clay plain. Sometimes they are also found on eroded remnants of drumlins associated with the limestone plain, near Hagersville. The topography ranges from nearly level on the tops of some drumlins, to steep slopes of 16-30%, on the sides of drumlins.

Parent Materials and Textures Seneca soils have developed on loam till that usually has somewhat siltier surficial materials. Surface textures are silt loam or loam, with a small percent of gravel. The texture of the materials underlying the surface is usually clay loam, from enrichment of clay by weathering. Finally, underlying this clay-enriched zone, the till has loam textures and contents of gravel that usually range between 16 and 30%.

Soil Moisture Characteristics Seneca soils are well-drained and moderately to rapidly permeable. Wet, groundwater seepage spots are sometimes present on steeper slopes after periods of heavy rain. Seneca soils have medium water-holding capacities. Surface runoff is slow to rapid, depending on slope.

General Soil Description The surface Ap horizons of Seneca soils usually consist of 15 cm of silt loam or loam, with minor amounts of gravel. East of Hagersville, there are a few hectares of sandy phase Seneca soils (SNA.C) with 15-40 cm of sandy-textured soils over loam till. On relatively level areas there may be a thin, light brown horizon of loam or silt loam underlying the surface and overlying the brown Bt horizons. The clay loam Bt horizons are wavy and tongue into the underlying Ck horizons. On the limestone plain near Hagersville, shallow phase (SNA.S) and very shallow phase (SNA.V) Seneca soils are mapped, with respective soil depths of 50-100 cm and 20-50 cm over bedrock. In many of these shallow soils over bedrock, the calcareous C horizon is absent. Loam textures predominate in Ck horizons, and the gravel content ranges from 16-30%. Ck horizons can be strongly, very strongly or extremely calcareous. Soil reaction is relatively alkaline, ranging from neutral in the surface soils to mildly alkaline in the subsoil. Soil classification is usually Orthic Gray Brown Luvisol.

Commonly Associated Soils The most common associates of Seneca soils are Haldimand (HIM) and Brantford (BFO) soils, which are components of map units SNA 6 and SNA 5, respectively. Haldimand soils differ from Seneca soils by being imperfectly drained and by having developed on lacustrine heavy clays. Brantford soils are developed on lacustrine silty clay loams and silty clays. Farmington soils, which are very shallow over bedrock and have various textures, are often associated with very shallow phase Seneca soils (SNA.V) in map unit SNA 13.

General Land Use Comments

(1) Seneca soils are good agricultural soils, well suited to common field crops such as grain corn, small grains and forages. Careful conservation management practices are necessary on slopes, where erosion can be severe.

(2) Forest productivity is high for most tree species, provided that erosion can be reduced or prevented on slopes.

Silver Hill Soils (SIH)

Location and Extent Silver Hill soils occur in the Langton-Walsh area, Waterford area, and east of Dunnville. There are 533 ha of pure Silver Hill map units, and 3808 ha of Silver Hill soils in complex map units where they are often associated with Vittoria and Walsingham soils.

Landform and Topography Silver Hill soils occupy level areas of shallow lacustrine and eolian sands over lacustrine silts on the Haldimand clay plain, and on smaller lacustrine plains in the Langton-Walsh and Dunnville areas. The topography is usually level, with slopes of 0.5-1.5%.

Parent Materials and Textures Silver Hill soils have developed on 40-100 cm of fine sandy loam or loamy fine sand lacustrine and eolian deposits over silt loam or very fine sandy loam lacustrine sediments.

Soil Moisture Characteristics Silver Hill soils are poorly drained. They are rapidly to moderately permeable through the upper sandy materials down to the sand-silt contact, where a weak hardpan often exists. The underlying silty materials are slowly permeable. Groundwater usually sits above this contact and saturates the soil until late spring or summer. Silver Hill soils have relatively high water-holding capacities and slow surface runoff.

General Soil Description The surface horizons of Silver Hill soils are usually about 20 cm thick, with fine sandy loam or loamy fine sand textures. The fine sandy loam, loamy sand, loamy fine sand or fine sand textures in the subsoil usually extend to 60-100 cm depth. Prominent strong brown or yellowish-brown mottles usually occur in the lower part of this sandy zone, and in the underlying stratified lacustrine materials. A weak hardpan or fragipan frequently occurs at this contact. These stratified deposits, that usually begin at 60-120 cm depth, have loam, silt loam or very fine sandy loam textures, and are strongly or very strongly calcareous. Soil reaction usually ranges from slightly acidic to mildly alkaline in the surface horizons, and is mildly alkaline in the subsoil. Soil classification is usually Orthic Luvic Gleysol.

Commonly Associated Soils The soils most commonly associated with Silver Hill soils are Vittoria (VIT) and Walsingham (WAM) soils, found in map units SIH 3 and SIH 5. Vittoria soils have textures similar to Silver Hill soils but are imperfectly drained. Walsingham soils are also imperfectly drained, but consist primarily of fine sand.

General Land Use Comments

(1) Silver Hill soils are good agricultural soils if drainage is artificially improved. Good crops of grain corn, winter wheat, tobacco, tomatoes and other vegetable crops are produced where drainage has been improved.

(2) Wetness is the main limiting factor for forest productivity.

Smithville Soils (SHV)

Location and Extent Smithville soils have a fairly wide distribution over the eastern part of the region, on the Haldimand clay plain. There are 3763 ha of pure Smithville map units, and 14381 ha of Smithville soils in complex map units in which they are often associated with Haldimand or Lincoln soils.

Landform and Topography Smithville soils occur on dissected, sometimes hummocky, deposits of lacustrine clay on the Haldimand clay plain. The topography ranges from very gently to strongly sloping, with slopes frequently short or hummocky. Slopes are usually between 3 and 6%.

Parent Materials and Textures Smithville soils have developed on deep-water, glaciolacustrine clays. Surface textures are usually silty clay or silty clay loam, although thin, loamy or sandy surfaces are present in some areas. Subsoil textures are usually heavy clay, with occasional layers of silty clay or clay.

Soil Moisture Characteristics Smithville soils are moderately well-drained. Surface horizons are slowly to moderately permeable, depending on the incidence of soil cracks, but subsoil horizons are usually slowly permeable. Groundwater sometimes remains in the upper subsoil horizons for short periods during the growing season. Smithville soils have medium to high water-holding capacities, but are often droughty during dry periods because of slow water release by the clays. Surface runoff is usually rapid.

General Soil Description Most surface horizons of Smithville soils consist of 10-20 cm of silty clay or silty clay loam. There are also some coarse phase Smithville (SHV.C) and loamy phase Smithville (SHV.L) soils, with 15-40 cm of surface fine sandy loam or loam. The subsurface B horizons of Smithville soils usually consist of heavy clay, having angular blocky or prismatic structures, and extending to depths ranging between 35 and 55 cm. In the areas between Hagersville and Cayuga, there are shallow phase (SHV.S) and very shallow phase (SHV.V) Smithville soils. The Ck horizons, which are usually strongly calcareous, begin at the 35-55 cm depth. They usually have heavy clay, or occasionally silty clay textures, and weak prismatic structures. Soil reaction ranges from strongly acidic to neutral in the surface horizons, and is mildly or moderately alkaline in the subsoil. Soil classification is usually Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Haldimand (HIM) and Lincoln (LIC) soils are most often associated with Smithville soils, in map units SHV 4 and SHV 5, respectively. They have similar parent materials but differ in drainage, because the Haldimand soils are imperfectly drained and the Lincoln soils are poorly drained.

General Land Use Comments

(1) Smithville soils are fairly good agricultural soils, but somewhat limited for use by their high clay contents. Some drainage improvement may be necessary on more level terrain; on slopes above 3-4%, erosion can be a problem. Grain corn, winter wheat, soybeans, sweet corn, and labrusca grapes are being commercially grown on Smithville soils.

(2) Mainly because of the high clay contents and associated soil structure problems, Smithville soils are rated fairly low for forest productivity.

St. Williams Soils (SLI)

Location and Extent St. Williams soils occupy depressional to level areas within the Norfolk sand plain, mostly near Lake Erie, in the Townships of Delhi and Norfolk. There are 342 ha of pure St. Williams map units, and 2220 ha of St. Williams soils in complex map units in which they are most often associated with Normandale and Wauseon soils.

Landform and Topography St. Williams soils are located on lacustrine sand plains that have surface materials which have been modified by wind action. These sand plains are often adjacent to, and merge into, lacustrine silt deposits. The topography is level, with slopes usually between 0.5 and 1.5%.

Parent Materials and Textures St. Williams soils have developed on fine sandy sediments. Surface textures are usually fine sandy loam, with subsoil textures of loamy fine sand to very fine sandy loam.

Soil Moisture Characteristics St. Williams soils are poorly drained, and rapidly to moderately permeable. Their surface runoff is slow. Groundwater is usually near the surface, except in summer when it may drop to 100 cm or lower. St. Williams soils have low to moderate water-holding capacities.

General Soil Description The surface horizons of St. Williams soils have a mean thickness of about 25 cm, and textures usually consisting of fine sandy loam. In the subsoil, loamy fine sand and very fine sandy loam textures predominate. Gley colors and prominent, strong brown mottles also commonly occur. The strongly calcareous Ck horizons usually begin at depths ranging from 30-80 cm. Soil reaction usually ranges from medium acidic to neutral in the surface horizons, and is mildly or moderately alkaline in the subsoil. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils Normandale soils (NDE) are fairly common associates of St. Williams soils, and are a component of map unit SLI 3. They have similar textures to St. Williams soils but are imperfectly drained. Wauseon soils (WUS), which also occur with St. Williams soils in map unit WUS 9, are poorly drained and contain 40-100 cm of sands over clays.

General Land Use Comments

(1) St. Williams soils can be good agricultural soils if artifically drained. Crops such as grain corn, sweet corn, tomatoes, cucumbers and peppers are feasible when drainage is improved.

(2) Although wetness is a limitation for many forest species, some species such as white pine, red pine, red oak and basswood are quite productive on St. Williams soils.

Styx Soils (SYX)

Location and Extent Most of the Styx soils are located on the till moraines in the northern part of the Township of Delhi. There are also a few occurrences in the Waterford area. There are only 29 ha of pure Styx map units, and 93 ha of Styx soils in complex map units associated with Muriel soils on the Tillsonburg moraine.

Landform and Topography Styx soils are located in poorly drained, enclosed depressions on the Tillsonburg, Galt and Paris moraines. Although the basin topography is level, the surrounding moraine topography is often moderately to steeply sloping.

Parent Materials and Textures Styx soils are deep organic soils consisting of more than 160 cm of organic material. The surface organic layer is well to moderately decomposed, whereas deeper layers are often fibric and less decomposed.

Soil Moisture Characteristics Styx soils are very poorly drained. They are rapidly permeable, but groundwater is close to, or above the surface, most of the year. They have high water-holding capacities and very slow surface runoff.

General Soil Description Styx soils are organic soils whose surface layers usually consist of about 40 cm of mesic or humic materials. Underlying these horizons, to a depth not exceeding 160 cm, organic textures are usually similar, but sometimes become less decomposed with depth. Soil classification is usually Typic Humisol.

Commonly Associated Soils Steeply sloping Muriel soils (MUI) are associated with, and enclose some of the swamps containing Styx soils in the Tillsonburg moraine. They are found on the soil map in map unit SYX 2.

General Land Use Comments

(1) Styx soils are useful for vegetable crops if cleared and drained, but the advisability of this, from an environmental standpoint, is questionable.

(2) Mainly because of the high watertables, Styx soils are of little value for commercial forestry.

Tavistock Soils (TVK)

Location and Extent Tavistock soils are mostly found in the Waterford and Port Dover areas. There are 363 ha of pure Tavistock map units, and 2468 ha of Tavistock soils in complex map units which are often associated with loamy phase Brantford and Brantford soils.

Landform and Topography Tavistock soils occupy areas of lacustrine clay plains where silt loam was deposited over the clays. The topography ranges from level to very gently sloping.

Parent Materials and Textures Tavistock soils are developed on 40-100 cm of deep-water glaciolacustrine silt loam to very fine sandy loam that usually overlies silty clay or silty clay loam.

Soil Moisture Characteristics Tavistock soils are imperfectly drained and moderately to slowly permeable. Groundwater temporarily saturates portions of the overlying silts, especially just above the clay contact, for short periods of time during the spring growing season. Although Tavistock soils have high water-holding capacities, surface runoff ranges from moderate to high depending on the slope.

General Soil Description The surface Ap horizons of Tavistock soils are usually about 20 cm thick, and consist of silt loam, loam or very fine sandy loam. Similar textures occur in the upper subsoil down to the clay contact. Distinct or prominent yellowish-brown mottles are present in this zone. A weak, compacted hardpan may also occur at the silt-clay contact. The moderately to very strongly calcareous Ck horizon, which usually begins in the clay zone, is usually silty clay loam or silty clay. Soil reaction usually ranges from strongly acidic to neutral in the surface horizons, and mildly or moderately alkaline in the deeper subsoil. Soil classification is usually Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Brantford soils (BFO) and loamy phase Brantford (BFO.L) soils are often associated with Tavistock soils. Both soils differ from Tavistock soils by being moderately well-drained. Both also have shallwer deposits of loamy soils over lacustrine clays than Tavistock soils. Loamy phase Brantford soils have 15-40 cm of loamy materials over clay, whereas Brantford soils may have loamy surfaces no thicker than 15 cm. Brantford and Tavistock soils are mapped together in map unit TVK 3; loamy phase Brantford soils and Tavistock soils occur together in map unit TVK 5.

General Land Use Comments

(1) Tavistock soils are very good agricultural soils, suitable for a wide range of field and horticultural crops. They may require some artificial drainage, especially if subsoils become compacted by heavy machinery.

(2) Tavistock soils are somewhat better than average for forest productivity, especially for European larch, white oak and tulip tree.

Figure 38. Tavistock soils occupy the level upland plain above the eroded Lake Erie shoreline near Normandale

Toledo Soils (TLD)

Location and Extent Toledo soils are mapped over all but the western portion of the region that is occupied by sand plains and till moraines. There are 4480 ha of pure Toledo map units, and 19458 ha of Toledo soils in complex map units where they are often associated with Brantford and Beverly soils.

Landform and Topography Toledo soils occur on poorly drained portions of the lacustrine clay plains that occupy most of the central and eastern part of the region. The topography ranges from level to very gently sloping.

Parent Materials and Textures Toledo soils have developed on medium to deep-water, glaciolacustrine clay deposits. Surface textures are usually silty clay loam or silty clay, but thin layers of fine sandy loam, silt loam or clay loam are not uncommon. Subsoil textures are usually silty clay loam or silty clay.

Soil Moisture Characteristics Toledo soils are poorly drained, except for peaty phase Toledo soils which are very poorly drained. Toledo soils are moderately to slowly permeable, depending on surface textures, incidence of soil cracks and subsoil compaction. Groundwater levels are near the surface much of the year except during the summer when they subside somewhat. Toledo soils have relatively high water-holding capacities. Surface runoff is usually moderate, but increases on slopes.

General Soil Description The surface Ap horizons of Toledo soils are usually composed of 15-20 cm of silty clay loam or silty clay or, less often, of silt loam, clay loam or fine sandy loam. Coarse phase Toledo soils (TLD.C), which often occur adjacent to sand plains, have surfaces consisting of 15-40 cm of fine sandy loam. In the Dunnville area, there are some peaty phase Toledo soils (TDL.P). Subsoil textures of Toledo soils are usually silty clay, occasionally silty clay loam or clay. Distinct and prominent yellowish-red to yellowish-brown mottles characterize the subsoil horizons. In cultivated soils, subsoil horizons are frequently overcompacted. Shallow phase Toledo soils (TLD.S) and very shallow phase Toledo soils (TLD.V) occur on the limestone plain in the vicinity of Hagersville. The depth to the C horizon usually ranges between 45 and 75 cm. Ck horizons are usually strongly or very strongly calcareous. Soil reaction usually ranges from strongly acidic to neutral in the surface horizons, and from mildly to moderately alkaline in the Ck horizons. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils Brantford (BFO) and Beverly (BVY) soils in map units TLD 6 and TLD 7 are the most common associates of Toledo soils. They have textures similar to Toledo soils, but Brantford soils are moderately well-drained, and Beverly soils are imperfectly drained. Coarse phase Toledo soils (TLD.C) are commonly associated with coarse phase Beverly soils (BVY.C) in map unit TLD 18.

General Land Use Comments

(1) Because of their poor drainage, Toledo soils require artificial drainage for maximum agricultural benefits. Grain corn, soybeans and spring grain are grown extensively on drained Toledo soils.

(2) In spite of the wetness limitation, Toledo soils provide good production of several forest species, including Norway spruce, white ash and white oak.

Tuscola Soils (TUC)

Location and Extent Tuscola soils are located on areas transitional between sand and clay plains in the region. Such areas are in the vicinities of Waterford, Langton, Walsh and Dunnville. There are 423 ha of pure Tuscola map units, and 3497 ha of Tuscola soils in complex map units in which they are most often associated with Brant and Colwood soils.

Landform and Topography Tuscola soils occur on plains of relatively deep-water, glaciolacustrine, loamy sediments. Some terrain dissection occurs near stream valleys. The topography ranges from level to very gently sloping.

Parent Materials and Textures Tuscola soils have developed on loamy, often stratified, lacustrine sediments. Surface textures may be loam, silt loam or very fine sandy loam, and occasionally sand. Silt loam textures prevail in the subsoil, except in Bt horizons, that may be composed of silty clay loam.

Soil Moisture Characteristics Tuscola soils are imperfectly drained. The surface horizons are usually moderately permeable, but subsoil horizons may be slowly permeable if they have been overcompacted by heavy machinery. Tuscola soils have temporarily high watertables that usually recede sufficiently during the growing season to minimize interference with plant growth. Tuscola soils have high water-holding capacities, and moderate to high surface runoff depending on slope.

General Soil Description The surface horizons of Tuscola soils usually range from 15-25 cm in thickness and consist of silt loam, loam or very fine sandy loam. In the western part of the region, there are a number of areas of coarse phase Tuscola soils (TUC.C). The subsoil horizons of Tuscola soils have textures similar to the surface horizons, except for increased clay in the lower B horizons. There are a few areas of shallow and very shallow phase Tuscola soils (TUC.S, TUC.V), mostly in the vicinity of Hagersville. Distinct or prominent, dark yellowish-brown mottles occur in the subsoil. The depth to the calcareous C horizons is quite variable because of the wavy, tongueing nature of the overlying Bt horizons, ranging from 25 to more than 100 cm. The Ck horizons are strongly to very strongly calcareous. Soil reaction varies from strongly acidic to mildly alkaline in the surface horizons, and mildly to moderately alkaline in the deeper subsoil. Soil classification is usually Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Brant (BRT) and Colwood (CWO) soils, which are the most common associates of Tuscola soils, have similar textures, but differ by being moderately well-drained and poorly drained, respectively. They are associated with Tuscola soils in map units TUC 3 and TUC 4. Coarse phase Tuscola soils (TUC.C) are sometimes associated with coarse phase Colwood soils (CWO.C) in map unit TUC 15.

General Land Use Comments

(1) Tuscola soils are very good agricultural soils for most field and horticultural crops, although tile drainage may be necessary to improve some wet spots. Corn, soybeans, winter wheat, spring grains, tomatoes, cucumbers, peppers, cabbages and strawberries are being commercially grown on these soils.

(2) Tuscola soils are excellent soils for forest productivity for most forest species, and have virtually no limitations.

Vanessa Soils (VSS)

Location and Extent Vanessa soils are found in the northwest part of the region on low areas of shallow sand overlying gravelly sands. There are 322 ha of pure Vanessa map units, and 827 ha of Vanessa soils in complex map units, most often associated with Oakland soils.

Landform and Topography Vanessa soils occur in poorly drained depressions on the Galt and Paris moraines, where shallow lacustrine and eolian sands overlie gravelly Wentworth Till. The topography of the depressions is nearly level, and slopes are usually less than 1.5%.

Parent Materials and Textures Vanessa soils have developed on 40-100 cm of nearshore lacustrine sand modified by wind action, over Wentworth till. The texture of the surface horizons is usually fine sandy loam, sometimes grading into fine sand or loamy sand with depth. The Wentworth till in this area ranges from somewhat gravelly loam to a gravelly fine sandy loam.

Soil Moisture Characteristics Vanessa soils are poorly drained. Peaty phase Vanessa soils are very poorly drained. They both are rapidly permeable. Groundwater levels are at or near the surface most of the year, receding somewhat in the summer. Vanessa soils have low water-holding capacities and low surface runoff.

General Soil Description The surface horizons of Vanessa soils usually consist of 20-30 cm of fine sandy loam. Exceptions to this are some peaty phase Vanessa soils (VSS.P), that have 15-40 cm of organic soils comprising the surface horizon. Underlying the surface is a zone of variable thickness, usually between 30 and 60 cm thick, of mainly fine sandy loam, or fine sand. Distinct or prominent, strong brown to dark yellowish-brown mottles occur in this zone and in the underlying till. The C horizon usually begins near the sand-gravel contact, and is strongly to very strongly calcareous. Textures of the grvelly till range from loam with 10-20% gravel, to gravelly fine sandy loam. Soil reaction is usually neutral in the surface horizons, ranging to mildly or moderately alkaline in the gravelly subsoil. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils Oakland (OKL) soils are often associated with Vanessa soils in map unit VSS 3. They have similar textures but differ from Vanessa soils by being imperfectly drained.

General Land Use Comments

(1) Vanessa soils require artificial drainage before they can be used feasibly for agricultural crops. Drained Vanessa soils are used for grain corn and spring grains, and to a lesser extent for tobacco and certain vegetable crops.

(2) Mainly because of their wetness, Vanessa soils are of little value for forest production.

Vittoria Soils (VIT)

Location and Extent Vittoria soils occur in the western part of the region, where shallow sands overlie loamy lacustrine sediments, mainly in the Langton, Waterford and Vittoria areas. There are 422 ha of pure Vittoria map units, and 4391 ha of Vittoria soils in complex map units in which they are most extensively associated with Walsher and Silver Hill soils.

Landform and Topography Vittoria soils occupy lacustrine plains, composed of shallow wind-modified sands over silts. The topography ranges from level to very gently sloping.

Parent Materials and Textures Vittoria soils have developed on 40-100 cm of fine sand to fine sandy loam lacustrine and eolian deposits, over lacustrine silt loam containing occasional layers of very fine sandy loam or silty clay loam.

Soil Moisture Characteristics Vittoria soils are imperfectly drained. They are usually rapidly permeable through the upper sandy materials, but slowly permeable through the underlying loamy materials that are often capped by a weak hardpan. Groundwater remains temporarily above this contact zone, sometimes into the growing season. Vittoria soils have relatively high water-holding capacities and slow surface runoff.

General Soil Description The depth of surface Ap horizons in Vittoria soils is usually 20-25 cm. The textures of the surface and upper subsoil horizons of the sandy overlay materials are dominantly loamy sand, fine sand, fine sandy loam and loamy fine sand. Distinct or prominent strong brown to yellowish-brown mottles may occur in this sandy overlay, and in the underlying loamy materials. These loamy materials, which begin at the 40-100 cm depth, usually have silt loam textures, but silty clay loam and very fine sandy loam layers are not uncommon. The surface of the loamy materials is often semicemented. The C horizon usually commences near the sand-silt contact, and is generally strongly or very strongly calcareous. Soil reaction ranges widely in the surface horizons, from very strongly acidic to mildly alkaline. In the lower subsoil horizons, soil reaction is usually mildly or moderately alkaline. Soil classification is usually Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Walsher (WSH) and Silver Hill (SIH) soils are often associated with Vittoria soils; they have similar textures, but differ by being well and poorly drained, respectively. Walsher soils are associated with Vittoria soils in map unit VIT 2; with Silver Hill soils in map unit VIT 3.

General Land Use Comments

(1) Vittoria soils are good agricultural soils. Some tile drainage may be necessary for certain crops, and supplemental irrigation will be needed for high-value crops like tobacco. Grain corn, sweet corn, tomatoes, apples, strawberries and some other vegetable crops are grown commercially on these soils, at the present time.

(2) Aside from minor limitations, related to the nutrient supply and erodibility of surface sands, Vittoria soils are eminently suitable for most commercial tree species.

Walsher Soils (WSH)

Location and Extent Walsher soils are mapped in the western part of the region, where shallow sands overlie loamy lacustrine sediments, mainly in the Langton, Waterford, and Walsh areas. There are 1154 ha of pure Walsher map units, and 3322 ha of Walsher soils in complex map units where they are most often associated with Vittoria soils.

Landform and Topography Walsher soils occupy loamy, lacustrine plains over which have been deposited shallow lacustrine sands, that have usually been modified by wind action. The topography ranges from nearly level to strongly sloping, but most slopes are in the 2-5% range.

Parent Materials and Textures Walsher soils have developed on 40-100 cm of sandy lacustrine and eolian deposits overlying loamy, lacustrine sediments. The texture of the sandy surface materials is dominantly loamy fine sand. The underlying loamy sediments usually have textures of silt loam or loam, with occasional layers of loamy very fine sand.

Soil Moisture Characteristics Walsher soils are well-drained. They are usually rapidly permeable through the upper sandy materials, then slowly permeable through the underlying loamy sediments, which are, in places, capped by a relatively impermeable, compacted layer. Groundwater may be above this layer for brief time periods, usually not long enough to adversely affect plant growth. Walsher soils have relatively high water-holding capacities, and surface runoff ranging from slow on level areas to relatively rapid on steeper slopes.

General Soil Description The surface Ap horizons of Walsher soils usually range between 15 and 25 cm in thickness. Textures are dominantly loamy fine sand, sometimes fine sand or fine sandy loam, and these textures persist to the 50-100 cm depth, where loamy sediments begin. These loamy sediments consist of silt loam or loam, with occasional layers of loamy very fine sand or very fine sandy loam. Sometimes the upper part of these loamy sediments is quite compact, almost semicemented. The C horizon is usually strongly or very strongly calcareous. Soil reaction of the sandy surface and upper subsoil ranges between strongly acidic and neutral, and in the lower loamy subsoil it ranges from neutral to moderately alkaline. Soil classification is usually Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Vittoria (VIT) soils, the most common associate of Walsher soils, have similar textures but differ by being imperfectly drained. These two soils are the components of map unit WSH 2.

General Land Use Comments

(1) Walsher soils are highly valued for most field crops, and for many horticultural crops. The surface sands can be droughty during dry summers when supplemental irrigation is necessary for high-value crops like tobacco. Apples, peaches, asparagus, carrots, sour cherries and strawberries are grown commercially on Walsher soils.

(2) Forest productivity is about average for most tree species on Walsher soils, mainly because of droughtiness and nutrient limitations of the sands.

Walsingham Soils (WAM)

Location and Extent Walsingham soils are fairly widespread in the Haldimand-Norfolk Region, occurring on level areas of the main Norfolk sand plain, and on the sand plain east of Dunnville. There are 2522 ha of pure Walsingham map units and 27673 ha of Walsingham soils in complex map units in which they are commonly associated with Plainfield, Waterin and Granby soils.

Landform and Topography Walsingham soils occur on wind-sorted, fine sands where the topography is subdued. Lacustrine clays and silts are not uncommon at depths below 1 m, and account for temporarily high watertables in the sands. Surface topography ranges from level to very gently sloping, sometimes with small dunes up to 50 cm in height.

Parent Materials and Textures Walsingham soils have developed on 1 m or more of wind-sorted sands. Textures are usually fine sand, except in the surface and lower B horizons where loamy fine sand sometimes occurs.

Soil Moisture Characteristics Walsingham soils are imperfectly drained. They are rapidly permeable, but drainage is imperfect because watertable levels are temporarily near the ground surface during the winter and spring of each year. This water table is usually perched on relatively impermeable silty or clayey layers that occur at depths below 1 m. Watertable levels decline during the summer, sometimes to the extent that the surface sands can become droughty. Walsingham soils have low water-holding capacities, and surface runoff is generally slow.

General Soil Description The thickness of the surface Ap horizons ranges between 15 and 30 cm. Textures are usually fine sand, although loamy fine sand does occur. Similar textures prevail in the subsoil horizons. Distinct or prominent, yellowish-red to yellowish-brown mottles are a common occurrence in the lower subsoil. C horizons are deep, usually commencing between 70 and 130 cm, and moderately or strongly calcareous. Soil reaction ranges from strongly acidic to neutral in the surface horizons, and tends to be mildly alkaline in the C horizon. Soil classification is Gleyed Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Plainfield (PFD) and Waterin (WRN) soils have similar textures, but differ by being, respectively, rapid to well-drained and poorly drained. They are mapped with Walsingham soils in map units WAM 2 and WAM 3. Granby (GNY) soils, which are associated in map unit WAM 6, have loamy sand and sand textures, and are poorly drained.

General Land Use Comments

(1) Walsingham soils are extensively used for flue-cured tobacco in the region. Their main limitation is the wet subsoil and cool soil temperatures during the early growing season. Field crops, such as winter wheat or rye, do reasonably well on Walsingham soils, but crops such as grain corn can suffer from summer droughtiness. Most horticultural crops would probably require some supplemental irrigation to overcome this summer moisture limitation.

(2) Forest productivity is good for most tree species on Walsingham soils. Minor nutrient and droughtiness problems are the only limitations.

Waterin Soils (WRN)

Location and Extent Waterin soils occur on some poorly drained and swampy areas of the western part of the Norfolk sand plain, and on the sand plain east of Dunnville. There are 1687 ha of pure map units, and 11089 ha of Waterin soils in complex map units. Walsingham soils are the soils most extensively associated with Waterin soils.

Landform and Topography Waterin soils occur on low, poorly drained portions of lacustrine sand plains that have been extensively reworked and sorted by wind action. The surface topography of these areas is almost invariably level, and slopes are rarely greater than 1%.

Parent Materials and Textures Waterin soils have developed on wind-sorted sand more than 1 m thick. The surface horizons of Waterin soils contain high organic matter contents, and sometimes up to 40 cm of organic soil has developed above the mineral soil. The texture of the surface mineral soil is usually loamy fine sand. Textures of the underlying subsoil are usually fine sand, and occasionally loamy fine sand.

Soil Moisture Characteristics Most Waterin soils are poorly drained, although some peaty phase Waterin soils (WRN.P) are very poorly drained. The poor drainage derives from groundwater levels being above, or close to, the soil surface for long periods. The high watertables are usually due to the presence of lacustrine silts and clays at depths greater than 1 m. Waterin soils are rapidly to moderately permeable, with moderate to high water-holding capacities in the organic-rich surface layers, then low capacities in the subsoil. Surface runoff is slow.

General Soil Description Surface Ah horizons range from 10-30 cm, whereas Ap horizons are 20-35 cm thick. Organic matter contents are high, usually between 3 and 8%. Organic soil has accumulated in some very poorly drained sites, to a depth of 15-40 cm, over sands, forming peaty phase Waterin soils (WRN.P). Textures of the surface mineral soils are dominantly loamy fine sand or occasionally fine sand, whereas subsoil horizons are fine sand. Gleyed gray colors are a feature of Waterin subsoils, usually with some prominent strong brown to brownish-yellow mottles. Most Ck horizons are strongly calcareous, have mildly alkaline reactions, and occur at depths of 40-120 cm. Soil reaction is extremely acidic in some surface Ah horizons but usually ranges between strongly acidic and neutral in the Ap and subsoil Bg horizons. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils Walsingham (WAM) soils, which are often closely associated with Waterin soils in map unit WRN 3, have similar textures, but are imperfectly drained.

General Land Use Comments

(1) Waterin soils require artificial drainage before they can be used productively for agriculture. Tobacco, grain corn, soybeans and some vegetable crops are grown commercially on drained Waterin soils.

(2) Excessive wetness limits productivity of many tree species, although white pine, white spruce, Norway spruce and black cherry seem to be well suited to Waterin soils.

Figure 39. Swampy areas like this are typical of most undrained Waterin soils

Wattford Soils (WAT)

Location and Extent Wattford soils are most prevalent on the Norfolk sand plain in the Waterford, Turkey Point and Simcoe areas. There are 3049 ha of pure map units, and 2710 ha of Wattford soils in complex map units in which their most common associate is Normandale soils.

Landform and Topography Wattford soils occur on lacustrine sand plains, where the sands have been wind-sorted and sometimes deposited into dune landforms. These plains often merge into lacustrine silt and clay plains. The topography ranges from level to moderately sloping, with strong slopes along stream valleys.

Parent Materials and Textures Wattford soils have developed on deep, lacustrine sands, modified in varying degrees by wind action. Surface textures are usually very fine sandy loam or loamy fine sand, whereas deeper subsoil textures are more variably sandy.

Soil Moisture Characteristics Wattford soils are well-drained and rapidly to moderately permeable. They have low to moderate water-holding capacities. Droughtiness is a limitation during dry summers. Surface runoff ranges from slow to rapid, depending mainly on slope.

General Soil Description The surface horizons of Wattford soils usually range between 15-25 cm thick. The predominant surface textures are loamy fine sand and very fine sandy loam. Subsoil textures are quite variable, ranging through loamy fine sand, very fine sandy loam, fine sand, and very fine sand. The contact of the B horizon with the calcareous Ck horizon is wavy and usually occurs at a depth of about 1 m. Ck horizons are usually strongly calcareous and mildly alkaline. Soil reactions of the surface horizons usually range between medium acidic and neutral. Subsoil Bg horizon reactions range from mildly acidic to neutral. Soil classification is usually Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Normandale (NDE) soils are most commonly associated with Wattford soils in map unit WAT 2, especially in the area adjacent to Lake Erie, between St. Williams and Simcoe. Their textures are similar to Wattford textures, but their drainage is imperfect.

General Land Use Comments

(1) Wattford soils are productive agricultural soils, but have summer moisture limitations, and erosion limitations on steeper slopes. They are extensively used for tobacco, but require sprinkler irrigation. Other horticultural crops that may require supplemental irrigation on Wattford soils are apricots, strawberries, peaches, sweet cherries, asparagus, peanuts, and onions.

(2) Somewhat better-than-average productivity can be expected from most tree species on Wattford soils, despite moisture and erosion limitations.

Figure 40. Cucumbers, and other vegetable crops, are grown extensively on Wattford soils.

Wauseon Soils (WUS)

Location and Extent Wauseon soils occur in the western part of the region west of Nanticoke, and at the eastern end of the region east of Dunnville. They occupy many poorly drained depressions where shallow sands overlie clays. There are 1688 ha of normal Wauseon map units, and 5487 ha of Wauseon soils in complex map units in which they are most frequently associated with Berrien and Normandale soils. There are also 1674 ha of till phase Wauseon soils mapped in the region.

Landform and Topography Wauseon soils are located on low, poorly drained areas of sand plains, where sands are shallow over clays. These sand plains are often adjacent to lacustrine or till clay plains. The origin of the sands is basically lacustrine, although some wind-sorting is inevitable. Surface topography is level or nearly level.

Parent Materials and Textures Wauseon soils have developed on 40-100 cm of sandy materials, usually fine sandy loam or loamy fine sand, that has been somewhat reworked by wind action. This is underlain by clayey materials, usually silty clay loam or silty clay. Most of the clays are of lacustrine origin, but in the northwest part of the region, some occur as Port Stanley till.

Soil Moisture Characteristics Most Wauseon soils are poorly drained, although there are some peaty phase Wauseon soils in the Waterford area that are very poorly drained. The poor drainage of Wauseon soils is mainly due to groundwater levels being near, or above, the ground surface for much of the year. The high watertables are due to the presence of impermeable clay at depths of 1 m or less. Wauseon soils are rapidly to moderately permeable. They have moderate to high water-holding capacities in the organic-rich surface horizons. Water-holding capacities are low in the sandy subsoil, but high again in the clayey subsoil. Surface runoff is slow.

General Soil Description The surface Ap horizons of Wauseon soils are usually 20-25 cm thick, and consist primarily of fine sandy loam. Peaty phase Wauseon soils (WUS.P) have 15-40 cm of surface organic materials over sands. Textures of the sandy subsoils are variable, but fine sandy loam and loamy fine sand seem to be most prevalent. In the Wauseon sands that overlie lacustrine clay at 40-100 cm depth, the lacustrine clay textures are usually silty clay loam or silty clay. In the till phase Wauseon soils (WUS.T), the underlying till textures are usually silty clay loam. Distinct or prominent, strong brown mottles are often present in the sands, and prominent, yellowish-brown mottles occur in the clays. Highly compacted, sometimes semicemented layers often occur at the sand-clay contact. The strongly to very strongly calcareous Ck horizons can occur in either or both of the sandy or clayey materials. Soil reaction ranges from medium acidic to mildly alkaline in the surface, and is usually mildly or moderately alkaline in the deeper subsoil. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils Berrien (BRR) and Normandale (NDE) soils are those most extensively associated with Wauseon soils. Berrien soils have textures similar to Wauseon soils, but are imperfectly drained. Normandale soils are also imperfectly drained, but are composed entirely of very fine sandy materials, with no clay textures in the upper metre of soil. Wauseon and Berrien soils are mapped together in map unit WUS 4; Wauseon and Normandale soils occur together in map unit NDE 8. Till phase Wauseon soils (WUS.T) commonly occur with till phase Berrien soils (BRR.T) in map unit WUS 11.

General Land Use Comments

(1) Artificial drainage is necessary for most Wauseon soils before reasonable crop production is possible. Some tobacco is grown on drained Wauseon soils, but grain corn and soybeans are the more usual crops.

(2) Forest productivity is generally not good on these wet soils, although white pine and red pine seem to do reasonably well.

Welland Soils (WLL)

Location and Extent Welland soils are only mapped on a few areas in the Town of Dunnville, near Lake Erie. There are 51 ha of pure Welland map units, and 1139 ha of Welland soils in complex map units in which they are often associated with Niagara soils.

Landform and Topography Welland soils occupy level till plain areas composed dominantly of reddish Halton clay till. However, the materials have been modified by the presence of glacial lakes, and are often transitional with glaciolacustrine clays. The topography is usually level.

Parent Materials and Textures Welland soils have developed on reddish Halton clay till that is often overlain by, or interspersed with, thin layers of lacustrine clay. Surface textures range from clay loam to clay, whereas subsoil textures are usually clay, with occasional heavy clay layers at depth.

Soil Moisture Characteristics Welland soils are poorly drained and slowly permeable. Groundwater levels remain at or near the surface for most of the year, except during the summer months. Although Welland soils have moderate to high water-holding capacities, moisture availability to plants may be affected during dry periods by the high clay contents. Surface runoff is slow to moderate.

General Soil Description Surface Ap horizons are usually 15-25 cm thick, with silty clay textures, but clay loam or clay txtures are not uncommon. There are some areas where coarse phase Welland soils (WLL.C) and loamy phase Welland soils (WLL.L) occur. Subsoil textures are usually clay, with occasional layers of silty clay or heavy clay. In cultivated soils, these subsoil horizons are often significantly compacted by heavy machinery. Distinct or prominent, dark yellowish-brown mottles occur in the subsoil horizons. Depth to the calcareous Ck horizon is usually 40-50 cm. Soil reaction is usually neutral or mildly alkaline throughout the profile. Soil classification is usually Orthic Humic Gleysol.

Commonly Associated Soils Niagara (NGR) soils are the main soils commonly associated with Welland soils. Their textures are similar, but Niagara soils are imperfectly drained. Map unit WLL 28 contains these two soils.

General Land Use Comments

(1) High watertables, coupled with relatively high clay contents, limit the use of Welland soils for most agricultural crops, unles they are artificially drained. When drained, they are used for grain and silage corn, soybeans and spring grain.

(2) Welland soils are only fair to average in productivity for most forest species, because of wetness and high clay limitations.

Wilsonville Soils (WIL)

Location and Extent Wilsonville soils occur on gravelly ridges that extend from north of Waterford down to Delhi and Simcoe. There are 1514 ha of pure map units, and 1855 ha of Wilsonville soils in complex map units which are most frequently associated with Scotland soils.

Landform and Topography The gravelly ridges on which the Wilsonville soils occur belong to the Galt and Paris moraines. They are constructed of Wentworth till that has undergone considerable reworking by waves and currents in glacial lakes. The topography of these moraines ranges from very gentle, long slopes to strong, short or hummocky slopes. Most slopes are between 3 and 9%.

Parent Materials and Textures Wilsonville soils have developed on gravelly, sandy till materials. Gravel contents of these soils usually increase with depth. Surface and upper subsoils consist of various sandy textures, with gravel contents up to 20%. In the lower subsoil, gravel contents are usually greater than 20%, and coarse sand textures dominate the sand fraction.

Soil Moisture Characteristics Wilsonville soils are rapidly to well-drained, and rapidly permeable. Wet spots sometimes occur on slopes in the spring and after heavy rains, due to groundwater seepage, but for most of the year, groundwater remains at least 1-2 m deep. Wilsonville soils have relatively low water-holding capacities, except in the finer-textured Bt horizons, where water-holding capacities are greater. Surface runoff varies, depending on slope, being moderate to rapid on slopes above 5%.

General Soil Description The mean thickness of the surface Ap horizons of Wilsonville soils is about 25 cm. The most prevalent surface textures are fine sandy loam, sandy loam and loamy sand. Some gravel is also present, but less than 20%. Some sandy phase Wilsonville soils (WIL.C) have 15-40 cm of sand overlying the gravelly sand. Other loamy phase Wilsonville soils (WIL.L) have 15-40 cm of loamy soil materials overlying the gravelly sand. Upper subsoil textures are dominantly loamy sand, with less than 20% gravel. The Bt horizons, which usually begin at depths of 25-65 cm, have the highest clay concentrations, culminating usually in sandy loam or sandy clay loam textures. They are distinctively reddish, wavy horizons that contact the calcareous Ck horizons at depths of 50-85 cm. Ck horizon textures are often gravelly sand, with high contents of coarse sand, and usually more than 20% gravel. They are usually very strongly calcareous. Soil reaction is quite variable in the surface horizons, ranging from very strongly acid to mildly alkaline. In the lower subsoil, reaction is usually mildly or moderately alkaline. Soil classification is usually Brunisolic Gray Brown Luvisol.

Commonly Associated Soils Scotland soils (STD) are commonly associated with Wilsonville soils, especially where the till moraines level and merge with the Norfolk sand plain. Scotland soils differ from Wilsonville soils in having a deeper (40-100 cm) overlay of stone-free sand over gravelly sand. The two soils occur together in map unit WIL 2.

General Land Use Comments

(1) Wilsonville soils are good agricultural soils, but have droughty tendencies that limit their use for some general field crops. However, they are used for winter wheat, grain corn, and spring grains. With supplemental irrigation, they are important soils for tobacco, and are also used for ginseng, apples and cherries.

(2) Nutrient and moisture limitations, resulting from the coarse textures of Wilsonville soils, reduce the productivity of most forest tree species on these soils.

Miscellaneous Land Units

Complex 1 (CPX 1)

This is a beach-scarp complex that is mapped along the Lake Erie shoreline wherever wave-eroded cliffs or scarps occur. The beach component of this complex is mainly composed of calcareous medium to coarse sand, with occasional gravel pebbles or cobbles. The gravel contents increase locally, especially near the strand lines. East of Rainham, bedrock outcrops occur along the shoreline and, in a few places, the beach consists entirely of cherty limestone bedrock. The width of the beach varies from almost nil to more than 100 m , but is usually less than 100 m.

The scarps along the shoreline are formed by active and continuous wave erosion which has caused some severe property losses in recent years. The height of the scarps ranges from a few metres, up to 50 m. Slopes are generally greater than 30%. The steepest slopes are usually devoid of vegetation, but on gentler slopes, vegetation often persists from soils that have slumped from the higher land surface. The total area of Complex 1 is 799 ha.

Complex 2 (CPX 2)

This is a beach-marsh complex mapped in some areas around the periphery of Long Point peninsula. The beach component of Complex 2 consists of level, sandy or gravelly beaches, or exposed sandbars, of variable width, that are closely associated with areas of marsh. The marsh component consists of deep and shallow marsh characterized by cattails, wild rice, reed grass, sedges, etc. The total area of Complex 2 is 773 ha.

Complex 3 (CPX 3)

This is a marsh-dune complex mapped on Long Point. It most often occurs just behind the beach-ridge and beach-dune complexes that surround much of Long Point. Most of the marsh areas are relatively shallow and dominated by grasses and sedges. The dunes are rarely higher than two or three m and have predominantly fine sand textures. Those nearest the lake usually have less vegetation and more blowouts. Cottonwood, red cedar, ground juniper and grasses are characteristic vegetation of these dunes. The more stabilized dunes farthest from the lake support similar vegetation, but also have more continuous grass cover and some white cedar, white birch and red oak. The total area of Complex 3 is 1229 ha.

Complex 4 (CPX 4)

This is a marsh-ridge complex that occupies many of the interior areas of the eastern part of the Long Point peninsula. The ridges are quite distinctive topographic features, up to 30 m high, with steep sides. The dominant texture of these ridges is fine sand, indicating an eolian origin. The dominant tree species are red oak, white ash, basswood, white pine, sugar maple and black cherry. The marsh component contains, in addition to marsh areas, small shrub-carr communities of water willow and buttonbush and some tamarack — white pine lowland associations. The total area of Complex 4 is 1072 ha.

Figure 41. Complex 4, consisting of alternate ridge and marsh areas, near the eastern end of Long Point

Complex 5 (CPX 5)

This is a beach-dune complex mapped along much of the southern shore and eastern end of the Long Point peninsula. The beach component consists mainly of coarse sands and gravels. The dune component, located just behind the beach, consists of low, eolian dunes or wave ridges composed mainly of fine or medium sand. Because of the instability of the beach areas, the vegetation is usually restricted to scattered clumps of grasses. The dunes are also somewhat unstable and contain numerous blowouts, but usually support more continuous areas of grass, in addition to cottonwood and red cedar, than the beach areas. The total area of Complex 5 is 368 ha.

Complex 6 (CPX 6)

This is a beach-ridge complex mapped along the shore, at the eastern end of Long Point peninsula. It is very similar to Complex 5, except that the dunes behind the beach are usually higher and steeper than the dunes in Complex 5, and are called ridges. Thus, they are somewhat more exposed, contain more blowouts, and have less continuous vegetative cover than the dunes of Complex 5. The total area of Complex 6 is 80 ha.

Marsh (MAR)

Large areas of marsh have been mapped along the Long Point and Turkey Point peninsulas, and in nearshore areas of the Grand River and Big Creek where they empty into Lake Erie. Marshes are characterized by water above the ground surface most of the year, and by thin organic-rich deposits on the surface overlying variable sedimentary deposits. The most characteristic plants of deep marsh areas are cattails, although reed grass and wild rice are also abundant at Long Point. Shallow marsh areas at Long Point typically have hummocks of various grasses and sedges, and herbaceous species such as bedstraw, bellflower and tufted loosestrife (18). The total area of marsh is 7063 ha.

Ridge (RID)

Ridges are large dunes on Long Point peninsula of sufficient size to be mapped separately, and not within a complex map unit. The largest and oldest ridges are on the western part of the forested portion of the peninsula, whereas smaller and younger ridges occur toward the eastern end.

These ridges can be up to 30 m high with steeply sloping sides, and are usually composed of fine sand, sorted and deposited by wind action. Ridges, such as the Courtright Ridge on the western side, are dominated by a red oak, basswood and hackberry forest community. Further east, the dominant forest community is red oak-white ash-red maple (18). On smaller ridges, near the southern shore and eastern end, the dominant tree species are often eastern cottonwood and red cedar.

Urban Land (U.L.)

These are delineated areas, usually centred on towns and cities in the region, that have significant concentrations of buildings, or other urban-related space such as parks, golf courses, railway yards, landfill sites, etc. There was 4657 ha of urban land mapped in the region.

SOIL INTERPRETATIONS FOR AGRICULTURE

A. AGRICULTURAL CAPABILITY CLASSIFICATION FOR COMMON FIELD CROPS

The Canada Land Inventory (CLI) was a comprehensive assessment of land capability for agriculture, forestry, wildlife and recreation. The agricultural capability classification for general field crops was derived mainly from information collected in earlier soil surveys (22).

The CLI classification system of land capability for agriculture is based on certain assumptions that the user should understand before using soil capability tables or maps, to avoid making erroneous deductions. These assumptions are outlined elsewhere (23).

In this classification system, mineral soils are grouped into seven classes according to their potential and limitation for agricultural use for common field crops. Common field crops include corn, oats, wheat, barley and perennial forage crops such as alfalfa, grasses and bird's-foot trefoil. Specialty crops such as soybeans, white beans, tobacco, fruit and vegetables are not covered by this classification.

The best soils, with no significant limitations for crop use, are designated class 1. Soils designated classes 2 to 6 have decreasing capability for agriculture, and class 7 soils have no agricultural potential. A brief outline of each agricultural capability class follows.

(1) Capability Classification for Mineral Soils

(a) Soil Capability Classes

Class 1 - Soils in this class have no significant limitations for crop use. They are usually level to very gently sloping, deep, well to imperfectly drained, and have good water-holding capacities.

Class 2 - Soils of this class have moderate limitations that restrict the range of crops, and require careful soil management to prevent soil deterioration or improve air and water relations. The limitations are readily correctable.

Class 3 - Soils of this class have moderately severe limitations, that restrict the range of crops. They require very careful soil management to prevent soil deterioration, or to improve air and water relations. The limitations are usually not readily correctable. Classes 1 to 3 are considered to be capable of sustained annual production of common field crops.

Class 4 - Soils of this class have severe limitations that restrict the choice of crops, and require special conservation practices, and/or very careful management. Class 4 soils are marginal for sustained production of common field crops.

Class 5 - Soils of this class have very severe limitations that make them unsuitable for sustained production of annual field crops. However, they may be improved sufficiently to produce permanent pasture or hay crops.

Class 6 - Soils in this class are unsuited to cultivation, but are capable of use for unimproved permanent pasture.

Class 7 - Soils of this class are unsuited for agriculture. They include land with very steep slopes, areas of exposed rock, and bodies of water too small to delineate on maps.

(b) Soil Capability Subclasses

Subclasses are divisions, within classes, that have the same kind of limitations for agricultural use as a result of soil and climate. Thirteen different kinds of limitations have been recognized, at the subclass level, and are described in CLI Report No. 2 (23). They are listed below.

C - adverse climate
D - undesirable soil structure and/or low permeability
E - erosion damage
F - low fertility
I - inundation or flooding by streams or lakes
M- moisture limitation in soils affected by droughtiness
N - salinity
P - stoniness
R - consolidated bedrock near surface
S - cumulative effects of 2 or more of subclasses D, F, M and N
T - topography
X - cumulative minor adverse characteristics

Subclasses C, N and X are not used in the classification of soils for Haldimand-Norfolk. Guidelines for determining most subclasses were obtained from (23). Assistance in determining subclasses W, M, D and R were obtained from a computer program developed by R.A. McBride (24). Guidelines for determining subclass E were determined after consultation with G.J. Wall, Agriculture Canada*, and reference to Tables 15, 22 and 26 in the soil erosion interpretations section of this report.

**Personal communication.*

(2) Capability Classification for Organic Soils

The previous discussion on soil capability classification applies only to mineral soils and cannot be used for organic soils. A separate capability system has been devised for organic soils, using seven capability classes that are determined according to the following soil characteristics: stage of decomposition (K), reaction (F), climate (C), substratum texture, wood content (L) and depth of organic soil (H). Definitions of these soil characteristics and how they are used to determine organic soil capability classes, are discussed by Hoffman and Acton (25). In this classification system, intensive agricultural use is assumed, e.g. vegetable production.

(a) Organic Soil Capability Classes

Class 1 - Organic soils of this class have no water, topographical or pH limitations, and are deep and level.

Class 2 - Organic soils in class 2 have one limitation that restricts their use in a minor way. The limitation may be woodiness, reaction, flooding, topography, depth or climate.

Class 3 - Organic soils in this class have moderately severe limitations that restrict the range of crops, or that require special management practices.

Class 4 - Soils in this class have limitations that severely restrict the range of crops, or require special development and management practices. Reclamation and management costs will be high.

Class 5 - Soils of this class have such severe limitations that they are restricted to the production of perennial forage or other specially adapted crops. Large-scale reclamation is not feasible.

Class 6 - Class 6 organic soils are capable of producing only indigenous crops, and improvement practices are not feasible.

Class 7 - Organic soils of this class have no capability for agriculture.

Developing of organic soils for agricultural use also depends on the feasibility of clearing vegetation, drainage and water level control (23). These are site-specific factors that are not considered for the general organic soil capabilities outlined in Table 10.

Table 10. Agricultural land capability for common field crops in the Regional Municipality of Haldimand-Norfolk*

Soil map unit component	Map symbol	Capability classification Slopes B	C	c	D	d	E	e	F	f	G,g
Alluvium 1	1-ALU	5I	5I	5I							
Alluvium 1 very shallow phase	1-ALU.V	6R	6R	6R							
Alluvium 2	2-ALU	3I	3I	3I							
Alluvium 3	3-ALU	3I	3I	3I							
Alluvium 4	4-ALU	3I	3I	3I							
Alluvium 4 coarse phase	4-ALU.C	3I	3I	3I							
Berrien	BRR	1	1	2T							
Berrien till phase	BRR.T	1	1	2T							
Berrien heavy clay phase	BRR.H	1	1	2T							
Beverly	BVY	2D	2^{D}_{E}	2^{D}_{T}							
Beverly coarse phase	BVY.C	1	1	2T							
Beverly loamy phase	BVY.L	2D	2^{D}_{E}	2^{D}_{T}							
Beverly shallow phase	BVY.S	3R	3R	3R							
Beverly very shallow phase	BVY.V	4R	4R	4R							
Bookton	BOO	2M	2M	2^{M}_{T}	2^{M}_{T}	3T					
Bookton till phase	BOO.T	2M	2M	2^{M}_{T}	2^{M}_{T}	3T	3T	4T			
Brady	BAY	2F	2F	2^{F}_{T}							
Brady loamy phase	BAY.L	2F	2F	2^{F}_{T}							
Brant	BRT	1	2E	2T	3T	3T	4T	4T	5T	5T	6T
Brant coarse phase	BRT.C	1	1	2T	3T	3T	4T	4T	5T	5T	6T
Brant very shallow phase	BRT.V	4R	4R	4R	4R	4R	4^{R}_{T}	4^{R}_{T}	5T	5T	6T
Brantford	BFO	2D	2^{D}_{E}	2^{D}_{T}	3T	3T	4T	5T	5T	5T	6T
Brantford coarse phase	BFO.C	1	1	2T	3T	3T	4T	4T	5T	5T	6T
Brantford loamy phase	BFO.L	2D	2^{D}_{E}	2^{D}_{T}	3T	3T	4T	4T	5T	5T	6T
Brantford shallow phase	BVO.S	3R	3R	3R	3^{R}_{T}	3^{R}_{T}	4T	4T	5T	5T	6T
Brantford very shallow phase	BFO.V	4R	4R	4R	4R	4R	4^{R}_{T}	4^{R}_{T}	5T	5T	6T
Brooke	BOK	6R	6R	6R							
Burford	BUF	2^{F}_{M}	2^{F}_{M}	2^{S}_{T}	2^{S}_{T}	3T	3T	4T	5T	5T	6T
Lonsdale	LDL	4HK-5HK†									
Lowbanks	LOW	3W	3W	3W	(5W)**						
Maplewood	MPW	2W	2W	2W	(4W-5W)**						
Marsh	MAR	7I									
Muriel	MUI	2D	2^{D}_{E}	2^{D}_{T}	3T	3T	4T	4T	5T	5T	6T
Muriel coarse phase	MUI.C	1	1	2T	3T	3T	4T	4T	5T	5T	6T
Muriel loamy phase	MUI.L	2D	2^{D}_{E}	2^{D}_{T}	3T	3T	4T	4T	5T	5T	6T
Niagara	NGR	2D	2^{D}_{E}	2^{D}_{T}							
Niagara coarse phase	NGR.C	2D	2D	2^{D}_{T}							
Niagara loamy phase	NGR.L	2D	2^{D}_{E}	2^{D}_{T}							
Normandale	NDE	1	2E	2T							
Normandale coarse phase	NDE.C	1	1	2T							
Oakland	OKL	2F	2F	2^{F}_{T}							
Oakview	OVW	4HK-5HK†									
Ontario	OTI	2D	2^{D}_{E}	2^{D}_{T}	3T	3T	4T	4T	5T	5T	6T
Ontario coarse phase	OTI.C	2D	2D	2^{D}_{T}	3T	3T	4T	4T	5T	5T	6T
Plainfield	PFD	3F	3F	3F	3F	3^{F}_{T}	3^{F}_{T}	4T	5T	5T	6T
Plainfield dune phase	PFD.D	3F	3F	3F	3F	3^{F}_{T}	3^{F}_{T}	4T	5T	5T	6T
Scotland	STD	2^{F}_{M}	2^{F}_{M}	2^{S}_{T}	2^{S}_{T}	3T	3T	4T	5T	5T	6T
Ridge	RID	NOT RATED									
Seneca	SNA	2D	2^{D}_{E}	2^{D}_{T}	3T	3T	4T	4T	5T	5T	6T
Seneca coarse phase	SNA.C	2D	2D	2^{D}_{T}	3T	3T	4T	4T	5T	5T	6T
Seneca shallow phase	SNA.S	3R	3R	3R	3^{R}_{T}	3^{R}_{T}	4T	4T	5T	5T	6T
Seneca very shallow phase	SNA.V	4R	4R	4R	4R	4R	4^{R}_{T}	4^{R}_{T}	5T	5T	6T
Silver Hill	SIH	2W	2W	2W	(4W-5W)**						
Smithville	SHV	3D	3D	3D	3^{D}_{T}	3^{D}_{T}	4T	4T	5T	5T	6T
Smithville coarse phase	SHV.C	3D	3D	3D	3^{D}_{T}	3^{D}_{T}	4T	4T	5T	5T	6T
Smithville loamy phase	SHV.L	3D	3D	3D	3^{D}_{T}	3^{D}_{T}	4T	4T	5T	5T	6T
Smithville shallow phase	SHV.S	3^{D}_{R}	3^{D}_{R}	3^{D}_{R}	3^{R}_{T}	3^{R}_{T}	4T	4T	5T	5T	6T

Colwood	CWO	2W 2^{W}_{E} 2^{W}_{T} (4W-5W)**
Colwood coarse phase	CWO.C	2W 2W 2^{W}_{T} (4W-5W)**
Colwood peaty phase	CWO.P	3W 3W 3W (5W)**
Complex 1	CPX 1	7T 7T 7T 7T 7T 7T 7T 7T 7T 7T
Complex 2	(CPX 2)	7I 7I 7I 7I 7I 7I 7I 7I 7I 7I
Complex 3	CPX 3	NOT RATED
Complex 4	CPX 4	NOT RATED
Complex 5	CPX 5	NOT RATED
Complex 6	CPX 6	NOT RATED
Farmington	FRM	6R 6R 6R 6R 6R 6R 6R 6R 6R 6^{R}_{T}
Fox	FOX	2^{F}_{M} 2^{F}_{M} 2^{S}_{T} 2^{S}_{T} 3T 3T 4T 5T 5T 6T
Fox shallow phase	FOX.S	3R 3R 3R 3^{R}_{T} 3^{R}_{T} 3^{R}_{T} 4T 5T 5T 6T
Fox very shallow phase	FOX.V	4R 4R 4R 4R 4R 4R 4^{R}_{T} 5T 5T 6T
Gobles	GOB	2D 2^{D}_{E} 2^{D}_{T}
Gobles coarse phase	GOB.C	1 1 2^{D}_{T}
Gobles loamy phase	GOB.L	2D 2^{D}_{E} 2^{D}_{T}
Granby	GNY	2W 2W 2W (4W-5W)**
Granby loamy phase	GNY.L	3W 3W 3W (4W-5W)**
Granby peaty phase	GNY.P	4W 4W 4W (5W)**
Granby very shallow phase	GNY.V	5W 5W 5W
Haldimand	HIM	3D 3D 3D
Haldimand coarse phase	HIM.C	3D 3D 3D
Haldimand loamy phase	HIM.L	3D 3D 3D
Haldimand shallow phase	HIM.S	3^{D}_{R} 3^{D}_{R} 3^{D}_{R}
Hampden	HMP	4HK-5HK†
Kelvin	KVN	3W 3W 3W (5W)**
Kelvin coarse phase	KVN.C	2W 2W 2W (5W)**
Kelvin loamy phase	KVN.L	3W 3W 3W (5W)**
Kelvin peaty phase	KVN.P	4W 4W 4W (5W)**
Lincoln	LIC	3^{W}_{D} 3^{W}_{D} 3^{W}_{D} (5W)**
Lincoln coarse phase	LIC.C	3^{W}_{D} 3^{W}_{D} 3^{W}_{D} (5W)**
Lincoln loamy phase	LIC.L	3^{W}_{D} 3^{W}_{D} 3^{W}_{D} (5W)**
Lincoln peaty phase	LIC.P	4W 4W 4W (5W)**
Lincoln shallow phase	LIC.S	4W 4W 4W (5W)**
Lincoln very shallow phase	LIC.V	5W 5W 5W (5W)**
Smithville very shallow phase	SHV.V	4R 4R 4R 4R 4R 4^{R}_{T} 4^{R}_{T} 5T 5T 6T
St. Williams	SLI	2W 2^{W}_{E} 2^{W}_{T} (4W-5W)**
Styx	SYX	2K-3KH†
Tavistock	TVK	1 2E 2T
Toledo	TLD	3^{W}_{D} 3^{W}_{D} 3^{W}_{D} (5W)**
Toledo coarse phase	TLD.C	3W 3W 3W (5W)**
Toledo peaty phase	TLD.P	4W 4W 4W (5W)**
Toledo shallow phase	TLD.S	4W 4W 4W (5W)**
Toledo very shallow phase	TLD.V	5W 5W 5W (5W)**
Tuscola	TUC	1 2E 2T
Tuscola coarse phase	TUC.C	1 1 2T
Tuscola shallow phase	TUC.S	3R 3R 3R
Tuscola very shallow phase	TUC.V	4R 4R 4R
Urban Land	U.L.	NOT RATED
Vanessa	VSS	2W 2W 2W (4W-5W)**
Vanessa peaty phase	VSS.P	4W 4W 4W (5W)**
Vittoria	VIT	1 1 2T
Walsher	WSH	2M 2M 2^{M}_{T} 2^{M}_{T} 3T 3T 4T 5T 5T 6T
Walsingham	WAM	3F 3F 3F
Waterin	WRN	3W 3W 3W (4W-5W)**
Waterin loamy phase	WRN.L	3W 3W 3W (4W-5W)**
Waterin peaty phase	WRN.P	4W 4W 4W (5W)**
Wattford	WAT	2M 2^{M}_{E} 2^{M}_{T} 3T 3T 4T 4T 5T 5T 6T
Wauseon	WUS	2W 2W 2^{W}_{T} (4W-5W)**
Wauseon peaty phase	WUS.P	4W 4W 4W (5W)**
Wauseon till phase	WUS.T	2W 2W 2W (4W-5W)**
Welland	WLL	3^{W}_{D} 3^{W}_{D} 3^{W}_{D} (5W)**
Welland coarse phase	WLL.C	3^{W}_{D} 3^{W}_{D} 3^{W}_{D} (5W)**
Welland loamy phase	WLL.L	3^{W}_{D} 3^{W}_{D} 3^{W}_{D} (5W)**
Wilsonville	WIL	2^{F}_{M} 2^{F}_{M} 2^{S}_{T} 2^{S}_{T} 3T 3T 4T 5T 5T 6T
Wilsonville coarse phase	WIL.C	2^{F}_{M} 2^{F}_{M} 2^{S}_{T} 2^{S}_{T} 3T 3T 4T 5T 5T 6T
Wilsonville loamy phase	WIL.L	2^{F}_{M} 2^{F}_{M} 2^{S}_{T} 2^{S}_{T} 3T 3T 4T 5T 5T 6T
Wilsonville shallow phase	WIL.S	3R 3R 3R 3^{R}_{T} 3^{R}_{T} 4T 4T 5T 5T 6T

(See Footnotes on page 60)

(Footnotes for Table 10)

†*Organic soil ratings are for intensive use such as vegetable production.*

**To determine the agricultural capability of map unit components with the help of Table 10, consider the following map unit examples:*

BRT1	BRT4	BRT4
C	C>B	CB

(1) Determine components of the map unit in the numerator by referring to the legent of the soil map on which the map unit appears, e.g. BRT1 is composed of Brant soils; BRT4 is composed of Brant and Tuscola soils.

(2) Determine the approximate proportions and slopes of the map unit components from the denominators of the units, e.g.

BRT1
C

has Brant soils on simple C (2-5%) slopes;

BRT4
C>B

has Brant soils on simple C slopes, and Tuscola soils on simple B (0-2%) slopes, in approximate 70:30 proportions;

BRT4
CB

has Brant and Tuscola soils in approximately equal 50:50 proportions, again with Brant soils on C slopes, and Tuscola soils on B slopes.

(3) To determine the capability of a map unit component, simply combine it with the appropriate slope in Table 10, e.g.

BRT1
C

indicates that a Brant soil is on a C slope, so the agricultural capability is class 2E;

BRT4
C>B

indicates a Brant soil on a C slope with a class 2E capability, and a Tuscola soil on a B slope with a class 2 capability. The agricultural capability of the map unit is 70% class 2E and 30% class 1, e.g. $2E^{7}1^{3}$.

***Approximate capability ratings of poorly drained soils without drainage improvements.*

B. AGRICULTURAL SUITABILITY CLASSIFICATION FOR SPECIAL CROPS

The CLI classification system of land capability for agriculture is designed for common field crops, such as forages, small grains and corn, but not for other less commonly grown field and horticultural crops, henceforth referred to as "special crops".

Since a large portion of the Haldimand-Norfolk Region is used for growing special crops, a suitability ratings system was devised for the soils of the region, and for a number of the most important special crops.

The ratings are based on information obtained from field observations, agricultural extension personnel, and research of relevant literature. Soil ratings for tobacco were prepared with the assistance of J. Elliot, N. Sheidow and M. Watson from the Delhi Research Station. Mr. Russ Chard, horticulture extension specialist at the Simcoe Horticultural Station, provided much of the information used for rating horticultural crops. General guidelines on soil and land requirements for many special crops were obtained from a literature search. The publication, *Climate and Soil Requirements for Economically Important Crops in Canada*, (26), was especially helpful. The concept of lumping special crops into crop groups (Table 11) was adapted from work done by D. Cressman and M. Hoffman for Ontario Hydro (27).

(1) Climatic Considerations

Because many special crops are less hardy than common field crops, and often have specialized moisture requirements, climatic factors are often as important as soil factors in determining the suitability of areas for special crops. Temperature, precipitation and growing season data for the region are given in the climate section of this report. In general the climate of the Haldimand-Norfolk Region is well suited for a wide range of special field and horticultural crops grown commercially in southern Ontario, mainly because of its southerly location and proximity to Lake Erie.

(2) Soil Considerations

Table 12 indicates the suitability ratings of a number of special crops for the soil map unit components of the region. Ratings were done for the following special crops: apples, apricots, asparagus, fava beans, green beans, lima beans, soybeans, white beans, beets, cabbages, canola, carrots, cauliflower, sour cherries, sweet cherries, sweet corn, cucumbers, ginseng, hybrid and vinifera grapes, labrusca grapes, lettuce, muskmelons, onions, peaches, peanuts, pears, peas, peppers, plums, potatoes, pumpkins, radishes, raspberries, rhubarb, squash, strawberries, tomatoes, turnips and watermelons.

These crops were grouped into four main groups, mainly on the basis of their response to soil conditions. Crop group A is comprised of crops that seem to thrive best on sandy and gravelly soils. Crop group B is composed of crops that seem to be adapted to both sandy and loamy soils. Crops in group C appear to be adapted to the broad spectrum of sandy, loamy and clayey soils. Crops in these three groups include field crops, vegetables and small fruits. Crop group D is composed of tree fruits having potential commercial significance in the region, and grapes.

Each crop group is divided into crop subgroups that are composed of one or more crops. The crops in each subgroup seem to respond similarly to most soils, and to differ significantly from crops in other subgroups. The relation of crop groups to crop subgroups, and the specific crops in each subgroup, are shown in Table 11.

Table 11. Distribution of special crops in crop group and subgroup categories for the Haldimand-Norfolk Region

Crop Group	Subgroup	Special Crops
A	1	asparagus
	2	peanuts
	3	potatoes
	4	tobacco
B	1	onions, beets, carrots
	2	ginseng, muskmelon, watermelon
	3	peppers, raspberries, rhubarb, strawberries
C	1	fava beans, soybeans, white beans
	2	green beans, peas, pumpkins, squash
	3	cabbage, cauliflower, canola, sweet corn, tomatoes, turnips
	4	cucumber, lettuce, radish
D	1	apricots, sour cherries, sweet cherries, peaches
	2	pears, plums
	3	hybrid and vinifera grapes, labrusca grapes
	4	apples

(3) How to Determine Special Crop Suitability Ratings

In Table 12, each crop subgroup is given a suitability rating for most soil map unit components. Organic soils and miscellaneous land units were not rated, and many alluvial units could not be rated because of their various textures or drainages. A six-class suitability rating system was used, with ratings of good (G), fair to good (F-G), fair (F), poor to fair (P-F), poor (P), and generally unsuitable (U).

Average levels of management are assumed. Although ratings are not improved in this system for superior management, they are assumed to improve for some soils if they are artificially drained or irrigated. In Table 12, those soils that are most commonly drained or irrigated, and that should improve by one or more suitability classes, if these practices are put into effect, are indicated by +1, etc., in the appropriate management factor column. Flue-cured tobacco is the only exception to this rule, because irrigation is virtually universal on the crop. Thus, the ratings shown in Table 12, for tobacco, assume that all tobacco soils are irrigated. Most soils that are considered unsuitable for certain crops will remain unsuitable even though artificial drainage or irrigation is employed. The main exception to this guideline are some poorly drained soils, denoted as U*, that are assumed to be improved to a "poor" suitability class with adequate artificial drainage.

Suitability ratings decrease with increasing slope, because of erosion and topography limitations. The rate of decrease varies, depending mainly on land slope, soil texture and crop type. The influence of these various factors on erosion is discussed in "Soil erosion interpretations", in this report. In Table 13 an attempt has been made, based on various erosion factors, to provide guidelines on the rate of decrease in suitability ratings as slope increases. To use this table, first find the suitability rating of a special crop from Table 12, and then, using Table 13, determine how the suitability rating decreases as slope percent increases.

(5)

Table 12. Agricultural land suitability ratings for special crops in the Regional Municipality of Haldimand-Norfolk

Soil map unit components	Map symbol	Management factors[1,2] Dr.	Irr.	Crop group A subgroups 1	2	3	4	Crop group B subgroups 1	2	3	Crop group C subgroups 1	2	3	4	Crop group D subgroups 1	2	3	4
Alluvium 1	1-ALU			U	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	U	U	U	U
Alluvium 1 very shallow phase	1-ALU.V			U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Alluvium 2	2-ALU			U	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	U	U	U	U
Alluvium 3	3-ALU			U	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	U	U	U	U
Alluvium 4	4-ALU			U	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	U	U	U	U
Alluvium 4 coarse phase	4-ALU.C			U	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	U	U	U	U
Berrien	BRR			P	P-F	P-F	P	F	P-F	F	F	F	F-G	F	F	F-G	F-G	F
Berrien till phase	BRR.T			P	P-F	P-F	P	F	P-F	F	F	F	F-G	F	F	F-G	F-G	F
Berrien heavy clay phase	BRR.H			P	P-F	P-F	P	F	P-F	F	F	F	F-G	F	F	F-G	F-G	F
Beverly	BVY	+1		U	U*	U*	U	P	U*	F	F-G	F	F	P-F	P	F	F-G	P-F
Beverly coarse phase	BVY.C	+1		U*	P	P	U*	P-F	P	F-G	G	F-G	F-G	F	P-F	F-G	G	F
Beverly loamy phase	BVY.L	+1		U*	P	P	U	P-F	P	F-G	F-G	F	F-G	F	P	F-G	G	F
Beverly shallow phase	BVY.S	+1		U	U*	U*	U	P	U*	F	F-G	F	F	P-F	P	P-F	F	P
Beverly very shallow phase	BVY.V			U	U	U	U	U	U	U	P	U	P	U	U	U	U	U
Bookton	BOO		+1	F	F	F	F	F	F-G	F-G	F-G	F-G	F-G	F-G	F	F-G	F-G	F-G
Bookton till phase	BOO.T		+1	F	F	F	F	F	F-G	F-G	F-G	F-G	F-G	F-G	F	F-G	F-G	F-G
Brady	BAY			F	F	P-F	P-F	F	P	P-F	P	P-F	F	F	P-F	P-F	F	P-F
Brady loamy phase	BAY.L			F	F	P-F	P-F	F	P	P-F	P	P-F	F	F	P-F	P-F	F	P-F
Brant	BRT			F-G	F-G	G	F	G	F-G	G	G	G	G	G	F-G	F-G	G	F-G
Brant coarse phase	BRT.C			F-G	G	G	F	G	G	G	G	G	G	G	F-G	G	G	G
Brant very shallow phase	BRT.V			P-F	P	P	U	P	P-F	P-F	P-F	P-F	P-F	P-F	U	U	U	U
Brantford	BFO			U	P	P	U	P-F	P-F	F-G	G	F-G	F-G	F	P-F	F-G	G	F
Brantford coarse phase	BFO.C			P	P-F	P-F	P	F	F	G	G	G	G	F-G	F	G	G	F-G
Brantford loamy phase	BFO.L			P	P-F	P-F	U	F	F	G	G	F-G	G	F-G	P-F	G	G	F-G
Brantford shallow phase	BFO.S			U	P	P	U	P-F	P-F	F-G	G	F-G	F-G	F	P	P-F	F	P-F
Brantford very shallow phase	BFO.V			U	U	U	U	U	P	P-F	P	P	P	P	U	U	U	U
Brooke	BOK			U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Burford	BUF		+1	F-G	U	P-F	F	P	F-G	F	P	P-F	P-F	P-F	F-G	F-G	F-G	F-G
Colwood	CWO	+2		P	P	P	P	P-F	P	P	P	P	P-F	P	U*	P	P	P
Colwood coarse phase	CWO.C	+2		P	P-F	P	P	P-F	P	P	P-F	P-F	P-F	P-F	P	P-F	P-F	P
Colwood peaty phase	CWO.P	+2		U	U	P	U	P	U	P	U*	U*	P	P	U	U*	U*	U*
Complex 1	CPX 1			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Complex 2	CPX 2			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Complex 3	CPX 3			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Complex 4	CPX 4			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Complex 5	CPX 5			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Complex 6	CPX 6			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Farmington	FRM			U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Fox	FOX		+1	G	F-G	F	G	F	F-G	F	P	F	F	F-G	F-G	F	F-G	P-F
Fox shallow phase	FOX.S		+1	G	F-G	F	G	F	F-G	F	P	F	F	F-G	P-F	P	P-F	P
Fox very shallow phase	FOX.V		+1	G	F-G	F	G	F	F-G	F	P	F	F	F-G	P-F	P	P-F	P
Gobles	GOB	+1		U	U	P	U	P	P	F	F-G	F	F	P-F	P	F-G	F-G	P-F
Gobles coarse phase	GOB.C	+1		U*	U*	P-F	U*	P-F	P-F	F	G	F-G	F-G	F	P-F	G	G	F
Gobles loamy phase	GOB.L	+1		U*	U*	P-F	U	P-F	P	F	F-G	F	F-G	F	P	G	G	F

Soil map unit components	Map symbol	Management factors[1,2] Dr.	Irr.	Crop group A subgroups 1	2	3	4	Crop group B subgroups 1	2	3	Crop group C subgroups 1	2	3	4	Crop group D subgroups 1	2	3	4
Granby	GNY	+3		P	P	P	P	P-F	P	P	P	P	P	P-F	P	P-F	P	P
Granby loamy phase	GNY.L	+3		P	P	P	P	P-F	P	P	P	P	P	P-F	P	P-F	P	P
Granby peaty phase	GNY.P	+2		P	P	P	U	P	U*	U*	U*	U*	U*	P	U	P	U*	U*
Granby very shallow phase	GNY.V			U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Haldimand	HIM	+1		U	U	U	U	U	U	U	F	P	P-F	P-F	U*	P-F	P-F	P
Haldimand coarse phase	HIM.C	+1		U	U	U	U	U*	U*	U*	F-G	P-F	F	F	P	F	F	P-F
Haldimand loamy phase	HIM.L	+1		U	U	U	U	U*	U	U*	F	P	F	F	U*	F	F	P-F
Haldimand shallow phase	HIM.S	+1		U	U	U	U	U	U	U	F	P	P-F	P-F	U*	P	P	P
Hampden	HMP			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Kelvin	KVN	+2		U	U	U*	U	U*	U	U	P	U*	P	U*	U*	P	P-F	P
Kelvin coarse phase	KVN.C	+2		U*	U*	P	U*	P	U*	U*	P-F	P	P-F	P	P	P-F	F	P-F
Kelvin loamy phase	KVN.L	+2		U*	U*	P	U	P	U	U*	P	U*	P-F	P	P	P-F	F	P-F
Kelvin peaty phase	KVN.P	+1		U	U	P	U	U*	U	U*	U*	U*	U*	U*	U	U*	U*	U*
Lincoln	LIC	+1		U	U	U	U	U	U	U	U*	U	U*	U	U	U*	P	U*
Lincoln coarse phase	LIC.C	+1		U	U	U	U	U	U	U	P-F	U*	P	U*	U*	P	P-F	P
Lincoln loamy phase	LIC.L	+1		U	U	U	U	U	U	U	P	U	P	U*	U*	P	P-F	P
Lincoln peaty phase	LIC.P	+1		U	U	U	U	U	U	U	U*	U	U*	U	U	U*	U*	U*
Lincoln shallow phase	LIC.S	+1		U	U	U	U	U	U	U	U*	U	U*	U	U	U*	P	U*
Lincoln very shallow phase	LIC.V			U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Lonsdale	LDL			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Lowbanks	LOW	+3		P	U*	P	U	P	U*	U	U*	U*	U*	U*	U*	P	U*	U*
Maplewood	MPW	+2		U*	P	P-F	U	P	P	P	P	P	P	P	U*	P	P	P
Marsh	MAR			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Muriel	MUI			U	U	P-F	U	P-F	P-F	F-G	G	F-G	F-G	F	P-F	F-G	F-G	F
Muriel coarse phase	MUI.C			P	P	F	P	F	F	G	G	G	G	F-G	F	G	G	F-G
Muriel loamy phase	MUI.L			P	P	F	U	F	P-F	G	G	F-G	G	F-G	P-F	G	G	F-G
Niagara	NGR	+1		U	U	U	U	U*	U	P-F	F-G	P-F	F	P-F	P	F	F	P-F
Niagara coarse phase	NGR.C	+1		U*	U*	U*	U*	P	U*	F	G	F	F-G	F	P-F	F-G	F-G	F
Niagara loamy phase	NGR.L	+1		U*	U*	U*	U	P	U	F	F-G	P-F	F-G	F	P	F-G	F-G	F
Normandale	NDE			F	F	F	P-F	F	P-F	F	P	F	F-G	F-G	F	F	F-G	P-F
Normandale coarse phase	NDE.C			F	F	F	P-F	F	P-F	F	P	F	F-G	F-G	F	F	F-G	P-F
Oakland	OKL			F	F	F	P-F	F	P-F	F	P	P-F	F	F	F-G	F	F-G	F-G
Oakview	OVW			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Ontario	OTI			P	U	P-F	U	P-F	P-F	F	G	F-G	F-G	F	P-F	F-G	F-G	F
Ontario coarse phase	OTI.C			P-F	P	F	U*	P-F	F	F-G	G	G	G	F-G	F	G	G	F-G
Plainfield	PFD		+1	F-G	P-F	P-F	F-G	P-F	P-F	P-F	P	P-F	P	P-F	P-F	P-F	P-F	P
Plainfield dune phase	PFD.D		+1	F-G	P-F	P-F	F-G	P-F	P-F	P-F	P	P-F	P	P-F	P-F	P-F	P-F	P
Scotland	STD		+1	F-G	F-G	F	F-G	F	F-G	F-G	P	F	F	F-G	G	F-G	F-G	G
Ridge	RID			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Seneca	SNA			P-F	P	F	U	P-F	F	F-G	F-G	F-G	G	F	F-G	G	F-G	G
Seneca coarse phase	SNA.C			F	P-F	F-G	U*	F	F-G	G	F-G	G	G	F-G	F-G	G	F-G	G
Seneca shallow phase	SNA.S			P-F	P	P-F	U	P-F	P-F	F-G	F-G	F-G	G	F	P-F	F	P-F	P-F
Seneca very shallow phase	SNA.V			U	U	U	U	U	P	P	P	P	P-F	U	U	U	U	U
Silver Hill	SIH	+3		P	P	P	P	P-F	P	P	P	P	P	P-F	P	P-F	P-F	P
Smithville	SHV			U	U	U	U	U	U	P-F	F-G	P-F	F	P-F	P	F	F-G	P-F

(Continued on page 64)

Table 12. Agricultural land suitability ratings for special crops in the Regional Municipality of Haldimand-Norfolk — *cont'd*

Soil map unit components	Map symbol	Management factors[1,2] Dr.	Irr.	Crop group A subgroups 1	2	3	4	Crop group B subgroups 1	2	3	Crop group C subgroups 1	2	3	4	Crop group D subgroups 1	2	3	4
Smithville coarse phase	SHV.C			U	U	U	U	P	P	F	G	F	F-G	F	P-F	F-G	G	F
Smithville loamy phase	SHV.L			U	U	U	U	P	U	F	F-G	P-F	F-G	F	P	F-G	G	F
Smithville shallow phase	SHV.S			U	U	U	U	U	U	P-F	F-G	P-F	F	P-F	P	P-F	P-F	P
Smithville very shallow phase	SHV.V			U	U	U	U	U	U	U	P	U	U	U	U	U	U	U
St. Williams	SLI	+3		P	P	P	P	P	P	P	P	P	P	P-F	P	P-F	P-F	P
Styx	SYX			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Tavistock	TVK	+1		U*	P	F	U	F	P	F-G	F-G	F-G	F-G	F	P-F	F-G	F-G	F
Toledo	TLD	+2		U	U	U*	U	U	U	U*	P	U*	P	U*	U*	P	P	P
Toledo coarse phase	TLD.C	+2		U*	U*	P	U*	U*	U*	P	P-F	P	P-F	P	P	P-F	P-F	P
Toledo peaty phase	TLD.P	+1		U	U	P	U	U*	U	U*	U*	U*	U*	U*	U	U*	U*	U*
Toledo shallow phase	TLD.S	+2		U	U	U*	U	U	U	U*	P	U*	P	U	U*	P	P	P
Toledo very shallow phase	TLD.V			U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Tuscola	TUC			P-F	F	F-G	P-F	F-G	P-F	F-G	F-G	F-G	F-G	F-G	P-F	F-G	F-G	F
Tuscola coarse phase	TUC.C			P-F	F	F-G	P-F	F	F	G	G	G	G	G	F	G	G	F-G
Tuscola shallow phase	TUC.S			P	P-F	F	P	F-G	P-F	F-G	F-G	F-G	F-G	F-G	P	F	F	P
Tuscola very shallow phase	TUC.V			U	U	U	U	U	U	U	P-F	P-F	P-F	P-F	U	U	U	U
Urban Land	U.L.			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Vanessa	VSS	+3		P	P	P	P	P	P	P	P	P	P	P	P	P-F	P-F	P
Vanessa peaty phase	VSS.P	+2		P	P	P	U	P	P	P	U*	U*	U*	U*	U	U*	U	U
Vittoria	VIT			F	F	F-G	P-F	F-G	P-F	F-G	F	F-G	F-G	F-G	F	F-G	F-G	F
Walsher	WSH		+1	F	F-G	F-G	F-G	F-G	F-G	G	F-G	G	F-G	G	F-G	F-G	F-G	F-G
Walsingham	WAM			F	P	P	P-F	P-F	P	P	P	P	P-F	P	P	P-F	P-F	P
Waterin	WRN	+3		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Waterin loamy phase	WRN.L	+3		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Waterin peaty phase	WRN.P	+2		P	P	P	U	P	U*	U*	U*	U*	U*	U*	U*	P	U*	U*
Wattford	WAT		+1	F-G	F-G	F-G	F-G	F-G	F-G	F-G	P-F	F-G	F-G	G	F-G	F-G	F-G	F
Wauseon	WUS	+2		P	P	P	U*	P	P	P	P	P	P	P-F	P	P-F	P-F	P-F
Wauseon peaty phase	WUS.P	+1		U*	P	P	U	P	U*	U*	U*	U*	U*	P	U*	P	U*	U*
Wauseon till phase	WUS.T	+2		P	P	P	U*	P	P	P	P	P	P	P-F	P	P-F	P-F	P-F
Welland	WILL	+1		U	U	U	U	U	U	U*	P-F	U*	P	U*	U*	P	P	U*
Welland coarse phase	WLL.C	+1		U*	U	U	U	U*	U*	P	F	P	P-F	P	P	P-F	P-F	P
Welland loamy phase	WLL.L	+1		U*	U	U	U	U*	U	P	P-F	U*	P-F	P	U*	P-F	P-F	P
Wilsonville	WIL		+1	F	P	F	P-F	F	F-G	F	P	F	F	F	F-G	F-G	F-G	G
Wilsonville coarse phase	WIL.C		+1	F-G	P-F	F-G	F	F-G	G	F-G	P	F	F	F-G	G	F-G	F-G	G
Wilsonville loamy phase	WIL.L		+1	F	P-F	F-G	P-F	F-G	G	F-G	P-F	F-G	F-G	F-G	G	F-G	F-G	G
Wilsonville shallow phase	WIL.S		+1	P-F	P	P-F	P	F	F-G	F	P	F	F	F	F	P-F	P-F	F

Suitability Classes

G - good
F-G - fair to good
F - fair
P-F - poor to fair
P - poor
U - generally unsuitable
U* - generally unsuitable, but some improvement is possible if the soil is artificially drained
NR - not rated

[1]*Supplemental irrigation is assumed for flue-cured tobacco on all soils, so the suitability ratings for this crop will not change from application of the irrigation management factor.*

[2]*It should be recognized that these management guidelines are only approximate because of insufficient data. Responses may be somewhat greater or lesser for certain crops than indicated. Also, under unfavorable climatic conditions, some additional soils may respond favorably to artificial drainage or irrigation.*

Table 13. Decrease in land suitability ratings for special crops according to slope group*

	Slope groups				
Crop subgroup	B (0-2%)	C,c (2-5%)	D,d (5-9%)	E,e (9-15%)	F,f,G,g (>15%)
A1	0	0	−1	−2	−3
A2	0	0	−1	−2	−3
A3	0	0	−1	−2	−3
A4	0	0	−1	−2	−3
B1	0	−1	−1	−2	−3
B2 -ginseng	0	0	0	−1	−2
-melons	0	0	−1	−2	−3
B3 -peppers	0	−1	−1	−2	−3
-other crops	0	0	−1	−2	−3
C1	0	−1	−1	−2	−3
C2 - green beans, peas	0	−1	−1	−2	−3
-pumpkins, squash	0	0	−1	−2	−3
C3	0	−1	−1	−2	−3
C4 - cucumbers	0	0	−1	−2	−3
-lettuce, radish	0	−1	−1	−2	−3
D1	0	0	0	−1	−2
D2	0	0	0	−1	−2
D3	0	0	−1	−2	−3
D4	0	0	0	−1	−2

**e.g. if the suitability rating for crop subgroup A1, e.g. asparagus, was good (G), for a particular soil, it would decrease to fair to good (F-G), on a D(5-9%) slope.*

C. SOIL EROSION INTERPRETATIONS

by **G.J. Wall**, Pedologist, Agriculture Canada, Ontario Institute of Pedology, Guelph; **J.W. Greuel**, and **I.J. Shelton**, Research Associates, Agriculture Canada, Ontario Institute of Pedology, Guelph.

(a) SOIL INTERPRETATIONS FOR WATER EROSION

(1) *Introduction*

Soil erosion by water is a naturally occurring process that can be greatly accelerated by man's activity. Any practice that accelerates soil runoff, or reduces the natural protection afforded by vegetative cover, will generally lead to increasing erosion levels. It is commonly held that soil erosion reduces production potential, depletes nutrients, and degrades soil tilth. However, recent studies in the Canadian Great Lakes basin have illustrated the need to look beyond the on-site effects of soil erosion and consider the role of sediments, derived from cropland, on water quality. Any comprehensive soil conservation program will recognize the dual nature of the problem of soil erosion by water.

The purpose of this section is to provide interpretations of the erosion potential of the Haldimand-Norfolk Region soils and soil landscapes. Specifically, the objectives may be summarized as follows:

(a) to determine the relative erodibility of surficial soil materials;
(b) to determine the effect of soil erodibility and slope on soil erosion potential;
(c) to provide information on the effects of different crops and associated cropping practices on soil erosion potential;
(d) to illustrate how the soil maps, in combination with information from the report, can be used to assess site-specific soil erosion problems and alternative solutions;
(e) to provide guidelines for estimating soil erosion potential at the regional scale.

(2) *Factors Affecting Soil Erosion by Water*

On-site planning for soil and water conservation requires information on the relationship between factors that cause soil erosion, and practices that may reduce soil erosion. The most important factors affecting agricultural erosion are usually considered to be rainfall runoff, soil erodibility, slope gradient and length, and vegetative cover.

Both rainfall and runoff parameters must be considered in the assessment of a water erosion problem. Rainfall-induced erosion is maximum when the energy of the rainfall is greatest. In Ontario, it is the high-intensity, short-duration thunderstorm activity of the summer months that produces the highest-energy rainfall events. On the other hand, runoff from agricultural land is greatest during the spring months when the soils are usually saturated, the snow is melting, and evapotranspiration is minimal. A good soil and water management program must address itself to rainfall and runoff problems, in both the spring and the summer periods.

Soil erodibility is defined as the inherent susceptibility of a soil material to erode. Soil properties that influence erodibility by water are those that affect the infiltration rate, permeability and water-holding capacity of the soil. Soil properties that resist the dispersion, splashing, abrasion and transporting forces of rainfall and runoff, also influence soil erodibility. Silt, silt loam and very fine sand soils often have the greatest soil erodibility potential, whereas sandy and clayey soils usually have the least inherent soil erodibility. Maintenance of soil organic matter and soil structure, through good soil management, can greatly affect soil erodibility potentials.

Soil erosion by water has been found to increase, with both increasing slope gradients and slope lengths. Steep slopes facilitate the runoff of water and reduce the infiltration of water. The potential for erosion on long slopes is enhanced by rapid and voluminous runoff which can generate high erosive energy at downslope positions. Hence the effective slope length should be an important soil conservation consideration in farm field consolidation efforts.

The effect of vegetative cover or mulches, in reducing soil erosion, is well known. Table 14 illustrates the relative effectiveness of common field crops in reducing water erosion potential in Ontario. If unvegetated or bare soil is assigned a numerical value of 1.0, then the vegetative cover afforded by bean, tomato, or cucumber crops has the potential to reduce water erosion by approximately 50% (Table 14). Similarly, a hay-pasture or permanent pasture

Table 14. The relative effectiveness of common field crops in reducing water erosion in Ontario

Cover type	C-factor value[1]
Fallow land (bare soil)	1.00
Beans	.47
Cucumber	.45
Tomato	.43
Continuous corn	
- fall plowed	.45
- spring plowed	.39
- chisel plowed	.27
- zero tillage	.08
Corn in rotation	.30
Mixed grains	.27
Winter wheat	.25
Rye	.25
Tobacco	.30
Hay-pasture (rotation)	.06
Permanent pasture	.03

[1]*Cropping-management factor, Wischmeier and Smith (28).*

vegetation cover has the potential of reducing water erosion to less than 10% of that from fallow or bare land.

(3) *Measurement of Factors Affecting Water Erosion*

In order to make meaningful recommendations, with respect to soil conservation practices, one must be able to recognize the significance of a soil erosion problem, and provide appropriate cost-effective erosion control alternatives when a problem is encountered. Although qualitative approaches can be useful in many circumstances, the temporal nature of soil erosion, as well as the difficulty in witnessing sheet erosion losses in the field, make a quantitative approach to erosion assessment and control recommendations more practical.

The quantification of the factors affecting agricultural erosion, *i.e.,* rainfall, soil erodibility, slope, vegetation and conservation measures, is based on widespread erosion research compiled from nearly 10 000 plot-years of field data, and from rainfall records obtained from about 2 000 weather stations in North America. The resulting soil erosion formula is in extensive use by the Soil Conservation Service of the United States Department of Agriculture, for applying and planning conservation measures that reduce soil erosion to acceptable amounts (28). It is only recently that the erosion factors have been quantified for use in Ontario (29, 30).

The water erosion formula, A=RKLSCP, used to predict average annual soil loss through sheet and rill erosion, is called the universal soil loss equation (28), where

A - is the computed soil loss in tons per acre per year.

R - the rainfall factor, is the number of erosion-index units in a normal year's rain.

K - the soil erodibility factor is the erosion rate, per unit of erosion index for a specific soil, in cultivated, continuous fallow. This unit is expressed in tons per acre.

L - the slope length factor is the ratio of soil loss from a field slope length, to soil loss from a 72.6 foot plot.

S - the slope gradient factor is the ratio of soil loss from the field slope gradient, to soil loss from a 9% plot slope.

C - the cropping-management factor is the ratio of soil loss from a field with specific vegetation or cover and management, to soil loss from the standard, bare or fallow condition. This factor measures the combined effect of all the interrelated cover and management variables, plus the growth stage and vegetal cover, during rainfall episodes.

P - the erosion control practice factor is the ratio of soil loss using a particular management practice, to soil loss from a field not using that practice.

When the numerical values for each variable are multiplied together, the product is the average annual soil loss, in t/ac/a (conversion to metric equivalents, t/ha/a, requires multiplication by 2.24). It should be emphasized that the formula estimates sheet and rill erosion but does not consider soil losses caused by gully erosion or stream channel erosion. Since the erosion formula does not contain a transport or delivery factor it does not predict sediment load of streams. A brief description of each factor in the soil erosion formula now follows.

(a) Rainfall Factor (R)

The R-value reflects the erosivity of rains, and is generally related to climatic factors. R-values for Ontario range from 25 to 100. The Haldimand-Norfolk Region has an approximate R-value of 80. The distribution of R-values, for southern Ontario, is shown in Figure 44 of the erosion appendix, and discussed elsewhere by Wall *et. al.* (31).

(b) Soil Erodibility Factor (K)

The K-value reflects the inherent erodibility of a soil due to the erosive activity of water.

Table 15 illustrates the K-values and K-ranges for the soils of the Haldimand-Norfolk Region. The K-values were computed by the method outlined by Wischmeier and Smith (28). These K-values range from a mean low of .05 for the Brady soils, due in part to the high proportion of medium and fine sands characteristic of these soils, to a mean high of .41 for the Brant soils, which contain a large proportion of easily erodible very fine sand and silt. In terms of relative erodibility, the Brant soils are about 8 times more erodible than the Brady soils (.41/.05), when all other soil loss factors are held constant.

Table 15 also categorizes the various soils into five soil erodibility classes (negligible to very severe) based upon their respective K-values. The guidelines used for establishing these soil erodibility classes are given in Table 16. The soils in the Haldimand-Norfolk Region range from negligible, e.g. Brady, to severe, e.g. Brant, in terms of their erodibility classes.

The particle size distribution (% sand, silt and clay) and organic matter content are important factors in determining soil erodibility. Table 17 provides an alternative method of approximating K-values, if only soil texture and organic matter content are known. The K-values reported in Table 17 were computed from data gathered from almost 1000 surface horizons, sampled during the soil mapping of the Haldimand-Norfolk Region. If the textural class is known, but not the organic matter content, a K-value can be estimated from the mean values of the last column of Table 17.

Continued on page 70

Table 15. K-values, K-ranges and erodibility classes for Haldimand-Norfolk soils

Soil map unit components	Map symbol	No. of sites	Mean K-values	K-ranges	Usual erodibility class**
Alluvium 1	1-ALU	2	0.14	0-0.33	Variable
Alluvium 1 very shallow phase	1-ALU.V	0	0.14*		Variable
Alluvium 2	2-ALU	1	0.27	0.27	1-2
Alluvium 3	3-ALU	2	0.30	0.29-0.34	2-3
Aluvium 4	4-ALU	1	0.27	0.27	2
Alluvium 4 coarse phase	4-ALU.C	0	0.20*		1-2
Berrien	BRR	9	0.27	0.12-0.45	2
Berrien heavy clay phase	BRR.H	2	0.08	0.03-0.13	1
Berrien till phase	BRR.T	16	0.16	0.03-0.32	1-2
Beverly	BVY	23	0.29	0.23-0.36	2-3
Beverly coarse phase	BVY.C	7	0.16	0.09-0.26	1-2
Beverly loamy phase	BVY.L	7	0.32	0.20-0.43	3
Beverly shallow phase	BVY.S	0	0.29*		2-3
Beverly very shallow phase	BVY.V	0	0.29*		2-3
Bookton	BOO	8	0.19	0.11-0.36	1-2
Bookton till phase	BOO.T	10	0.17	0.03-0.38	1-2
Brady	BAY	18	0.05	0-0.22	1
Brady loamy phase	BAY.L	0	0.26*		2
Brant	BRT	13	0.41	0.30-0.55	3-4
Brant coarse phase	BRT.C	1	0.12	0.12	1
Brant very shallow phase	BRT.V	0	0.41*		3-4
Brantford	BFO	40	0.30	0.19-0.42	2-3
Brantford coarse phase	BFO.C	2	0.07	0.02-0.12	1
Brantford loamy phase	BFO.L	11	0.34	0.26-0.54	3
Brantford shallow phase	BFO.S	0	0.30*		2-3
Brantford very shallow phase	BFO.V	1	0.30	0.30	2-3
Brooke	BOK	1	0.24	0.24	2
Burford	BUF	6	0.13	0-0.28	1
Colwood	CWO	21	0.30	0.01-0.45	2-3
Colwood coarse phase	CWO.C	1	0.16	0.16	2
Colwood peaty phase	CWO.P	0	0.23*		2
Complex 1	CPX 1				Variable
Complex 2	CPX 2				Variable
Complex 3	CPX 3				Variable
Complex 4	CPX 4				Variable
Complex 5	CPX 5				Variable
Complex 6	CPX 6				Variable
Farmington	FRM	1	0.29	0.29	2-3
Fox	FOX	71	0.06	0-0.33	1
Fox shallow phase	FOX.S	0	0.06*		1
Fox very shallow phase	FOX.V	0	0.06*		1
Gobles	GOB	7	0.31	0.24-0.36	2-3
Gobles coarse phase	GOB.C	7	0.24	0.12-0.39	2
Gobles loamy phase	GOB.L	8	0.30	0.19-0.45	2-3
Granby	GNY	20	0.05	0-0.21	1
Granby loamy phase	GNY.L	0	0.26*		2
Granby peaty phase	GNY.P	2	0.23	0.22-0.25	2
Granby very shallow phase	GNY.V	0	0.05*		1
Haldimand	HIM	50	0.25	0.18-0.33	2
Haldimand coarse phase	HIM.C	0	0.14*		2
Haldimand loamy phase	HIM.L	12	0.29	0.23-0.39	2-3
Haldimand shallow phase	HIM.S	0	0.25*		2
Hampden	HMP	2	0.17	0.14-0.21	2
Kelvin	KVN	5	0.25	0.18-0.34	2
Kelvin coarse phase	KVN.C	1	0.08	0.08	1
Kelvin loamy phase	KVN.L	8	0.31	0.21-0.40	2-3
Kelvin peaty phase	KVN.P	0	0.23*		2
Lincoln	LIC	33	0.23	0.13-0.33	2
Lincoln coarse phase	LIC.C	3	0.14	0.10-0.22	2
Lincoln loamy phase	LIC.L	7	0.28	0.21-0.36	2-3
Lincoln peaty phase	LIC.P	0	0.23*		2

(Continued on page 68)

Table 15. K-values, K-ranges and erodibility classes for Haldimand-Norfolk soils — *continued*

Soil map unit components	Map symbol	No. of sites	Mean K-values	K-ranges	Usual erodibility class**
Lincoln shallow phase	LIC.S	0	0.23*		2
Lincoln very shallow phase	LIC.V	0	0.23*		2
Lonsdale	LDL	2	0.28	0.26-0.30	2
Lowbanks	LOW	4	0.16	0.02-0.38	1-2
Maplewood	MPW	3	0.27	0.21-0.31	2
Marsh	MAR				Variable
Muriel	MUI	7	0.32	0.24-0.42	2-3
Muriel coarse phase	MUI.C	6	0.23	0.06-0.36	2
Muriel loamy phase	MUI.L	4	0.28	0.22-0.42	2-3
Niagara	NGR	2	0.25	0.23-0.27	2
Niagara coarse phase	NGR.C	0	0.14*		2
Niagara loamy phase	NGR.L	0	0.29*		2-3
Normandale	NDE	17	0.33	0.14-0.55	3
Normandale coarse phase	NDE.C	0	0.10*		1
Oakland	OKL	6	0.13	0.01-0.17	1
Oakview	OVW	1	0.25	0.25	2
Ontario	OTI	1	0.29	0.29	2-3
Ontario coarse phase	OTI.C	1	0.14	0.14	1
Plainfield	PFD	68	0.10	0-0.37	1
Plainfield dune phase	PFD.D	29	0.06	0-0.29	1
Scotland	STD	26	0.11	0-0.24	1
Ridge	RID				Variable
Seneca	SNA	8	0.30	0.28-0.32	2-3
Seneca coarse phase	SNA.C	0	0.10*		1
Seneca shallow phase	SNA.S	0	0.30*		2-3
Seneca very shallow phase	SNA.V	0	0.30*		2-3
Silver Hill	SIH	10	0.13	0.07-0.22	1-2
Smithville	SHV	31	0.28	0.20-0.38	2-3
Smithville coarse phase	SHV.C	0	0.14*		1
Smithville loamy phase	SHV.L	4	0.28	0.20-0.33	2-3
Smithville shallow phase	SHV.S	0	0.28*		2-3
St. Williams	SLI	17	0.20	0.06-0.41	2
Styx	SYX	1	0.24	0.24	2
Tavistock	TVK	4	0.36	0.31-0.43	3
Toledo	TLD	19	0.28	0.23-0.35	2-3
Toledo coarse phase	TLD.C	3	0.15	0.14-0.16	1-2
Toledo peaty phase	TLD.P	0	0.23*		2
Toledo shallow phase	TLD.S	0	0.28*		2-3
Toledo very shallow phase	TLD.V	0	0.28*		2-3
Tuscola	TUC	16	0.35	0.20-0.52	3
Tuscola coarse phase	TUC.C	0	0.14*		1
Tuscola shallow phase	TUC.S	0	0.35*		3
Tuscola very shallow phase	TUC.V	0	0.35*		3
Urban Land	U.L.				Variable
Vanessa	VSS	3	0.19	0.18-0.21	2
Vanessa peaty phase	VSS.P	0	0.23*		2
Vittoria	VIT	17	0.15	0.03-0.32	1-2
Walsher	WSH	13	0.11	0.02-0.33	1
Walsingham	WAM	56	0.09	0-0.27	1
Waterin	WRN	35	0.09	0-0.19	1
Waterin loamy phase	WRN.L	1	0.26	0.26	2
Waterin peaty phase	WRN.P	3	0.22	0.13-0.29	2
Wattford	WAT	23	0.28	0.06-0.67	2-3
Wauseon	WUS	6	0.21	0.09-0.31	2
Wauseon peaty phase	WUS.P	0	0.23*		2
Wauseon till phase	WUS.T	3	0.16	0.13-0.21	1-2
Welland	WLL	3	0.26	0.25-0.27	2
Welland coarse phase	WLL.C	0	0.14*		1
Welland loamy phase	WLL.L	0	0.29*		2-3
Wilsonville	WIL	22	0.13	0-0.27	1-2
Wilsonville coarse phase	WIL.C	0	0.10*		1
Wilsonville loamy phase	WIL.L	0	0.29*		2-3

Smithville very shallow phase	SHV.V	0	0.28*	2-3
Wilsonville shallow phase	WIL.S	0	0.13*	1-2

**Estimated K-values because laboratory data not available.*

***See Table 16 for erodibility class definitions.*

Continued from page 66

(c) Slope Gradient (S) and Slope Length (L) Factors

The close interaction between slope and field length has resulted in their combination into one variable, LS, known as the topographic factor. Table 25 in the erosion appendix presents, in chart form, the LS-values covering a wide range of slope and field lengths. For slope or field lengths within the range of the table, but not presented explicitly, linear interpolation will provide a satisfactory value.

(d) Cropping-management Factor (C)

C-values reflect the influence of various types of crop canopy and management practices on soil erosion by water. The C-values prepared for the Haldimand-Norfolk Region were calculated using crop data obtained from regional agricultural extension personnel. Management practices, stages of crop growth, and dates of planting and harvesting, often varied significantly between the former Counties of Haldimand and Norfolk. Thus a set of C-values was computed for each former county in order to represent the most common practices in each county as accurately as possible.

Due to the clayey nature of many of the Haldimand County soils, fall plowing is a common practice, and the spring planting dates for Haldimand tend to be later than those for Norfolk. Consequently, a protective crop canopy develops approximately one week earlier in much of Norfolk, which accounts for the slightly lower C-values for this area as compared to corresponding Haldimand values. In Haldimand County, for example, a corn crop which is preceded by a bean crop and fall plowing, has a C-value of .50 (one-half the amount lost from corresponding fallow), compared with the corresponding value of .48 from Norfolk County. This slight difference is probably due to a variance in crop stage dates between the counties. For other crops or systems, the values may be the same for both former counties, e.g., corn after fall plowing, following corn or grain. These C-values represent the soil loss during a particular crop year. Rotational systems have much lower C-values, because the C-values of all crops in each system are averaged to obtain an average, annual, rotational C-value. The comparatively high C-values of corn are offset by the relatively low C-values of crops such as meadows, so that rotational averages are generally lower than C-values for most individual crops. For example, a Haldimand rotation of four years of corn, two years of soybeans, and one year each of winter wheat and barley, has a C-value of .42, as compared to the .44 value of corn after corn or grain. A rotation which contains a sod-forming meadow has an even lower C-value. For example, a Norfolk rotation of two years of corn, one year of grain and four years of alfalfa and brome grass, initially underseeded to the grain, has a C-value of .09.

Table 18 shows the C-values for the rotational field crops and management practices in Haldimand County. The C-values for major rotational field crops and management practices in Norfolk County are shown in Table 19. C-values for horticultural crops in the Haldimand-Norfolk Region are found in Table 20. Information on common cropping systems and crop rotations was obtained from the regional agricultural extension offices, to determine C-values for common rotations in the Haldimand-Norfolk Region (Table 21).

C-values can be used to estimate the effectiveness of a particular crop or system for controlling soil erosion. For example, the residue from a soybean crop, after harvest, does not protect the soil effectively. In Haldimand, the C-value for continuous soybeans which are fall-plowed is .56, or 56% of the amount of erosion that would occur under fallow or bare soil conditions. To reduce this amount the

Table 16. Guidelines for establishing soil erodibility classes

Class	Soil erodibility potential	K-value[1]	Soil characteristics *significant for* water erosion
1	Negligible	less than .15	Silt and very fine sand <25%; > 4% organic matter; very fine granular structure; rapid permeability
2	Slight	.15-.30	Silt and very fine sand, 25-40%; <4% organic matter; medium or coarse granular structure; moderate permeability
3	Moderately severe	.30-.40	Silt and very fine sand, 40-80%; <3% organic matter; medium or coarse granular structure; slow to moderate permeability
4	Severe	.40-.50	Silt and very fine sand, > 80%; <2% organic matter; blocky, platy or massive structure; slow permeability
5	Very severe	more than .50	Silt and very fine sand, > 90%; <1% organic matter; blocky, platy or massive structure; very slow permeability

[1]*Adapted from Wischmeier, W.H. and D.D. Smith (28)*

Table 17. Soil erodibility (K factor) values for common surface textures in the Haldimand-Norfolk Region

	K factors		
Textural class	Samples with <2% organic matter	Samples with > 2% organic matter	Mean value of all samples
Sand	.03	.01	.02
Fine Sand	.09	.06	.08
Very fine sand	.46	.37	.43
Loamy sand	.05	.04	.04
Loamy fine sand	.15	.09	.11
Loamy very fine sand	.44	.25	.39
Coarse sandy loam	—	.07	.07
Sandy loam	.14	.12	.13
Fine sandy loam	.22	.17	.18
Very fine sandy loam	.41	.33	.35
Loam	.34	.29	.30
Silt loam	.41	.37	.38
Sandy clay loam	—	.20	.20
Clay loam	.33	.28	.30
Silty clay loam	.35	.30	.32
Silty clay	.27	.26	.26
Clay	.24	.21	.22
Heavy clay	.19	.15	.17

farmer can spring-plow the crop or, if this is not feasible, use an alternative tillage practice such as fall chiselling, which gives a C-value of .53. Further reductions in soil loss can be achieved by not growing the crop continuously. Soybeans grown after a year of corn or grains have a C-value of .53. Soybeans grown the second year after a sod crop have a C-value of .42 for the year, and if grown the first year after sod, the C-value is .24.

The previous C-values, with the exception of continuous soybean C-values, are for single crop years of soybeans. These values represent the amount lost only during the year the field is in soybeans. Estimates of the average, annual C-values for common or known rotational systems in Haldimand, that contain one or two years of soybeans, are listed in Table 21. Those rotational C-values are also an improvement on the initial C-values, shown in Table 18, for the continuous soybean crops.

To assist in interpreting the management practices outlined in abbreviated form in Tables 18, 19 and 20, refer to the following legend:

Sprg - spring
TP - moldboard plowing
Cult. - shallow disked
HV - harvest
Gr - grain
Chisel - chisel plowed
RdR - residue from crop removed at or after harvest
RdL - residue from crop left on field.
Note that all residues are assumed to be left on the field unless otherwise stated.

Table 18. C-values for continuous and rotational crops in the Haldimand Region

Crop	Previous crop	Management before crop	Management after crop	C-value
Alfalfa	Field crops	Fall TP, direct seeded (Sprg)		.23
		- establishing year		.02
		- each full year in meadow		.02
	Winter wheat, grain	Underseeded in previous crop		.02
		- each full year in meadow		.02
Barley	Field crops	Fall TP	Fall TP or meadow	.28
	Field crops (2nd yr after meadow or sod)	Fall TP	Fall TP	.27
	Meadow or sod	Fall TP	Fall TP	.14
Clover	Field crops	Fall TP, direct seeded (Sprg)		
		- establishing year		.22
		-each full year in meadow		.015
	Field crops	Underseeded in previous crop		.015
Corn	Corn, grain	Fall TP (RdR)	Fall TP or chisel	.63
	Beans	Fall TP (RdL)	Fall TP or chisel	.50
	Beans (2nd year after meadow or sod)	Fall TP (RdL)	Fall TP or chisel	.46
	Corn, grain	Fall TP (RdL)	Fall TP or chisel	.44
	Beans	Fall chisel	Fall TP or chisel	.44
	Beans	Sprg TP	Sprg TP or chisel	.42
	Corn, grain (2nd yr after meadow or sod	Fall TP	Fall TP or chisel	.40
	Beans	Sprg chisel	Sprg TP or chisel	.38
	Corn, grain	Sprg TP	Sprg TP or chisel	.33
	Meadow or sod (RdR)	Fall TP	Fall TP or chisel	.31
	Corn, grain	Sprg chisel	Sprg TP or chisel	.30
	Meadow or sod	Fall TP	Fall TP or chisel	.22
	Meadow or sod	Sprg TP	Sprg TP	.12
Oats	Field crops	Fall TP	Fall TP or meadow	.26
	Field crops (2nd yr after meadow or sod)	Fall TP	Fall TP	.25
	Meadow or sod	Fall TP	Fall TP	.12
Soybeans	Beans	Fall TP	Fall TP or chisel	.56
	Beans	Fall chisel or disk	Fall TP or chisel	.53
	Corn, grain	Fall TP	Fall TP or chisel	.53
	Field crops (2nd yr after meadow or sod)	Fall TP	Fall TP or chisel	.42
	Meadow or sod	Fall TP	Fall TP or chisel	.24
Winter Wheat	Field crops	Fall TP	Fall TP or underseeded meadow	.36
	Field crops (2nd yr after meadow or sod)	Fall TP	Fall TP or underseeded meadow	.32
	Corn (RdR)	Fall disk	Fall TP or underseeded meadow	.30
	Grain, beans	Fall disk	Fall TP or underseeded meadow	.27
	Corn (RdR) (2nd yr after meadow or sod)	Fall disk	Fall TP or underseeded meadow	.26
	Grain, beans (2nd yr after meadow or sod)	Fall disk	Fall Tp or underseeded meadow	.24
	Meadow	Fall disk	Fall TP	.14

Table 19. C-values for continuous and rotational crops in the Norfolk Region

Crop	Previous crop	Management before crop	Management after crop	C-value
Beans	Beans	Fall TP	Fall TP	.58
	Corn, grain	Fall TP	Fall TP	.52
	Beans	Sprg TP	Sprg TP	.35
	Beans	Sprg chisel	Sprg chisel	.29
	Corn, grain	Sprg TP	Sprg TP	.29
	Corn, grain	Sprg chisel, disk	Sprg chisel, disk	.24
Corn	Beans	Fall TP	Fall TP	.48
	Corn, grain	Fall TP	Fall TP	.44
	Field crops	Fall chisel or disk, sprg disk	Fall TP or chisel	.43
	Beans	Sprg TP	Sprg TP	.42
	Beans	Sprg disk	Sprg TP	.36
	Corn, grain	Sprg TP	Sprg TP	.34
	Beans, 2nd yr after meadow	Sprg disk	Sprg TP	.33
	Corn, 2nd yr after meadow or sod	Sprg TP	Sprg TP	.30
	Corn, grain	Sprg chisel, disk	Sprg TP	.23
	Meadow or sod	Sprg TP	Sprg TP	.17
Grain	Corn (RdR)	Sprg disk	Sprg disk or TP	.16
	Field crops	Sprg disk or TP	Sprg disk or TP	.12
Meadow (alfalfa and brome grass)	Field crop	Direct seeded (Sprg)	Sprg TP	
		- establishing year		.02
		- each full year in established meadow		.004
Peanuts	Peanuts	Fall and sprg disk	Fall (RdL)	.54
	Grain	Sprg TP	Sprg disk	.31
Tobacco	Tobacco	Sprg TP	Sprg TP, winter fallow	.49
	Winter wheat, rye	Sprg TP	Fall disk (yearly rotational average given)	.25
Winter wheat or rye	Field crops, vegetables	Fall TP	Fall TP or underseeded	.32
	Vegetables (RdR)	Fall TP	Fall TP or underseeded	.28
	Vegetables (RdR)	Fall disk	Fall TP or underseeded	.24
	Field crops, vegetables	Fall disk	Fall TP or underseeded	.18

Table 20. C-values for horticultural crops grown in rotation in the Haldimand-Norfolk Region

Crop	Previous crop	Management before crop	Management after crop	Following crop(s)	C-value
Asparagus	20 years continuous	Sprg disk			.56
Beans	Field, vegetable crops	Fall TP	Fall disk or TP	Winter or Sprg crop	.54
	Field, vegetable crops	Sprg TP	Sprg disk or TP	Winter or Sprg crop	.34
Cabbage	Vegetables, grain	Sprg disk	Sprg disk or TP	Winter or Sprg crop	.57
Carrots	Vegetables (carrots)	Fall TP at HV	Fall disk or TP at HV	Sprg crop	.48
	Rye	Sprg TP	Fall disk	Rye (rotational average)	.27
Cauliflower	Potatoes	TP after potato HV	Fall or Sprg disk	Sprg crop	.57
Corn (sweet)	Field, vegetable crops	Fall TP	Fall TP	Sprg crop	.53
	Field, vegetable crops	Sprg TP	Sprg TP	Sprg crop	.45
	2nd year after sod	Sprg TP	Sprg disk or TP	Sprg crop	.40
	Corn, grain	Sprg chisel	Sprg disk, chisel or TP	Sprg crop	.27
	Sod	Sprg TP	Sprg TP	Sprg crop	.23
Cucumbers	Field, vegetable crops	Sprg TP	Sprg disk or TP	Sprg crop	.23
	Field, vegetable crops	Sprg cult	Sprg disk, cult or TP	Sprg crop	.19
Orchards	Continuous	13 ft in height, 0% ground cover, 25% canopy			.42
	Continuous	13 ft in height, 0% ground cover, 50% canopy			.39
	Continuous	13 ft in height, 95% ground cover, 25-50% canopy			.003
Peas	Field, vegetable crops	Fall TP	Fall TP (RdR)	Sprg crop	.61
	Field, vegetable crops	Sprg TP	Sprg TP (RdR)	Sprg crop	.53
Peppers	Field, vegetable crops	Fall TP	Fall TP	Sprg crop	.52
	Field, vegetable crops	Sprg TP	Sprg TP	Sprg crop	.43
Potatoes	Field, vegetable crops	Fall disk or TP at HV	Fall disk or TP at HV	Sprg crop	.44
	2nd year after sod	Sprg TP	Sprg disk or TP	Sprg crop	.43
	Sod	Sprg TP	Sprg disk or TP	Sprg crop	.30
	Winter crop	Sprg TP	Sprg disk or TP	Winter crop (rotational average)	.27
Pumpkins	Field, vegetable crops	Sprg TP	Sprg disk or TP	Sprg crop	.20
Raspberries	10-15 yrs continuous	50% canopy cover, 0% ground cover			.29
	10-15 yrs continuous	75% canopy cover, 0% ground cover			.24
	10-15 yrs continuous	50% canopy cover, 50% ground cover			.14
	10-15 yrs continuous	75% canopy cover, 75% ground cover			.09
Spanish onions	Vegetables	Fall disk or TP	Fall disk or TP	Winter or Sprg crop	.50
	Winter crop, grain	Sprg disk or TP	Sprg disk or TP	Winter crop (rotational average)	.31
Squash	Field, vegetable crops	Sprg cult	Sprg disk or TP	Sprg crop	.16
Strawberries	4 years continuous		Straw cover (Fall)		.29
	5 years continuous		Straw cover (Fall)		.28
Tomatoes	Field, vegetable crops	Fall TP	Fall TP	Sprg crop	.49
	Field, vegetable crops	Sprg TP	Sprg TP	Sprg crop	.36
Turnips	Field, vegetable crops	Fall TP at HV	Fall disk or TP at HV	Sprg crop	.49
Wooded or idle lands		45-100% canopy cover, 75-100% of area covered in duff			.002

Table 21. C-values for common crop rotations in the Haldimand-Norfolk Region

Rotational system	Management	C-value (yearly average)	Number of crop years in system
Corn-Corn-Corn-Corn-Soybeans-Soybeans-Winter Wheat	Fall TP after corn; fall disk or chisel after soybeans, winter wheat	.44	7
Corn-Corn-Corn-Corn-Soybeans-Soybeans-Winter Wheat-Barley	Fall TP after corn; fall disk or chisel after soybeans, winter wheat, grain	.42	8
Corn-Corn-Soybeans-Winter Wheat-Red Clover	Fall TP after corn, meadow; fall disk or chisel after soybeans; 1 yr meadow, underseeded in winter wheat	.29	5
Tobacco-Rye or-Winter Wheat	Spring TP before tobacco; disk before winter crop	.25	2
Corn-Corn-Barley-Winter Wheat-Red Clover	Fall TP after corn, meadow; disk after barley; 1 yr meadow underseeded in winter wheat	.24	5
Corn-Corn-Oats-Winter Wheat-Red Clover	Fall TP after corn, meadow; disk after oats; 1 yr meadow, underseeded in winter wheat	.23	5
Barley-Corn-Winter Wheat-Red Clover	Fall TP after corn; disk after barley; 1 yr meadow, underseeded in winter wheat	.23	4
Peanuts-Grain	Sprg disk after peanuts; TP or disk after grain	.22	2
Corn-Corn-Barley-Winter Wheat-Alfalfa or Trefoil	Fall TP after corn, meadow; disk after barley; 3 yr meadow, underseeded in winter wheat	.20	7
Corn-Winter Wheat-Red Clover	Fall disk after corn (RdR), meadow; 1 yr meadow, underseeded in winter wheat	.20	3
	Fall disk after corn (RdL), meadow; 1 yr meadow, underseeded in winter wheat	.19	3
Corn-Corn-Alfalfa or Trefoil	Fall TP after corn, meadow; 3 yr meadow, directly seeded	.18	5
Barley-Winter Wheat-Red Clover	Fall TP after meadow; disk after barley; 1 yr meadow, underseeded in winter wheat	.14	3
Corn-Corn-Grain-Alfalfa and Brome Brass	Sprg TP after corn; disk after grain (if meadow directly seeded), or meadow underseeded in grain		
	4 yr meadow	.09	7
	5 yr meadow	.08	8

(4) *Soil Erosion Assessment*

Regional or site-specific assessment of soil erosion potential may be calculated using the quantitative relationships developed in the universal soil loss equation (28), and information contained in this report. A graphical solution of the universal soil loss equation, in the form of a nomograph, is available for ease of computation. The soil loss nomograph provides a rapid method for assessing the effect of many land uses on soil loss potentials, for various soil and slope conditions. The following discussion illustrates how information contained in this section, and elsewhere in the soils report, may be used for predicting soil loss potentials on either a regional or site-specific basis.

(a) Regional Soil Loss Potential

The soil maps of the Haldimand-Norfolk Region provide delineations of soil, slope, and drainage conditions, at a scale of 1:25 000. Information contained in this section, with respect to soil erosion, can be used with information contained on the soil maps and legends to assess the relative erosion potential of most map unit delineations. Figure 42 illustrates part of a soil map and legend for the Haldimand-Norfolk Region.

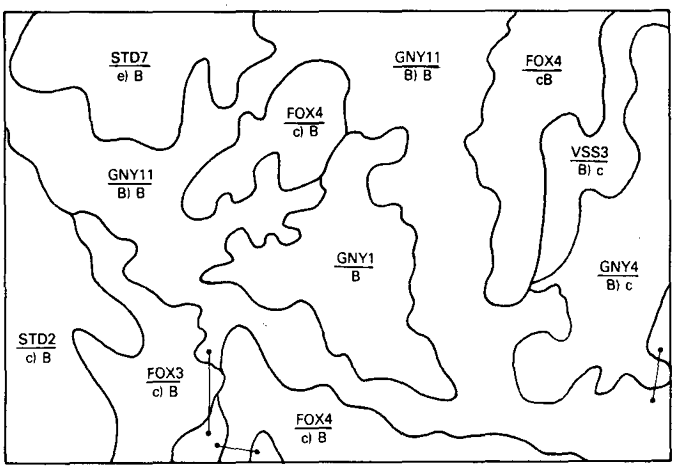


Figure 42. Portion of a soil map and legend for the Haldimand-Norfolk Region

LEGEND

Map unit symbol	Map unit components #1	#2	Parent material components #1	#2	Drainage components #1	#2
FOX 3	FOX	GNY	Mainly lacustrine sand and loamy sand	Mainly lacustrine sand and loamy sand	Rapid to well	Poor
FOX 4	FOX	BAY	see Fox 3	Mainly lacustrine sand and loamy sand	Rapid to well	Imperfect
GNY 4	GNY	BAY	see Fox 3	see Fox 4	Poor	Imperfect

SLOPE GROUPS

Simple	Complex	Percent
B		0-2
C	c	2-5
D	d	5-9
E	e	9-15
F	f	15-30
G	g	30+

Using Figure 42 as an example, the following discussion illustrates how interpretations of regional soil potential from erosion can be made.

1. In Figure 42, locate areas on the map for which the erosion potential is desired, and note the map unit symbol (e.g., Fox 3/c > B).
2. Go to the map legend and find the appropriate map unit symbol (e.g. Fox 3). The Fox 3 map unit is composed of dominantly Fox soils on c slopes, with a significant component of Granby soils on B slopes, in approximate proportions of 70:30.
3. Determine the erodibilities (K-values) of the Fox and Granby soils from Table 15 (Fox = .06, Granby = .05).
4. Determine the topographic factors (LS-values) for C and B slopes of the Fox and Granby soils, respectively, from Table 26 (C = .40, B = .19).
5. Using the soil loss prediction nomograph (Figure 43), locate the K- and LS-values for the Fox soil on the appropriate axes (K = .06, LS = .40). Draw a line between the K and LS values to intersect the pivot line. Draw another line from the current or proposed land use through the point where the K-LS and the pivot lines intersect, to the soil loss potential axis. For example, if corn was the existing or proposed crop, the soil loss for the corn land use on Fox soils would be approximately 4 t/ha, a negligible amount.

   Repeat this procedure for the Granby soil, K = .05 and LS = .19. The potential soil loss for a corn crop on Granby is approximately 2 t/ha, again a negligible amount.

   Therefore, the potential soil loss for this soil map unit is negligible.
6. Repeat interpretations for other map unit symbols of interest, to gain a regional perspective of the potential soil erosion loss.

The potential soil loss, calculated in this way, provides a general estimate of the potential erosion for a region. However, if the regional estimate is applied to specific fields, differences will exist because the regional information lacks the accuracy of a site-specific assessment.

An erosion potential classification system has been developed to quantify potential soil erosion losses into a five-class system, ranging from negligible to very severe (Table 22). Results derived from the soil loss prediction nomograph can be assessed, using Table 22, to determine whether unacceptable losses occur. If so, the crops or conservation measures that would be most appropriate to reduce erosion, can be determined.

Table 22. Guidelines for assessing soil erosion potential classes

Soil erosion class	Soil erosion potential t/ha/a soil loss	
1	Negligible	(<6)
2	Slight	(6-11)
3	Moderately Severe	(11-22)
4	Severe	(22-33)
5	Very Severe	(<33)

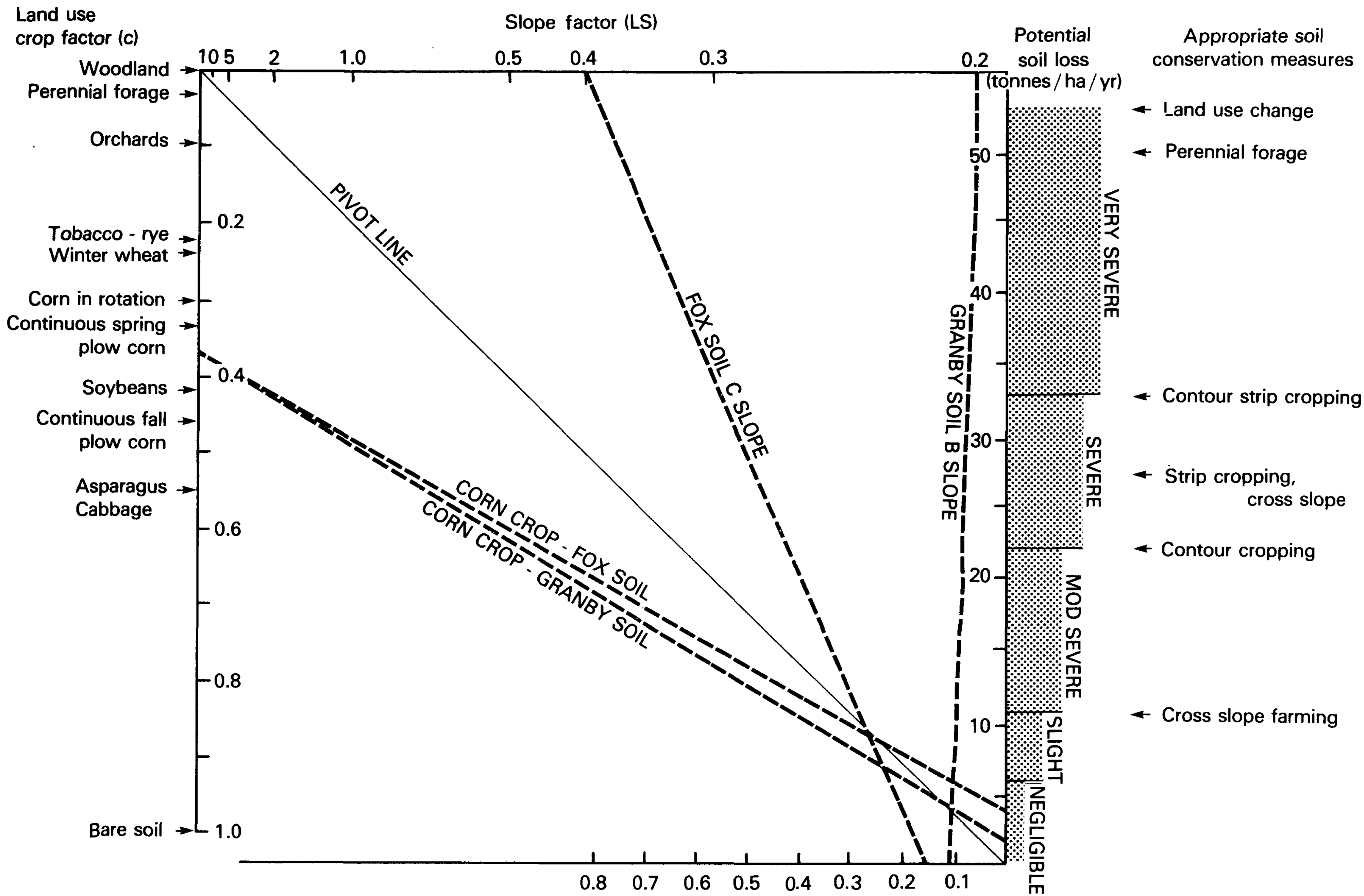


Figure 43. Nomograph for the prediction of cropland erosion potential in the Haldimand-Norfolk Region

(b) Site Specific Soil Loss Potential

Information contained on the soil maps, and in this erosion section, can also be used to make site-specific assessments of soil loss levels, and the effects of alternative remedial measures as follows:

(a) Determine the K-value of the specific site from Table 15, or Table 16. Then locate the appropriate position for the K-value on the soil erodibility axis of the nomograph in Figure 43.

(b) Determine the slope gradient and slope length directly from the site. Use these values, along with Table 23, to arrive at the LS-value for the site. Locate this value at the appropriate position on the LS axis of the nomograph in Figure 43.

(c) Draw a line between the K-value and the LS-value to determine the intercept point on the pivot line in Figure 43.

(d) Draw a line from the land use in question, through the point where the soil erodibility-slope/length (K-LS) line intersects the pivot line, to the potential soil loss axis.

A sample calculation is provided:

Soil K value — Tavistock soil series = .36

L = ⎤
S = ⎦ from Table 23, LS = 1.0

Site LS-value = 1.0

Draw a line joining the K and LS values.

Table 23. Generalized slope effect (LS) values for the Haldimand-Norfolk Region

Slope %	Simple slope	LS-value	Complex slope	LS-value
0-2	B	0.2		
2-5	C	0.5	c	0.4
5-9	D	1.5	d	1.0
9-15	E	2.8	e	2.0
15-30	F	6.5	f	4.8
30-45	G	10.1	g	10.1

In the site example previously outlined, if in (d), the land use in question was asparagus, the potential erosion loss as determined from the potential soil loss axis in Figure 43 would be 35 t/ha/a. The potential erosion loss for tobacco would be about 14 t/ha/a.

The rainfall factor (R-value) for the Haldimand-Norfolk Region is built into Table 26 in the erosion appendix. The potential soil loss for given soil and slope conditions may be obtained from this table if the slope length (L), slope gradient (S), and soil erodibility (K) factors are known. L-values are assumed to be 100 m for simple slopes, e.g. D, and 50 m for complex slopes, e.g. d.

A simple calculation of potential soil loss using Table 26 is as follows:

Soil erodibility (K) = 0.20
Slope length (L) = 100 m
Slope gradient (S) = 5%

The K-value of .20 is located in the K-values column, and a 100 m, 5% slope, which corresponds to a C slope, is found in the C slope group column. The potential soil loss is found at the intersection of the appropriate K-value and slope group column. In this example, potential soil loss is about 9.0 t/ha/a.

(b) SOIL INTERPRETATIONS FOR WIND EROSION

(1) Introduction

Wind erosion of the sandy soils of the region was a severe problem until the 1920's, when reforestation, windbreaks and management practices, associated with the tobacco crop, greatly decreased the severity of the problem. At the present time, wind erosion is usually only a problem on tobacco soils during the spring period, from the time when rye is plowed down until the tobacco plants develop sufficient canopy cover to protect the soil surface.

On many sandy soils, however, where tobacco is not grown, and also on some soils with loamy or silty surfaces, wind erosion is an increasing problem. This is related to the major expansion in recent years of cash crops, such as corn and soybeans, at the expense of forages and small grains. This change has been accompanied by organic matter loss, soil structure deterioration and higher proportions of exposed, bare soil, all of which are conducive to increasing soil losses from wind erosion.

(2) Wind Erodibility Groups

In Table 24, an attempt has been made to rate the soils of the Haldimand-Norfolk Region according to their susceptibility to wind erosion. This evaluation utilizes wind erodibility groups developed by Hayes (32) for the U.S. Great Plains Region, on the basis of soil textural classes. Table 27 in the erosion appendix, which shows the composition and soil loss of these wind erodibility groups, was taken from Lyles (33).

Four classes — very high, high, moderate, and low — have been used in Table 24 to rate the susceptibility to wind erosion of Haldimand-Norfolk soils. Each class represents one or more wind erodibility groups (WEG's) of Table 27, *i.e.,* the very high class comprises WEG 1; the high class comprises WEG 2; the moderate class combines WEG's 3, 4 and 4L; and the low class combines WEG's 5, 6 and 7.

All map unit soil components, except organic soils and peaty phase soils, are rated in Table 24. The susceptibility ratings obviously apply to dry soils. Poorly drained soils that may have long periods of moisture saturation of the surface horizons will be susceptible to wind erosion for shorter periods of time than their better-drained counterparts. Management practices, such as increasing the organic matter content, vegetative cover, or surface plant residues, will help decrease the severity of soil loss by wind erosion.

Table 24. Estimated susceptibility of soils to wind erosion in the Haldimand-Norfolk Region

Soil map unit component	Map symbol	Susceptibility to wind erosion
Alluvium 1	1-ALU	Variable
Alluvium 1 very shallow phase	1-ALU.V	Variable
Alluvium 2	2-ALU	Moderate to high
Alluvium 3	3-ALU	Moderate
Alluvium 4	4-ALU	Moderate
Alluvium 4 coarse phase	4-ALU.C	Moderate to high
Berrien	BRR	Moderate
Berrien till phase	BRR.T	Moderate to high
Berrien heavy clay phase	BRR.H	Moderate
Beverly	BVY	Low to moderate
Beverly coarse phase	BVY.C	Moderate
Beverly loamy phase	BVY.L	Low
Beverly shallow phase	BVY.S	Low to moderate
Beverly very shallow phase	BVY.V	Low to moderate
Bookton	BOO	Moderate
Bookton till phase	BOO.T	Moderate to high
Brady	BAY	High
Brady loamy phase	BAY.L	Low
Brant	BRT	Low
Brant coarse phase	BRT.C	Moderate to high
Brant very shallow phase	BRT.V	Low
Brantford	BFO	Moderate
Brantford coarse phase	BFO.C	Moderate
Brantford loamy phase	BFO.L	Low
Brantford shallow phase	BFO.S	Moderate
Brantford very shallow phase	BFO.V	Moderate
Brooke	BOK	Low to moderate
Burford	BUF	Moderate to high
Colwood	CWO	Low to moderate
Colwood coarse phase	CWO.C	Moderate
Colwood peaty phase	CWO.P	Not rated
Complex 1	CPX 1	Variable
Complex 2	CPX 2	Variable
Complex 3	CPX 3	Variable
Complex 4	CPX 4	Variable
Complex 5	CPX 5	High to very high
Complex 6	CPX 6	High to very high
Farmington	FRM	Low to moderate
Fox	FOX	Moderate to high
Fox shallow phase	FOX.S	Moderate to high
Fox very shallow phase	FOX.V	Moderate to high
Gobles	GOB	Low
Gobles coarse phase	GOB.C	Low to moderate
Gobles loamy phase	GOB.L	Low
Granby	GNY	Moderate to high
Granby loamy phase	GNY.L	Low to moderate
Granby peaty phase	GNY.P	Not rated
Granby very shallow phase	GNY.V	Moderate to high
Haldimand	HIM	Moderate
Haldimand coarse phase	HIM.C	Moderate
Haldimand loamy phase	HIM.L	Low
Haldimand shallow phase	HIM.S	Moderate
Hampden	HMP	Not rated
Kelvin	KVN	Low
Kelvin coarse phase	KVN.C	Low to moderate
Kelvin loamy phase	KVN.L	Low
Kelvin peaty phase	KVN.P	Not rated
Lincoln	LIC	Moderate
Lincoln coarse phase	LIC.C	Moderate
Lincoln loamy phase	LIC.L	Low
Lincoln peaty phase	LIC.P	Not rated
Lincoln shallow phase	LIC.S	Moderate
Lincoln very shallow phase	LIC.V	Moderate
Lonsdale	LDL	Not rated
Lowbanks	LOW	Moderate to high
Maplewood	MPW	Low to moderate
Marsh	MAR	Low
Muriel	MUI	Low
Muriel coarse phase	MUI.C	Moderate
Muriel loamy phase	MUI.L	Low
Niagara	NGR	Moderate
Niagara coarse phase	NGR.C	Moderate
Niagara loamy phase	NGR.L	Low
Normandale	NDE	Moderate to high
Normandale coarse phase	NDE.C	High
Oakland	OKL	Moderate
Oakview	OVW	Not rated
Ontario	OTI	Low
Ontario coarse phase	OTI.C	Moderate
Plainfield	PFD	Very high
Plainfield dune phase	PFD.D	Very high
Scotland	STD	High
Ridge	RID	Very high
Seneca	SNA	Low
Seneca coarse phase	SNA.C	Moderate
Seneca shallow phase	SNA.S	Low
Seneca very shallow phase	SNA.V	Low
Silver Hill	SIH	Moderate to high
Smithville	SHV	Moderate
Smithville coarse phase	SHV.C	Moderate

(Continued on page 80)

Table 24. Estimated susceptibility of soils to wind erosion in the Haldimand-Norfolk Region — *continued*

Soil map unit component	Map symbol	Susceptibility to wind erosion
Smithville loamy phase	SHV.L	Low
Smithville shallow phase	SHV.S	Moderate
Smithville very shallow phase	SHV.V	Moderate
St. Williams	SLI	Moderate to high
Styx	SYX	Not rated
Tavistock	TVK	Low to moderate
Toledo	TLD	Low to moderate
Toledo coarse phase	TLD.C	Moderate
Toledo peaty phase	TLD.P	Not rated
Toledo shallow phase	TLD.S	Low to moderate
Toledo very shallow phase	TLD.V	Low to moderate
Tuscola	TUC	Low
Tuscola coarse phase	TUC.C	Moderate
Tuscola shallow phase	TUC.S	Low
Tuscola very shallow phase	TUC.V	Low
Urban Land	U.L.	Variable
Vanessa	VSS	Moderate
Vanessa peaty phase	VSS.P	Not rated
Vittoria	VIT	Moderate to high
Walsher	WSH	High
Walsingham	WAM	High to very high
Waterin	WRN	High
Waterin loamy phase	WRN.L	Moderate
Waterin peaty phase	WRN.P	Not rated
Wattford	WAT	Moderate to high
Wauseon	WUS	Moderate
Wauseon peaty phase	WUS.P	Not rated
Wauseon till phase	WUS.T	Low to moderate
Welland	WLL	Moderate
Welland coarse phase	WLL.C	Moderate
Welland loamy phase	WLL.L	Low
Wilsonville	WIL	Moderate to high
Wilsonville coarse phase	WIL.C	Moderate to high
Wilsonville loamy phase	WIL.L	Low to moderate
Wilsonville shallow phase	WIL.S	Moderate to high

(c) EROSION APPENDIX

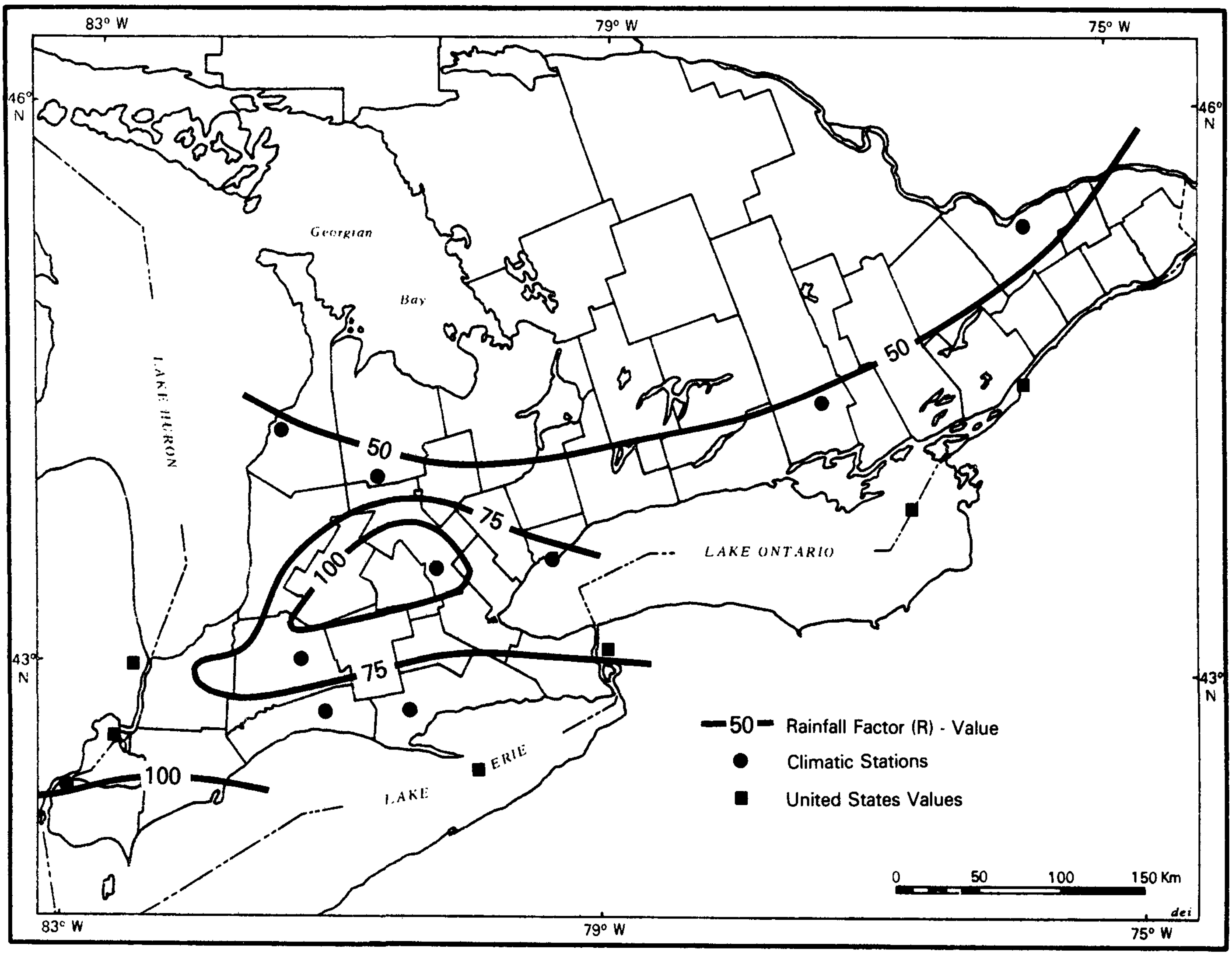


Figure 44. Distribution of the rainfal factor "R" for southern Ontario

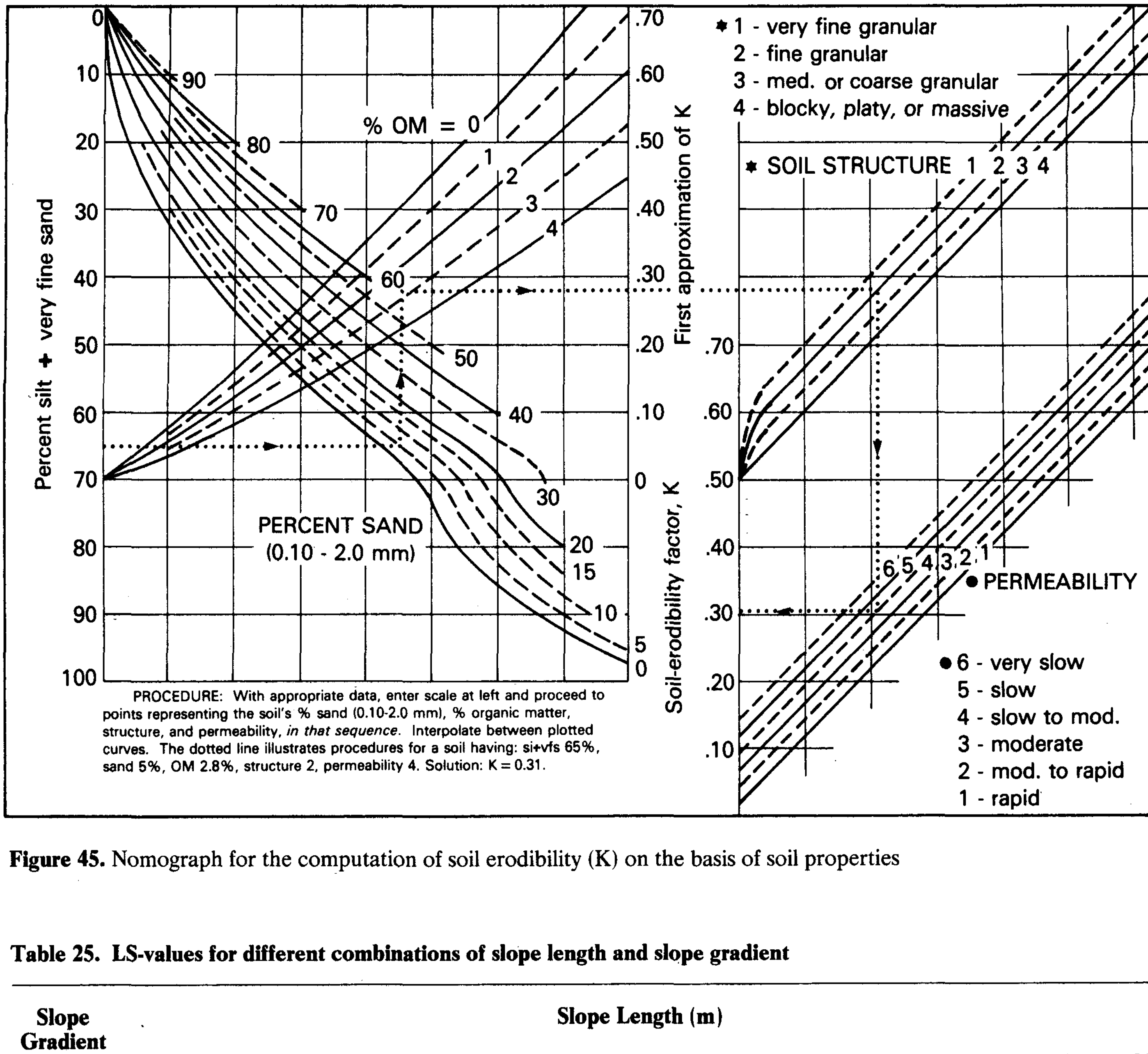


Figure 45. Nomograph for the computation of soil erodibility (K) on the basis of soil properties

Table 25. LS-values for different combinations of slope length and slope gradient

Slope Gradient Percent	Slope Length (m) 10	15	20	25	30	40	50	60	75	100	125	150	200	250	300
0.2	.063	.069	.073	.076	.080	.084	.088	.091	.095	.101	.105	.109	.116	.121	.125
0.5	.076	.083	.088	.092	.095	.101	.105	.109	.114	.121	.126	.131	.139	.145	.151
0.8	.090	.098	.104	.108	.112	.119	.124	.129	.135	.143	.149	.155	.164	.172	.178
2	.144	.162	.177	.189	.200	.218	.233	.246	.263	.287	.307	.324	.353	.377	.399
3	.205	.232	.253	.270	.285	.311	.333	.351	.376	.410	.438	.463	.504	.539	.570
4	.256	.301	.338	.369	.397	.446	.487	.524	.573	.643	.703	.756	.849	.928	.998
5	.306	.375	.433	.485	.531	.613	.685	.751	.839	.969	1.08	1.19	1.37	1.53	1.68
6	.385	.472	.545	.609	.667	.770	.861	.943	1.05	1.22	1.36	1.49	1.72	1.93	2.11
8	.568	.695	.803	.898	.983	1.14	1.27	1.39	1.56	1.80	2.01	2.20	2.54	2.84	3.11
10	.784	.960	1.11	1.24	1.36	1.57	1.75	1.92	2.15	2.48	2.77	3.04	3.51	3.92	4.29
12	1.03	1.27	1.46	1.63	1.79	2.07	2.31	2.53	2.83	3.27	3.65	4.00	4.62	5.17	5.66
14	1.13	1.61	1.86	2.08	2.28	2.63	2.94	3.22	3.60	4.16	4.65	5.09	5.88	6.57	7.20
16	1.63	1.99	2.30	2.57	2.82	3.25	3.63	3.98	4.45	5.14	5.75	6.30	7.27	8.13	8.90
18	1.97	2.41	2.78	3.11	3.41	3.93	4.40	4.82	5.39	6.22	6.95	7.62	8.80	9.83	10.8
20	2.34	2.86	3.30	3.69	4.05	4.67	5.22	5.72	6.40	7.39	8.26	9.05	10.4	11.7	12.8

Table 26. Potential soil erosion losses for given K-values and slope conditions in the Haldimand-Norfolk Region (t/ha/a)

K-Values	Slope Groups B	C	c	D	d	E	e	F	f	G	g
.04	.64	1.79	1.28	4.54	3.23	9.15	6.46	22.4	15.8	37.2	37.2
.06	.96	2.69	1.92	6.82	4.85	13.7	9.70	33.6	23.7	55.8	55.8
.08	1.28	3.58	2.56	9.09	6.46	18.3	12.9	44.9	31.6	74.4	74.4
.10	1.60	4.48	3.20	11.4	8.08	22.9	16.2	56.1	39.5	93.0	93.0
.12	1.92	5.38	3.84	13.6	9.70	27.5	19.4	67.3	47.4	112	112
.14	2.24	6.27	4.48	15.9	11.3	32.0	22.6	78.5	55.3	130	130
.16	2.56	7.17	5.12	18.2	12.9	36.6	25.9	89.7	63.2	149	149
.18	2.88	8.06	5.76	20.4	14.5	41.2	29.1	101	71.1	167	167
.20	3.20	8.96	6.40	22.7	16.2	45.8	32.3	112	79.0	186	186
.22	3.52	9.86	7.04	25.0	17.8	50.3	35.6	123	86.9	205	205
.24	3.84	10.8	7.68	27.3	19.4	54.9	38.8	135	94.8	223	223
.26	4.16	11.6	8.32	29.5	21.0	59.5	42.0	146	103	242	242
.28	4.48	12.5	8.96	31.8	22.6	64.1	45.2	157	111	261	261
.30	4.80	13.4	9.60	34.1	24.2	68.6	48.5	168	119	279	279
.32	5.12	14.3	10.2	36.4	25.9	73.2	51.7	179	126	298	298
.34	5.44	15.2	10.9	38.6	27.5	77.8	54.9	191	134	316	316
.36	5.76	16.1	11.5	40.9	29.1	82.4	58.2	202	142	335	335
.38	6.08	17.0	12.2	43.2	30.7	86.9	61.4	213	150	354	354
.40	6.40	17.9	12.8	45.4	32.3	91.5	64.6	224	158	372	372
.42	6.72	18.8	13.4	47.7	33.9	96.1	67.9	236	166	391	391
.44	7.04	19.7	14.1	50.0	35.6	100	71.1	247	174	409	409
.46	7.36	20.6	14.7	52.3	37.2	105	74.3	258	182	428	428
.48	7.68	21.5	15.4	54.5	38.8	110	77.6	269	190	447	447
.50	8.00	22.4	16.0	56.8	40.4	114	80.8	280	198	465	465

Table 27. Description of wind erodibility groups (WEG)[1]

WEG	Predominant soil texture class	Dry soil aggregates >0.84mm (%)	Soil erodibility "I" (t/ac/yr)
1	Very fine sand; fine sand; sand; dune sand	1	310
2	Loamy sand; loamy fine sand	10	134
3	Very fine sandy loam; fine sandy loam, sandy loam	25	86
4	Clay; silty clay; noncalcareous clay loam and silty clay loam with more than 35% clay content	25	86
4L	Calcareous loam and silt loam; calcareous clay loam and silty clay loam with less than 35% clay content	25	86
5	Nóncalcareous loam and silt loam with less than 20% clay content; sandy clay loam; sandy clay	40	56
6	Noncalcareous loam and silt loam with more than 20% clay content; noncalcareous clay loam with less than 35% clay content	45	48
7	Silt; noncalcareous silty clay loam with less than 35% clay content	50	38

[1]*Data source, Hayes (32)*

D. SOIL INTERPRETATIONS FOR DRAINAGE

by **P.S. Chisholm**, P.Eng., Associate Professor, and **R.S. Irwin**, P.Eng., Professor, School of Engineering, University of Guelph.

The removal of excess water from subsurface horizons of the soil profile is recognized as an effective management practice. Drainage pipes placed at a depth of a metre or less provide an outlet for groundwater, and intercept surface water after it passes vertically into the soil profile. Generally, soil drainage controls hazards to agriculture caused by saturation in the soil profile and improves the plant growth environment. Improvements include early warming of surface soils and more effective germination, increase in oxygen supply to the root zone, increase in activity of soil micro-organisms and increase in capillary water supply to the root zone during protracted dry periods (34).

(1) **Hazards to Agriculture**

Four different types of hazards to agriculture are associated with the soil-water environment. These are: (1) excess water in the soil profile in relation to rainfall and/or ground water; (2) excess surface water in relation to overflow from water courses; (3) reduced efficiency in field operations caused by poorly drained inclusions in otherwise well-drained fields; and (4) soil degradation due to compaction of saturated soil under heavy equipment.

Of the four hazards noted, the first two are labelled "w" and "i" in the Canada Land Inventory soil capability classification for agriculture (23). Individual soil series in which the hazards "w" and "i" occur alone or in combination, in southern Ontario, have been identified by the Ontario Soil Survey and are summarized by Chisholm (35).

The third type of hazard occurs in locations where part of a field, perhaps only a fraction of a hectare, contains soil series in which the hazards "w" and/or "i" occur. Such inclusions present obstacles to be detoured, and impose inefficient patterns of movement on field operations (36).

The fourth type of hazard results when wheel loads exceed the load bearing capacity, which is reduced when the profile is saturated, causing compaction (37). Compaction is accompanied by closure of hydraulic passages related to soil structure and biopores, and gravity drainage is impaired.

Whereas the "w" and "i" hazards have long been recognized, hazards due to poorly drained soil inclusions and soil compaction are recent concerns. The latter two hazards are subjects of current study.

It is generally accepted that removal of excess surface water and/or groundwater provides effective control of the "w" and "i" hazards related to internal soil drainage, and would also control hazards related to poorly drained soil inclusions. Buried drains are required to remove excess water from the soil profile, and to provide drainage outlets.

Typically, outlet drains provide only limited hydraulic capacity and usually overflow during the infrequent flood events. Consequently the agricultural capability of drained lands is not considered to be equivalent to class 1 land under the Canada Land Inventory soil capability classification. Also it is recognized that relief of "w" and "i" hazards is not gained by installation of an outlet drain alone; the relief wanted is not anticipated without installation of necessary buried drains in property abutting to the outlet drain.

(2) **Factors that Affect Drainage for Agriculture**

The primary effect of agricultural drainage works is to increase the hydraulic capacity of natural drainage systems, both on the landscape surface and vertically downwards through the soil profile. Increased hydraulic capacity reduces periods of soil saturation, lowers the groundwater table and generally enhances the soil water regime in relation to plant growth. In a specific soil profile, the effectiveness of agricultural drainage works is dependent upon the soil drainage class, the ability of the soil to transmit water vertically through the soil profile, the source of excess water in the soil profile (groundwater vs. surface water), the landform, and the slope.

Drainage class, landform and land slope are determined in the field during regional soil survey. Generalized interpretations of the ability of the soil to transmit water vertically through the profile, and the source of excess water in the soil profile, are based upon regional soil survey data, together with data from laboratory analyses of soil samples.

Each of the five preceding factors was considered in interpretation of the drainage characteristics of individual soils identified in the Haldimand-Norfolk Region. The results of the interpretations formed, are summarized in a five-symbol drainage code given for each soil in Table 28. Each of the symbols of the drainage code is explained, in relation to individual soils of the study area, according to the following information.

Table 28. Drainage characteristics and codes for Haldimand-Norfolk soils

Map unit components	M.U.C. symbols	Drainage	Drainage code
Alluvium 1	1-ALU	Var.	Floodplain
Alluvium 1 very shallow phase	1-ALU.V	Var.	Floodplain
Alluvium 2	2-ALU	Var.	Floodplain
Alluvium 3	3-ALU	Var.	Floodplain
Alluvium 4	4-ALU	Var.	Floodplain
Alluvium 4 coarse phase	4-ALU.C	Var.	Floodplain
Berrien	BRR	I	S3IH4
Berrien heavy clay phase	BRR.H	I	S3IH4
Berrien till phase	BRR.T	I	S3IH4
Beverly	BVY	I	S2IH4
Beverly coarse phase	BVY.C	I	S2IH4
Beverly loamy phase	BVY.L	I	S2IH4
Beverly shallow phase	BVY.S	I	S6IH3
Beverly very shallow phase	BVY.V	I	S6IH3
Bookton	BOO	W	S3WK6
Bookton till phase	BOO.T	W	S3WK6
Brady	BAY	I	G2IJ4
Brady loamy phase	BAY.L	I	G2IJ4
Brant	BRT	W	S3WU7
Brant coarse phase	BRT.C	W	S3WU7
Brant very shallow phase	BRT.V	W	S6WH6
Brantford	BFO	MW	S2MU6
Brantford coarse phase	BFO.C	MW	S2MU6
Brantford loamy phase	BFO.L	MW	S2MU6
Brantford shallow phase	BFO.S	MW	S6ML6
Brantford very shallow phase	BFO.V	MW	S6MH6
Brooke	BOK	P	S6PA3
Burford	BUF	R to W	G3WG6
Colwood	CWO	P	G1PA2
Colwood coarse phase	CWO.C	P	G1PA2
Colwood peaty phase	CWO.P	VP	G1VA2
Complex 1	CPX 1	Var.	Beach-Scarp
Complex 2	CPX 2	Var.	Marsh-Beach
Complex 3	CPX 3	Var.	Marsh-Dune
Complex 4	CPX 4	Var.	Marsh-Ridge
Complex 5	CPX 5	Var.	Beach-Dune
Complex 6	CPX 6	Var.	Beach-Ridge
Farmington	FRM	R	S6WG4
Fox	FOX	R to W	G2WH7
Fox shallow phase	FOX.S	R to W	S6WH7
Fox very shallow phase	FOX.V	R to W	S6WH6
Gobles	GOB	I	S2IU7
Gobles coarse phase	GOB.C	I	S2IK6
Gobles loamy phase	GOB.L	I	S2IK6
Granby	GNY	P	G2PA2
Granby loamy phase	GNY.L	P	G2PA2
Granby peaty phase	GNY.P	VP	G2VA2
Granby very shallow phase	GNY.V	P	S6PA2
Haldimand	HIM	I	S1IH4
Haldimand coarse phase	HIM.C	I	S1IH4
Haldimand loamy phase	HIM.L	I	S1IH4
Haldimand shallow phase	HIM.S	I	S6IH4
Hampden	HMP	VP	G2VA2
Kelvin	KVN	P	S2PA2
Kelvin coarse phase	KVN.C	P	S2PA2
Kelvin loamy phase	KVN.L	P	S2PA2
Kelvin peaty phase	KVN.P	VP	S2VA2
Lincoln	LIC	P	S1PA2
Lincoln coarse phase	LIC.C	P	S1PA2
Lincoln loamy phase	LIC.L	P	S1PA2
Lincoln peaty phase	LIC.P	VP	S5VA2
Lincoln shallow phase	LIC.S	P	S6PA2
Lincoln very shallow phase	LIC.V	P	S6PA2
Lonsdale	LDL	VP	S5VA2
Lowbanks	LOW	VP	G2VA2
Maplewood	MPW	P	S3PA2
Marsh	MAR	VP	–
Muriel	MUI	MW	S2MU7
Muriel coarse phase	MUI.C	MW	S2MK6
Muriel loamy phase	MUI.L	MW	S2MK6
Niagara	NGR	I	S1IH5
Niagara coarse phase	NGR.C	I	S1IH5
Niagara loamy phase	NGR.L	I	S1IH5
Normandale	NDE	I	G2IH5
Normandale coarse phase	NDE.C	I	G2IH5
Oakland	OKL	I	G3IF3
Oakview	OVW	VP	S5VA2
Ontario	OTI	MW	S2MT7
Ontario coarse phase	OTI.C	MW	S2MT7
Plainfield	PFD	R to W	G2WH4
Plainfield dune phase	PFD.D	R to W	G2WW7
Scotland	STD	R to W	G3WM7
Ridge	RID	R to W	–
Seneca	SNA	W	G1WO7
Seneca coarse phase	SNA.C	W	G1W07
Seneca shallow phase	SNA.S	W	S6W07
Seneca very shallow phase	SNA.V	W	S6W07
Silver Hill	SIH	P	S3PA3
Smithville	SHV	MW	S1MU7

(Continued on page 86)

Table 28. Drainage characteristics and codes for Haldimand-Norfolk soils — *continued*

Map unit components	M.U.C. symbols	Drainage	Drainage code
Smithville coarse phase	SHV.C	MW	S1MU7
Smithville loamy phase	SHV.L	MW	S1MU7
Smithville shallow phase	SHV.S	MW	S6MU6
Smithville very shallow phase	SHV.V	MW	S6MU6
St. Williams	SLI	P	G2PA2
Styx	SYX	VP	S5VA2
Tavistock	TVK	I	S3IC4
Toledo	TLD	P	S2PA2
Toledo coarse phase	TLD.C	P	S2PA2
Toledo peaty phase	TLD.P	VP	S5VA2
Toledo shallow phase	TLD.S	P	S6PA2
Toledo very shallow phase	TLD.V	P	S6PA2
Tuscola	TUC	I	G1IC4
Tuscola coarse phase	TUC.C	I	G1IC4
Tuscola shallow phase	TUC.S	I	S6IC4
Tuscola very shallow phase	TUC.V	I	S6IC4
Urban Land	U.L.	Var.	—
Vanessa	VSS	P	G3PA2
Vanessa peaty phase	VSS.P	VP	G3VA2
Vittoria	VIT	I	S3IH4
Walsher	WSH	W	S3WH6
Walsingham	WAM	I	G2IA2
Waterin	WRN	P	G2PA2
Waterin loamy phase	WRN.L	P	G2PA2
Waterin peaty phase	WRN.P	VP	G2VA2
Wattford	WAT	W	G2WH7
Wauseon	WUS	P	S3PA2
Wauseon peaty phase	WUS.P	VP	S3VA2
Wauseon till phase	WUS.T	P	S3PA2
Welland	WLL	P	S1PA2
Welland coarse phase	WLL.C	P	S1PA2
Welland loamy phase	WLL.L	P	S1PA2
Wilsonville	WIL	R to W	G3WI7
Wilsonville coarse phase	WIL.C	R to W	G3WI7
Wilsonville loamy phase	WIL.L	R to W	G3WI6
Wilsonville shallow phase	WIL.S	R to W	S6WI7

Legend

R - rapid
W -well
MW - moderately well
I -imperfect
P - poor
VP - very poor
Var. - variable

(a) *Soil Drainage Class*

Six soil drainage classes are recognized in *The System of Soil Classification for Canada (21)*. These are rapidly drained, well-drained, moderately well-drained, imperfectly drained, poorly drained and very poorly drained. The drainage class of individual soils of the Haldimand-Norfolk Region is given in the third column of Table 28. Also in Table 28, the drainage class of an individual soil is represented by the third symbol of the drainage code assigned to that soil.

Consistent with the Canada Land Inventory agricultural capability system as applied to Ontario soils, excess soil water and/or excess surface water are recognized as hazards to the growth of common field crops only in poorly drained soils and very poorly drained soils. However, recent studies show that the zone of free water saturation regularly extends to within 600 mm from the surface of some well-drained and imperfectly drained Ontario soils well into the growing season (38). Consistent with the latter, current subsurface drainage practice in Ontario includes drainage by buried pipes placed in well-drained and imperfectly drained soil (39). In these instances, drainage by pipes may be introduced when specialty crops are grown, or as a management practice directed at control of soil degradation under vehicular traffic and livestock during periods of soil saturation. Also, Sheard (40) has shown that drainage of imperfectly drained soils leads to reduced moisture content in corn, at time of harvesting, thereby reducing costs of grain drying.

To estimate agricultural benefits from drainage, a comparison of agricultural productivity with drainage to agricultural productivity without drainage, is required. For soils that require drainage, the Canada Land Inventory, as applied in Ontario, gives estimates of agricultural capability of individual soil series with the necessary drainage works in place. Corresponding estimates of agricultural capability of individual soil series, without the necessary drainage works in place, are given in Table 10 of section A of the soil interpretation section.

(b) *Ability of the Soil to Transmit Water*

Interpretation of the ability of individual soils to transmit water vertically through the soil profile was based upon the U.S.D.A. Soil Conservation Service (41) concept of hydrologic soil groups. This concept differentiates between soils with very slow, slow, moderate and high rates of water movement vertically through the profile. Differentiation is based upon soil depth, texture, soil particle size, presence of a soil layer that would impede internal drainage, proximity of bedrock to the soil surface, and soil structure.

In terms of the properties noted, deep soils, coarse-textured throughout the profile, located well above local groundwater tables and bedrock, are grouped as providing high transport or transmission rates for soil water. Conversely, soils fine-textured throughout the soil profile, or shallow to an impeding layer or local groundwater table, are grouped as providing low transmission rates for soil water.

Application of the Soil Conservation Service concept to southern Ontario soils resulted in the differentiation of nine soil drainage groups (42). Generalized profile descriptions for each of the nine groups formed are given on Figure 46. The soil groups illustrated on Figure 46 are ordered according to ability of the soil to transmit water vertically through the soil profile, e.g. group S-1 is interpreted as having the slowest rate of internal drainage. Criteria used to differentiate between soil groups are given in Table 29.

Table 29. **Generalized profile criteria used to differentiate between soil drainage groups**

Drainage group	General description and criteria	"A" horizons	"B" horizons	"C" horizons
S-1	Fine texture; fine clayey; blocky to massive; lacustrine/ marine deposits.	Fine to medium texture, C, SiC or SiCL; granular structure.	Fine texture, C; coarse blocky structure.	Fine texture, C; medium to coarse, blocky to massive structure.
S-2	Medium to fine texture; fine loamy and fine clayey; blocky to massive; ground moraine till or lacustrine deposits.	Medium texture, L, SiL, CL or SiCL; platy or granular structure.	Fine to medium texture, C, SiCL, CL; medium to coarse, subangular to angular blocky structure.	Fine to medium texture, C, SiC, SiCL, CL; medium to coarse, blocky, prismatic to massive structure.
S-3	Medium to coarse texture; coarse loamy over fine clayey or fine loamy; blocky structure; shallow water-lain sediments over ground moraine till deposits.	Medium to coarse texture, L, SL, LS or S; single grain or weak subangular structure.	Medium to coarse texture, SCL, L, SL, S; fine to coarse subangular blocky structure.	Fine to medium texture, C, SiC, SiCL, CL, SCL, SiL; coarse angular blocky structure.
S-4	Medium to coarse texture; fine loamy; blocky "B" horizon that may impede internal drainage; ground moraine till or lacustrine deposits.	Medium to coarse texture, SCL, SiL, L, SL, LS, S; medium granular structure.	Fine to medium texture, C, SiC, SiCL, SCL; medium subangular to medium angular blocky structure.	Medium texture, L, CL, SiL, SCL, SiCL; weak prismatic to blocky structure.
S-5	Organic material overlying sandy to clayey particle size; massive structure; no generalized mode of deposition.	Organic	Fine to coarse texture.	Fine texture, C; massive.
S-6	Coarse loamy over bedrock.	Medium to coarse texture; granular structure.	Fine to medium texture, C, SiC, SCL; medium subangular to medium angular blocky structure.	Bedrock.
G-1	Medium texture; coarse loamy; blocky to massive structure; ground moraine tills.	Medium texture, L, SiL; granular structure.	Medium texture, L, SiL; medium subangular blocky structure.	Medium texture, L, SiL; may be stratified coarse subangular blocky to massive structure.
G-2	Coarse texture; sandy; structureless; shallow water sediments, variable in depth, overlying ground moraine tills or lacustrine deposits.	Coarse texture, S, SL; granular structure.	Coarse texture, S, SL; single grain to medium subangular blocky structure.	Coarse texture, S, SL; single grain structure, loose.
G-3	Medium to coarse texture; coarse loamy over sandy skeletal; structureless; fluvial deposits.	Medium to coarse texture, L, SL; granular structure.	Medium to coarse texture, L, SL; granular structure.	Sand or gravel, possibly over bedrock.

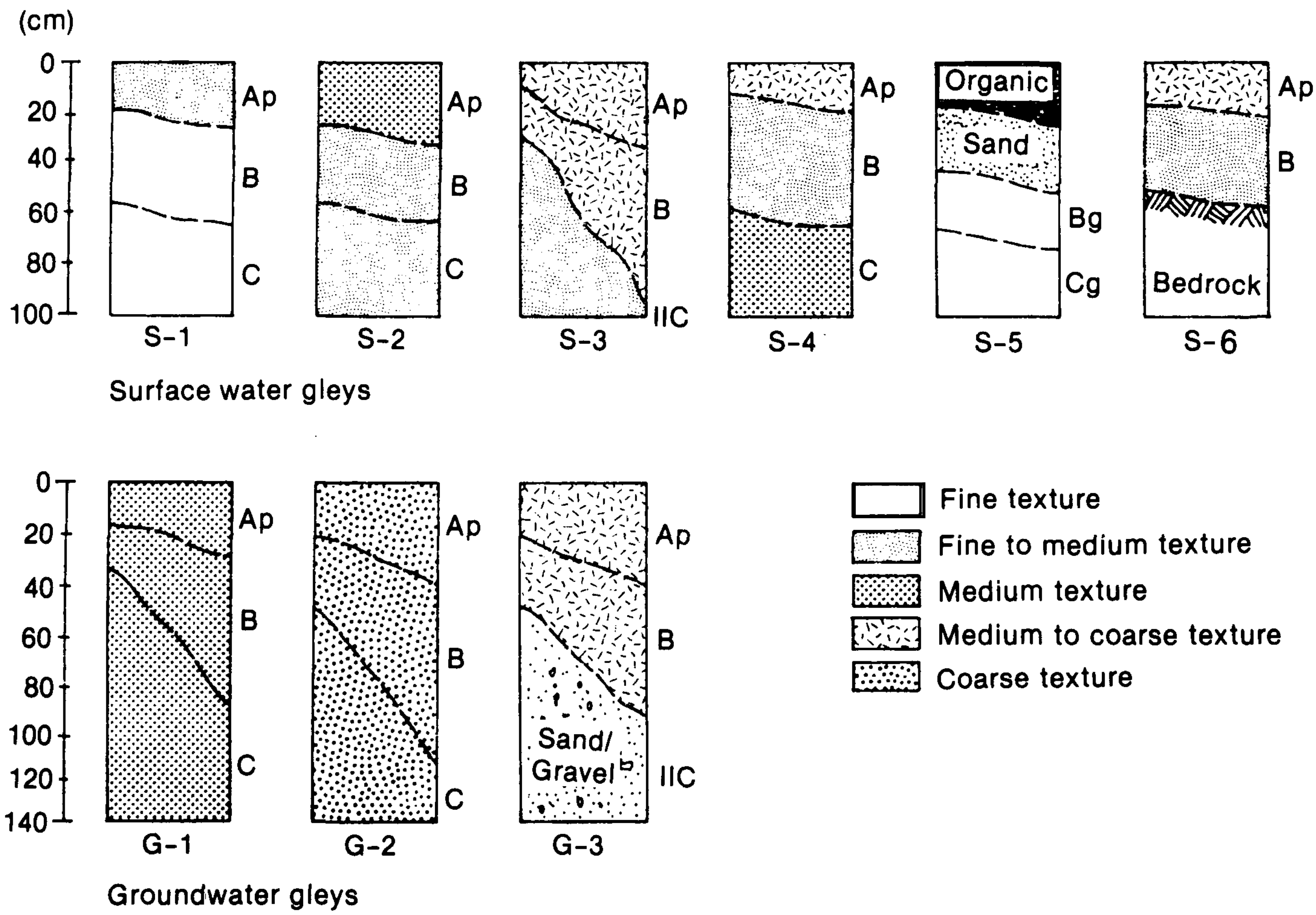


Figure 46. Generalized surface water and groundwater soil groupings

Soil profile descriptions taken from the survey of the Haldimand-Norfolk Region were compared to the generalized profile descriptions illustrated on Figure 46. Examples were found of all groups except group S-5. Individual soil series of the Haldimand-Norfolk Region were assigned to one of the eight drainage groups represented. The group for each series is identified by the first two symbols of the drainage code given in Table 28. An example is the Haldimand soil for which the drainage code is S1IH4. The first two symbols, S1, indicate that the Haldimand soil is assigned to the drainage group S-1.

(c) Source of Excess Water in the Soil Profile

Interpretation of the principal source of excess water in the soil profile was based upon the European concepts for surface water gleysols and groundwater gleysols. Surface water gleysols are soils in which the principal source of excess soil water is interpreted to be surface water. Groundwater is interpreted to be the principal source of excess soil water in groundwater gleysols.

Robson and Thomasson (43) propose the following definitions for surface water gleys and groundwater gleys.

> "Surface water soils occur where the downward movement of water is restricted by an impermeable or slowly permeable layer in sites remote from a regional groundwater table. This layer usually was related to inherent lithological features or a result of soil-forming processes such as a Bt horizon of translocated clay" (surface water gleys).
>
> "Groundwater soils occur where waterlogging is mainly a result of proximity to a groundwater table" (groundwater gleys).

In relation to Robson and Thomasson's definitions, Table 29 gives three soil characteristics used to differentiate between drainage groups. For each drainage group, the column headed "General description and criteria" gives general textural class and family particle size class for the profile and soil structure of the least permeable horizon in the upper metre of the profile. The depth of one metre was chosen as it includes conventional depths for installation of buried drainage pipes.

By the criteria noted, Haldimand-Norfolk Region soils grouped in drainage groups S-1 through S-6 inclusive, are interpreted to contain slowly permeable horizons within the upper metre of the profile, in locations well above a regional groundwater system but subject to soil saturation by perched groundwater at depths of a metre or less. In such soils, the principal source of excess soil water is interpreted to be surface water. This interpretation is applied to an individual soil listed in Table 28 by the first symbol, S, in the drainage code for the soil, e.g. S3IH4. The symbol S stands for the surface water gleysol.

By the three criteria used to differentiate drainage groups, each of the groups G-1, G-2 and G-3 is represented in Haldimand-Norfolk Region soils. These soils are interpreted to contain soil material deeper than one metre that provides moderate to high rates of internal drainage, with necessary drainage works in place. Without appropriate drainage works, and during periods of high groundwater table, relief of soil saturation is dependent upon natural controls on the rate of groundwater movement. In such soils, the principal source of excess soil water is interpreted to be groundwater. This intepretation is applied to individual soils listed in Table 28 by the symbol, G, in the drainage code for the soil, e.g. G2IJ4. The symbol G stands for groundwater gleysol.

(d) *Landform and Land Slope*

The fourth and fifth symbol of the drainage code assigned to individual soils, in Table 28, represent landform and slope, respectively. For the Brady series the complete code is G2IJ4, in which J stands for level to undulating landform, and the fifth symbol, 4, stands for slope range of 0.5-5%.

The landform and slope designations given in Table 28 are based upon standard landform and slope classes given in *The Canadian System of Soil Classification* (21). However, in some instances, the range of landform and slope parameters observed during field survey of individual soil series, included more than one of the standard classes. To represent ranges in parametrs found during soil survey, combinations of standard landform and slope classes were used. Combinations assigned to individual soil series of the Haldimand-Norfolk Region are taken from Tables 30 and 31 which were developed during original interpretation of the nine drainage groups shown on Figure 46.

Table 30. Drainage code landform classes

Code symbol	Landform
A	level
B	level, dissected
C	level to inclined, dissected
D	level, complex
E	level, terraced
F	level, midslope terraced
G	level to inclined
H	level to undulating
I	level to undulating, midslope
J	level to undulating, midslope terraced
K	undulating
L	undulating, dissected midslope
M	undulating, midslope
N	undulating, ridged
O	inclined
P	inclined, midslope
Q	inclined to undulating, terraced
R	inclined, dissected
S	inclined to hummocky
T	undulating to rolling
U	undulating to rolling, dissected
V	hummocky
W	hummocky, ridged
X	rolling
Y	rolling, dissected
Z	rolling, ridged
a	terraced, dissected
b	undulating to inclined, midslope, complex dissected

Table 31. Drainage code slope classes

Code symbol	Slope range	Definition	Canadian System of Soil Classification slope classes
1	0-0.5%	level	1
2	0-2%	level to nearly level	1 and 2
3	0.5-2%	nearly level	2
4	0.5-5%	nearly level to very gentle slopes	2 and 3
5	2-5%	very gentle slopes	3
6	2-9%	very gentle to gentle slopes	3 and 4
7	2-15%	very gentle to moderate slopes	3, 4 and 5
8	6-15%	gentle to moderate slopes	4 and 5
9	10-30%	moderate to strong slopes	5 and 6

(3) **Summary**

The preceding interpretations give generalized information about drainage characteristics of individual soils in the Haldimand-Norfolk Region. Relationships between the given interpretations and field investigations required for design of agricultural drainage works are examined in the following summary.

(a) *Site Analysis*

For cartographic reasons, the minimum size of map delineation on the Haldimand-Norfolk soil maps is approximately 2.4 ha (6 ac). The average map delineation is approximately 33 ha (83 ac) but size of delineation is variable, depending upon landscape and soil conditions.

However, site-specific knowledge of the extent and location of individual soil deposits smaller than 2.4 ha (6 ac), is required for design of surface and subsurface drainage works, within individual farm properties. So, also, is knowledge of relationships between individual soil deposits and field scale surface water drainage channels. Such relationships provide insight to locations within which integrated design of surface and subsurface drainage works may be required to provide relief of soil saturation.

Site-specific soil survey and topographic survey are required to identify microdrainage features within individual farm properties. Also, such surveys provide information by which drainage characteristics of soil identified within an individual farm property can be related to interpretations developed from regional soil survey. The process of relating site-specific information to regional interpretations is greatly enhanced when it is possible to apply map unit components, given on the soil maps, and in Table 28, to soil deposits found in a specific location.

(b) *Problem Analysis*

Identification and mapping of soil deposits within a farm property are usually completed before design of drainage works is started. Soil survey data, and their interpretations, given in this report, provide guides to site-specific investigations. After individual soil deposits are identified and mapped, the drainage code for each soil deposit present can be applied to describe drainage characteristics of individual soils delineated on the property.

By the process outlined, knowledge and experience of the farm operator can be incorporated into details from the site-specific survey, to assist in the analysis of individual drainage problems, before design is initiated. Distinctions can be drawn between soil deposits in which drainage works are required, and those in which drainage works are not required. Also, the requirement for surface drainage works and/or subsurface drainage works, in specific deposits, can be determined. Given the preceding analyses, site-specific design can proceed, guided by soil drainage characteristics and information about drainage problems gained from site-specific investigations.

(c) *Drainage Guide for Ontario*

In addition to the preceding information, site-specific estimates are required for the actual rate of water movement in soils in which buried drainage pipes are to be placed, and the rate at which excess water is to be removed from the soil profile. The former of the two rates is based upon measurement of saturated hydraulic conductivity of the soils to be drained: the latter is referred to as the drainage coefficient, values for which are based upon regional design practice.

In a specific design, the depth and spacing of buried drainage pipes are calculated from values selected for the saturated hydraulic conductivity of the soil to be drained, and from the drainage coefficient. Values for the saturated hydraulic conductivity and the drainage coefficient differ according to circumstances encountered in specific design instances. On the basis of current investigation, there is no general guide which applies to the selection of depth and spacing of buried drainage pipes in all soils that require drainage. However, current design practice, in relation to depth and spacing, is summarized by Irwin (44) in Ontario Ministry of Agriculture and Food Publication 29, *Drainage Guide for Ontario*. The summary given by Irwin is based upon the nine drainage groups, illustrated on Figure 46 of this report, and according to which current design practice is related to individual soils of the Haldimand-Norfolk Region.

E. SOIL INTERPRETATIONS FOR FOREST LAND MANAGEMENT

by:

E.P. Taylor, Forest Pedologist, Ontario Ministry of Natural Resources Contract Appointment to Ontario Institute of Pedology, University of Guelph, Guelph; and **R.K. Jones**, Forest Ecologist, Agriculture Canada, Ontario Institute of Pedology, Guelph Agriculture Centre, Guelph

(1) **Introduction**

Table 32 summarizes soil interpretations for forest land management in the Regional Municipality of Haldimand-Norfolk. It is designed to be used with the Haldimand-Norfolk soil maps and report. It lists productivity ranges of major commercial tree species, and limitations to forest land management, for most map unit components identified during the soil survey. All concepts, abbreviations and symbols used in Table 32 are defined in this text or in Tables 33, 34 and 35.

(2) **Methods**

The soil interpretations were developed from the results of soil-forest productivity research conducted in Haldimand-Norfolk and surrounding areas (i.e., Brant, Oxford, Elgin and Niagara). This research program included the collection of soil, site and stand productivity data on over 300 sample plots. The information was analyzed, classified and correlated with the soils of Haldimand-Norfolk. Average productivity values, stratified by tree species and map unit components (MUC's), were determined and then placed into five levels of productivity called site classes, described in section 4. Map unit components with similar site classes, and which are considered to have similar limitations to forest land management (see limitations column, Table 32, and definitions, in Table 35), were then grouped into forest land suitability groups (FLS groups), which are described next.

(3) **Forest Land Suitability (FLS) Groups**

Map unit components are classified into FLS groups by the level of tree productivity (site class), nature of limitations, and response to silvicultural prescription. The purpose of the FLS system is to hierarchically classify MUC's into meaningful groups. FLS groups constitute the basis of a framework for forest management decisions. The FLS system is explained through the following example from Table 32:

	FLS CLASS
2s1	FLS GROUP
	FLS SUBCLASS

FLS CLASS — represents the average site class (or level of productivity) value of the commercial tree species measured on a particular soil. Productivity is gauged in terms of site index or the height of a tree at 50 years of age, e.g. an FLS Class of 2 indicates that 2 is the average site class for that species in the above example.

FLS SUBCLASS — groups MUC's with similar limitations to forest land management. The subclasses from Table 32 are defined below:

o - no limitations
c - limitations due to high clay content
d - limitations due to shallow soils to bedrock
e - limitations due to highly eroded soils
s - limitations due to high sand content
w - limitations due to excessive moisture
k - limitations due to high soil carbonates

The s subclass from the above example indicates a low moisture- and nutrient-holding capacity of this soil, due to a high sand content.

FLS GROUP — are soils with similar FLS classes and subclasses that have been differentiated according to varying levels of response to forest management. For example, a 2s1 soil (e.g. WAM) as in above example, would react more slowly than a 2s2 soil (e.g. VIT) to a short-term silvicultural operation such as thinning.

(4) **Site Classes**

Site classes represent levels of productivity, in descending order from 1 to 5, for each commercial tree species listed in Table 32. The site classes were determined through frequency distribution analyses of the site index data (height in metres at 50 years) of each species. A site class represents a cumulative frequency of 1/5 (20%) of the average site index data for an individual commercial tree species. For example, site class 1 symbolizes the upper 20%, and site class 5 the lower 20%, of the cumulative frequency distribution of the data. The ranges of site index are unique to the site classes of each species (e.g. class 1 Aw = class 1 His). This accounts for the inherent growth rate differences between species (i.e. white ash grows more quickly than shagbark hickory, regardless of soil condition). For the actual site index ranges for each site class, by species, see Table 34.

(5) **Explaining and Using Table 32**

In Table 32, the productivities of 24 commercial tree species, and the symbols for the limitations to forest land management, are listed for most of the map unit components (MUC's) mapped in Haldimand-Norfolk. The left hand column lists the MUC's in descending alphabetical order. The second column from the left, labelled FLS, lists the forest land suitability classification (see above) of each MUC. The soil limitations column on the far right hand side, lists the symbols of the qualitatively assessed limitations of each MUC for forest land management (see Table 35 for definition of limitations).

The remaining columns are labelled by the symbols for commercial tree species measured in the study area (see Table 33). The plantation species, including Pw, Pr, Sw, Sn, Le and Ce are listed on the left hand side of the table. The remaining species are primarily 'naturally' occurring, except for some of the black walnut (Wn) examples. The numbers ranging from 1 to 5 in each species column represent the site classes (see Table 34). The symbols used in conjunction with the FLS site classes are defined as follows:

* - denotes an extrapolation of data to determine the FLS site class due to insufficient sample size

\+ - denotes a site index value which is near the top of the designated FLS site class

— - denotes insufficient occurrence of a species in an MUC, to obtain any site index data

n - represents naturally occurring black walnut data

p - represents plantation black walnut data

How to Use Table 32

(a) Locate areas of concern on appropriate Haldimand-Norfolk soil map.

(b) Find soil map unit component (MUC) symbol(s) in Table 32, from the second column.

(c) Note site class(es) for desired species and note the limitations for forest land management from the soil limitations column. For further definitions of species symbols, site class ranges and limitations symbols, see Tables 33, 34 and 35, respectively.

(d) Make forest land use decisions for area(s) of interest using interpretations from Table 32 as guidelines. For larger-scale or on-site assessments, see NOTE below.

Note. This interpretative information is designed to be used with the Regional Municipality of Haldimand-Norfolk soil maps and report, as a planning guide, and not as a list of strict rules with which to match the suitability of species to site. Table 32 provides interpretations for map unit components of the soil map units that are shown on the soils maps. It should be noted that the map unit components are designed to account for the majority of soils in a map unit delineation, but not for a minority of inclusions of other soils. Therefore, the potential presence of these soil inclusions, within soil map units, should be considered before extrapolating interpretations from Table 32 designed for specific map unit components.

For on-site, intensive sampling of forested land, or land to be reforested, contact your local Ontario Ministry of Natural Resources or Conservation Authority office, whose professional forestry staffs are trained to assess land, and to recommend appropriate forest land management practices.

Table 32. Soil interpretations for forest land management in the Haldimand-Norfolk Region

Soil map unit components (MUC)	MUC symbols	FLS groups	FLS classes Site classes of commercial tree species Pw	Pr	Sw	Sn	Le	Ce	Mh	Ms	Mr	Aw	Ag	Bd	Hib	His	Cb	Wn	Ow	Or	Obu	Osw	Op	Obl	Be	Tu	Soil limi-tations
Alluvium 1	1-ALU	1w1	*2	*3	1	1	*1	*1	2	*2	—	1	*1+	*5	1	—	1+	n1	*1	1	*1	—	—	—	—1+		Mtck
Alluvium 1 very shallow phase	1-ALU.V	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Alluvium 2	2-ALU	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Alluvium 3	3-ALU	1w1	*2	*3	*1	2	1+	2+	*2	*2	*1	1	*1	4	1+	—	*1	n2	*1	*1	*1	—	—	—	—	*1	Mtck
Alluvium 4	4-ALU	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Alluvium 4 coarse phase	4-ALU.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Berrien	BRR	2s3	1	*1+	3	*2	*2	*2+	1	—	3	1	2	*2	2	3	2	n5	3	4	*2	—	—	1	2	*2	dn
Berrien heavy clay phase	BRR.H	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Berrien till phase	BRR.T	3s3	*1	*1	*3	*2	*2	*2	1	—	*3	5	*2	*2	4	4	*2	*n5	*3	*4	4	—	*1	*2	*2	*2	dn
Beverly	BVY	3c2	4	5	4	*2	*1	*1+	2	—	*2	1	—	*3	*3+	5	*4	*2	2	4	*3+	—	—	—	*4+	*3	cep
Beverly coarse phase	BVY.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Beverly loamy phase	BVY.L	3c3	3	3	4	4	1	1	1	—	3	5	2	1	3	3+	1	2	3	2	2	—	—	—	4	3	Ecp
Beverly shallow phase	BVY.S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Beverly very shallow phase	BVY.V	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Bookton	BOO	3s3	*1	1	*3+	*3	*2	*2	3	—	*4	4	—	*3	3	—	5	p1	*3	*4+	*3	—	—	3	3	*3	dnp
Bookton till phase	BOO.T	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brady	BAY	2s1	1+	1+	1	2	*4	*4+	1	—	1+	2	—	*2	3	—	1	n5	*3	1	*4	—	—	*2	*4+	*5	dnc
Brady loamy phase	BAY.L	2s3	1+	2	1	1	1+	3	*3	—	*1	3	—	*2	3	—	2	n3	*3	1	*4	—	—	*2	*3	*3	cedn
Brant	BRT	1e1	2+	2	1	2	*1	*1	2	—	—	1+	—	1+	2	—	1	*2	*3	2+	*1	—	—	—	*1	1+	Ect
Brant coarse phase	BRT.C	1e2	1+	1	1	*2	*2	*1	*1	—	*1	2+	—	*2	*2	—	1	*n2	*2	2+	—	—	—	—	*1	*1	ect
Brant very shallow phase	BRT.V	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brantford	BFO	3c1	3	*4	*4+	*3	*2	*1	2	—	—	4+	2	*3	3	*2	1	2	2	3	*4+	—	—	—	4	*4	Epct
Brantford coarse phase	BFO.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brantford loamy phase	BFO.L	3e1	3	3+	3	5	*2	*1	*1	—	*4	*3	—	*2	*2	—	*1	n2+	2	4	3	—	—	—	4	*3	ECpt
Brantford shallow phase	BFO.S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brantford very shallow phase	BFO.V	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brooke	BOK	5d2	*5	*5	*5	*5	*5	*5	—	*5	—	*5	—	*2	—	5	—	—	—	—	*5	—	—	—	—	—	RWMn
Burford	BUF	4s2	5	4	2	2	*3	*5	5	—	*4	4	—	*3+	*3+	—	4	p5	*3	*1	—	—	—	4	*5	—	DKnt
Colwood	CWO	1w2	1+	1+	1	*1	*1+	*2	—	3+	—	1+	2+	1	1+	*1	—	—	—	3+	*2	*1	*2	—	4	—	Cm
Colwood coarse phase	CWO.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Colwood peaty phase	CWO.P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Complex 1	CPX 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Complex 2	CPX 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Complex 3	CPX 3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Complex 4	CPX 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Complex 5	CPX 5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Complex 6	CPX 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Farmington	FRM	5d1	*5	*5	*5	*5	*5	*5	5	—	*5	*5	—	*5	—	5	—	—	*5	*5	*5	—	—	—	*5	—	RDk
Fox	FOX	4s2	*2	2	2	2	*4	*5	2	—	*3	3	—	*3	5	3	4	n2	5	3	*5	—	—	*4	*4	—	DN
Fox shallow phase	FOX.S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Fox very shallow phase	FOX.V	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gobles	GOB	2e2	3	4	3	*3	*1	*1+	1	—	3	2	—	2	3	3	4	n2	*2+	2	3	—	—	—	3	*3	Cpek

Gobles coarse phase	GOB.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gobles loamy phase	GOB.L	2e3	1	4	3	2	*1	*1	1	—	*3	3	—	3	1	1	4	*n2	*2	3	—	—	—	—	3	2	Ecpk
Granby	GNY	3w2	2+	2	3	1	*4	*4	3	2+	5	2	*4+	2	*4	—	5	—	—	1+	*5	4	4	—	—	—	MWnc
Granby loamy phase	GNY.L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Granby peaty phase	GNY.P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Granby very shallow phase	GNY.V	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Haldimand	HIM	4c2	*5	*4	3+	*4	*3	*3+	1	—	*3+	5	5	*5	*5	*4+	*3	n2	4	3	*4+	—	—	—	*4	*4	Cpe
Haldimand coarse phase	HIM.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Haldimand loamy phase	HIM.L	4c3	*4	*4	3+	3	*3	*3	1	—	*3	1+	5	*4	*4	3	*3	2	*4	4	—	—	—	—	—	4	ECp
Haldimand shallow phase	HIM.S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hampden	HMP	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kelvin	KVN	3w1	4+	5	1	4	*3	*3	*4	1	*2+	3+	4	2	3+	2	—	n5	2	2	*4+	3	*1	—	2	—	Cmpk
Kelvin coarse phase	KVN.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kelvin loamy phase	KVN.L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kelvin peaty phase	KVN.P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lincoln	LIC	4w1	4	*5	3	*4	*5	*4	5	5	3	5	4	*5	5	3	—	—	5	5	*4	*3	*3	—	—	—	Mcp
Lincoln coarse phase	LIC.C	4w2	*4	*4	*3	*3	*3	*3	—	*4	*4	*4	*4	*4	4	4	4	—	4	3	4	*4	*3	—	—	—	MWc
Lincoln loamy phase	LIC.L	3w2	3	*3	*3	*3	—	3	—	*3	*3	*3	*3	*2	*5	*4	*3	—	4	5	*4	3	*3	—	—	—	MCw
Lincoln peaty phase	LIC.P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lincoln shallow phase	LIC.S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lincoln very shallow phase	LIC.V	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lonsdale	LDL	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lowbanks	LOW	5w1	*5	*5	*5	*5	*5	*5	—	*4	—	*5	*4	—	—	—	—	—	—	—	—	*3	*5	—	—	—	MWNc
Maplewood	MPW	2w1	3	*3	2	3	*2	*3	—	1	*2	2	1	1	*4	2+	—	—	—	*4	*2	3+	*4+	—	—	—	Mpcw
Marsh	MAR	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Muriel	MUI	3c1	2	3	4	4+	*2	*2	2	—	—	3	—	*3+	4	1	2+	n3	*3+	4+	*2+	—	—	—	3	*3	Pcekt
Muriel coarse phase	MUI.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Muriel loamy phase	MUI.L	2c1	3+	*3	*3	*3	*2	*2	1	—	—	1+	—	*3	*2	*2	3+	n2	*3	*3	*2	—	—	—	3	*3	EPkct
Niagara	NGR	3c2	4	*3	1+	*2	*2	*1	3	—	*3	1	—	*3	*2	5	4+	*3	2	4	*3	—	—	—	4	*5+	Cpe
Niagara coarse phase	NGR.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Niagara loamy phase	NGR.L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Normandale	NDE	2o1	2+	2+	3	1+	1	2	2	—	3	3+	—	1	4	—	2	n3	3	2	—	—	—	*2+	3	*1	ecn
Normandale coarse phase	NDE.C	2o1	2	*2	*2	2	2	*2	1+	—	2	3	2	3	2	—	2	*4	*3	*2	—	—	—	—	1+	*2	ecn
Oakland	OKL	3s2	2+	2	3	*2	*2	*4	3+	—	1	2	—	3	3	—	2	*4+	*3+	1+	*4+	—	—	3+	*4	—	dkn
Oakview	OVW	5w2	5	*5	5	*5	5	5	—	*4	—	*5	4	—	—	—	—	—	—	—	—	5	*5	—	—	—	MWNc
Ontario	OTI	4c1	*4+	*4	*4	*4	*3	*2	4+	—	—	2	—	5	*4	*3	*3	*4	*3+	4	*4	—	—	—	5	*5	pced
Ontario coarse phase	OTI.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Plainfield	PFD	3s1	3	3	4+	*4	4	*5	3	—	3+	3	—	*3	*2	—	2+	p1	*3	3	*3	—	—	*3	1	—	dnet
Plainfield dune phase	PFD.D	4s1	*4	*4+	*4	*5	*5	*5	4	—	*4	*5	—	*3	—	—	*3	—	—	*4	—	—	—	*5	—	—	EDNt
Ridge	RID	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Scotland	STD	3s2	3	*2	1	*3	*3	*5	4	—	3	3+	—	*3	3	—	2+	*5	*4+	2+	—	—	—	3	*4	—	dknt
Seneca	SNA	2e1	2+	1+	*2	*3	*1	*1+	4	—	3	4+	—	2	2+	—	1	*2	*2+	3	*2+	—	—	—	2	*4	eptck
Seneca coarse phase	SNA.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Seneca shallow phase	SNA.S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Seneca very shallow phase	SNA.V	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Silver Hill	SIH	3w2	4	3	*3+	5	*4	*3	—	*2	*4	*3	*3+	*3	*4+	—	*3	—	—	*3+	*3	*4+	*3	—	—	—	MWn
Smithville	SHV	4c1	*4	*4+	4	*4	*4	*3	4	—	—	1	—	2	*4	3	3	*4	4	*4	4	—	—	—	5	*4	pced
Smithville coarse phase	SHV.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Smithville loamy phase	SHV.L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

(Continued on page 94)

Table 32. Soil interpretations for forest land management in the Haldimand-Norfolk Region — *continued*

Soil map unit components (MUC)	MUC symbols	FLS groups	FLS classes — Site classes of commercial tree species																								Soil limitations
			Pw	Pr	Sw	Sn	Le	Ce	Mh	Ms	Mr	Aw	Ag	Bd	Hib	His	Cb	Wn	Ow	Or	Obu	Osw	Op	Obl	Be	Tu	
Smithville shallow phase	SHV.S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Smithville very shallow phase	SHV.V	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
St. Williams	SLI	3w2	1	1	*3+	*1	*3	*3	—	4+	*5+	*4	2+	*1	*5	—	*4	—	—	1	*4	*3	—	—	—	—	mwnc
Styx	SYX	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tavistock	TVK	3o2	2	3+	3	4	1	*2	3	—	*3+	*3	—	3	2	3	4	n3	1	4+	*1	—	—	—	4+	*1	Cep
Toledo	TLD	3w1	4	*5	*4	5	*3	*3	3	3+	4	1	3	3	5	3	4+	3+	2	3	*4	5+	1	—	4	—	Cm
Toledo coarse phase	TLD.C	3w3	3	*4	3	*4	*3	*3	—	*2	*3	1	1	4	3	3	*3	*3	*2	3	*3	*4	*2	—	—	—	Mcn
Toledo peaty phase	TLD.P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Toledo shallow phase	TLD.S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Toledo very shallow phase	TLD.V	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tuscola	TUC	2e2	1	3	2	1	5	*1+	2	—	3	2	—	4	3	1	1	3	*1+	1	*1+	—	—	—	1	2	Cet
Tuscola coarse phase	TUC.C	2e2	2	3	2	1	5	*1	1	—	1+	4	—	3	3	1	1	*3	*3	1	—	—	—	—	*2	*2	Cet
Tuscola shallow phase	TUC.S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tuscola very shallow phase	TUC.V	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Urban Land	U.L.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vanessa	VSS	4w2	*2	*3	*3	*3	4	*4+	—	*4	5	3	3	4	*4	—	5	—	—	3+	*5	4	4	—	—	—	MWn
Vanessa peaty phase	VSS.P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vittoria	VIT	2s2	4	4	4	*3	*1	*1	1	—	*2	*2	—	*2	1	—	1	*3	*2	*2	*1	—	—	2+	*1	*1	dm
Walsher	WSH	3s3	*3	*3+	*3	*3	*2	*2	2	—	*3	*3+	—	*3	*2	—	1	*3	*3+	*4+	*2	—	—	3	*1	*2	dmn
Walsingham	WAM	2s1	3	3+	3	*1	4	*4+	1	—	4+	4	—	2+	1	—	2	p1+	*3	2	*3+	—	—	1+	2	*4	ncd
Waterin	WRN	4w2	4	3	1+	1	*3	*4	5	4	*4	4	*4	3	2	—	2	—	—	3	4	2	*4	—	—	—	WMn
Waterin loamy phase	WRN.L	3w2	*3	*3	2	*2	*3	*3	—	1	*1	*3	*3	3+	2	—	*2	—	—	*3	4	*2	*3	—	—	—	MWn
Waterin peaty phase	WRN.P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wattford	WAT	3e1	1	2+	2	3+	1+	*2	3	—	*3	5	—	3	3+	—	4	n3	2	4+	*4	—	—	*3	2+	*2	Endt
Wauseon	WUS	3w2	2	*2+	4	*4+	*3	*3	—	1+	2	4	1	3	5	4	*3	p2	—	3	2	2	1	—	—	—	WMn
Wauseon peaty phase	WUS.P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Wauseon till phase	WUS.T	3w2	2	*2	4	*4	*3	*3	2	1	*2	5	*4	*3	5	4	*3	n2	—	3	*2	*2	*1	—	—	—	WMn
Welland	WLL	3w1	*4	*5	*3	*4+	*4+	*3	—	1	*2	2	2	2	3	2	—	—	*3+	3	*4	1	*2	—	—	—	Mcp
Welland coarse phase	WLL.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Welland loamy phase	WLL.L	2w2	*4	*5	*3	*4	*4	*3	—	1	1	2	2	3	3	2	—	—	1	1+	3	1	1	—	—	—	Mc
Wilsonville	WIL	4s1	*5	4	2	2	*5	*3	1	—	*3	*4	—	2	*4+	4	4	*5	*2	*3	—	—	—	*3	*4	—	DNTk
Wilsonville coarse phase	WIL.C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wilsonville loamy phase	WIL.L	3s2	2	2	*2	*2	*4	*3	1	—	*3	*3	—	2	*3	4	3	*4	*3	*3	—	—	—	—	—	—	TDkn
Wilsonville shallow phase	WIL.S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 33. Definitions of species' symbols used for commercial tree species in Table 32

Symbol	Common name	Scientific names
Pw	White pine	Pinus strobus L.
Pr	Red pine	Pinus resinosa Ait.
Sw	White spruce	Picea glauca (Moench) Voss.
Sn	Norway spruce	Picea exelcis
Le	European larch	Larix decidua L.
Ce	White cedar	Thuja occidentalis L.
Mh	Hard maple	Acer saccharum Marsh.
Ms	Silver maple	Acer saccharinum L.
Mr	Red maple	Acer rubrum L.
Aw	White ash	Fraxinus americana L.
Ag	Green ash	Fraxinus pennsylvania Marsh.
Bd	Basswood	Tilia americana L.
Hib	Bitternut hickory	Carya cordiformis (Wang) K. Koch
His	Shagbark hickory	Carya ovata (Mill.) K. Koch
Cb	Black cherry	Prunus serotina Ehrh.
Wn	Black walnut	Juglans nigra L.
Ow	White oak	Quercus alba L.
Or	Red oak	Quercus rubra L.
Obu	Bur oak	Quercus macrocarpa Michx.
Osw	Swamp white oak	Quercus bicolor Willd.
Op	Pin oak	Quercus palustris Meunchh.
Obl	Black oak	Quercus velutina Lam.
Be	Beech	Fagus grandifolia Ehrh.
Tu	Tulip	Liriodendron tulipifera L.

Table 34. Ranges of productivity* of tree species for site classes shown in Table 32

Tree species	Site classes 1+	1	2	3	4	5
Pw	≥29.7	27.5 to 29.6	25.4 to 27.4	23.8 to 25.3	21.4 to 23.7	≤21.3
Pr	≥26.2	24.7 to 26.1	23.2 to 24.6	21.4 to 23.1	19.3 to 21.3	≤19.2
Sw	≥29.0	25.7 to 28.9	24.5 to 25.6	23.0 to 24.4	21.1 to 22.9	≤21.0
Sn	≥32.1	28.8 to 32.0	26.6 to 28.7	25.6 to 26.5	24.2 to 25.5	≤24.1
Le	≥29.1	27.2 to 29.0	26.3 to 27.1	25.1 to 26.2	23.6 to 25.0	≤23.5
Ce		≥15.6	14.5 to 15.5	13.2 to 14.4	12.0 to 13.1	≤11.9
Mh	≥24.2	23.3 to 24.1	22.0 to 23.2	21.1 to 21.9	19.9 to 21.0	≤19.8
Ms	≥27.5	25.7 to 27.4	24.9 to 25.6	24.2 to 24.8	21.1 to 24.1	≤21.0
Mr	≥27.8	24.8 to 27.7	23.0 to 24.7	21.1 to 22.9	19.3 to 21.0	≤19.2
Aw	≥28.5	26.0 to 28.4	24.5 to 25.9	23.3 to 24.4	22.4 to 23.2	≤22.3
Ag	≥27.5	25.4 to 27.4	23.6 to 25.3	22.7 to 23.5	21.4 to 22.6	≤21.3
Bd	≥31.7	24.2 to 31.6	22.7 to 24.1	21.1 to 22.6	19.6 to 21.0	≤19.5
Hib	≥25.9	23.9 to 25.8	22.7 to 23.8	22.0 to 22.6	21.1 to 21.9	≤21.0
His		≥23.9	21.4 to 23.8	19.9 to 21.3	18.7 to 19.8	≤18.6
Cb	≥27.5	24.5 to 27.4	23.3 to 24.4	22.0 to 23.2	20.5 to 21.9	≤20.4
Wn	≥27.5	24.5 to 27.4	23.0 to 24.4	21.1 to 22.9	20.5 to 21.0	≤20.4
Ow		≥23.0	21.4 to 22.9	19.9 to 21.3	18.4 to 19.8	≤18.3
Or	≥27.5	26.0 to 27.4	24.5 to 25.9	23.0 to 24.4	21.4 to 22.9	≤21.3
Obu		≥21.4	20.5 to 21.3	19.3 to 20.4	18.1 to 19.2	≤18.0
Osw		≥21.1	19.6 to 21.0	18.4 to 19.5	16.9 to 18.3	≤16.8
Op		≥23.6	22.7 to 23.5	20.8 to 22.6	18.7 to 20.7	≤18.6
Obl		≥24.5	23.3 to 24.4	22.0 to 23.2	21.4 to 21.9	≤21.3
Be		≥21.4	20.5 to 21.3	19.3 to 20.4	18.1 to 19.2	≤18.0
Tu		≥27.5	26.3 to 27.4	25.1 to 26.2	23.0 to 25.0	≤22.9

**Range of productivity for each species is measured in ht (m) at 50 years*

+ *denotes a site index value above site class 1*

Table 35. Explanation of terms and symbols used in the soil limitations column of Table 32

Symbol*	Limitation	Nature	Forest land management recommendation
C,c	Plant competition	Favourable plant growing conditions, such as adequate available moisture and nutrients enhance the growth of unwanted trees, shrubs, herbs, grasses and sedges.	Intensive mechanical and/or chemical site preparation is recommended before planting. Herbicidal tending techniques are recommended on severely limited sites after planting.
D,d	Droughtiness	Moisture deficiencies caused solely or in combination by low rainfall, coarse textures and low watertables during the growing season may result in physical stresses and diminished productivity of commercial tree species on these sites.	Softwoods such as Pw, Sw, Pr and Le (see Table 33) should be planted on drier sites, and black locust, jack pine and Scots pine on the driest sites. Fire hazard precautions should be emphasized on these sites. Replanting will be more frequent on drier sites.
E,e	Erodibility	Soils with these limitations have been subjected to or have a high potential for wind and water erosion. See Soil Erosion Interpretations in this report.	Windbreak establishment and the planting of species tolerant to heavily eroded conditions (e.g. black locust) are recommended for these sites. High seedling mortality rates will occur.
K,k	Carbonates	Excessive contents of soil carbonates (lime) will inhibit and eventually cause the mortality of several species (e.g. Pr, Pw). Generally, the closer to the surface a soil reacts with 10% HC1, the greater the severity of the carbonate limitation.	The planting of Sw, Sn, Le, and Ce on shallow to lime soils will reduce seedling mortality. Hardwood productivity is not significantly affected by high lime soils.
M,m	Excessive moisture	Tree suitability and productivity are limited by periods of excessive moisture during the growing season.	Species which are tolerant to high watertables should be planted on these soils (e.g. Pw, Sw, Ce, Ag, Ms, His).
N,n	Nutrient deficiency	Nutrient deficiencies are usually caused by natural inherent infertility or past land management. Low organic matter and clay contents, extreme pH ranges and poor soil management contribute to infertility.	Growth may be diminished for nutrient-demanding species (e.g. Wn, Mh, Aw, Le). Fertilizers may be applied to amend soil fertility problems. Consult with OMNR staff regarding fertilization of forest soils.
P,p	Soil compaction	Former glacial activity, soil genesis and the use of heavy machinery are the major causes of the development of soils with this limitation. Compacted soil layers may restrict root growth and reduce tree productivity.	Species which tolerate shallow rooting environments should be planted (e.g. Sw, Ce and Sn).
R,r	Shallow bedrock	Shallow bedrock restricts the rooting and productive capacity of trees due to the shallow veneer (usually <30 cm) of soil material over bedrock. These soils have a rockness class of <2 (or rock exposures cover <10% of landscape).	Forest land management hazards may be reduced by planting Ce, Sw, Ps and Pw on abandoned farmland and by reducing proportions of basal area removed in logging practices.
T,t	Topography	Soils with these limitations occur on slopes with FLS Class of <3 (i.e., 2% slope).	Site preparation, tending and harvesting techniques will be more energy-demanding on these sites. Some practices may be severely limited on slopes <10%.
W,w	Windthrow	Trees growing on these sites are susceptible to windthrow. Windthrow may be caused by natural hazards (i.e. shallow watertable, shallow to bedrock) or by management (i.e. excessive cutting).	Windthrow may be reduced by planting species which will tolerate shallow rooting environments (see R,r above). Lighter harvests will reduce windthrow hazards on these sites.

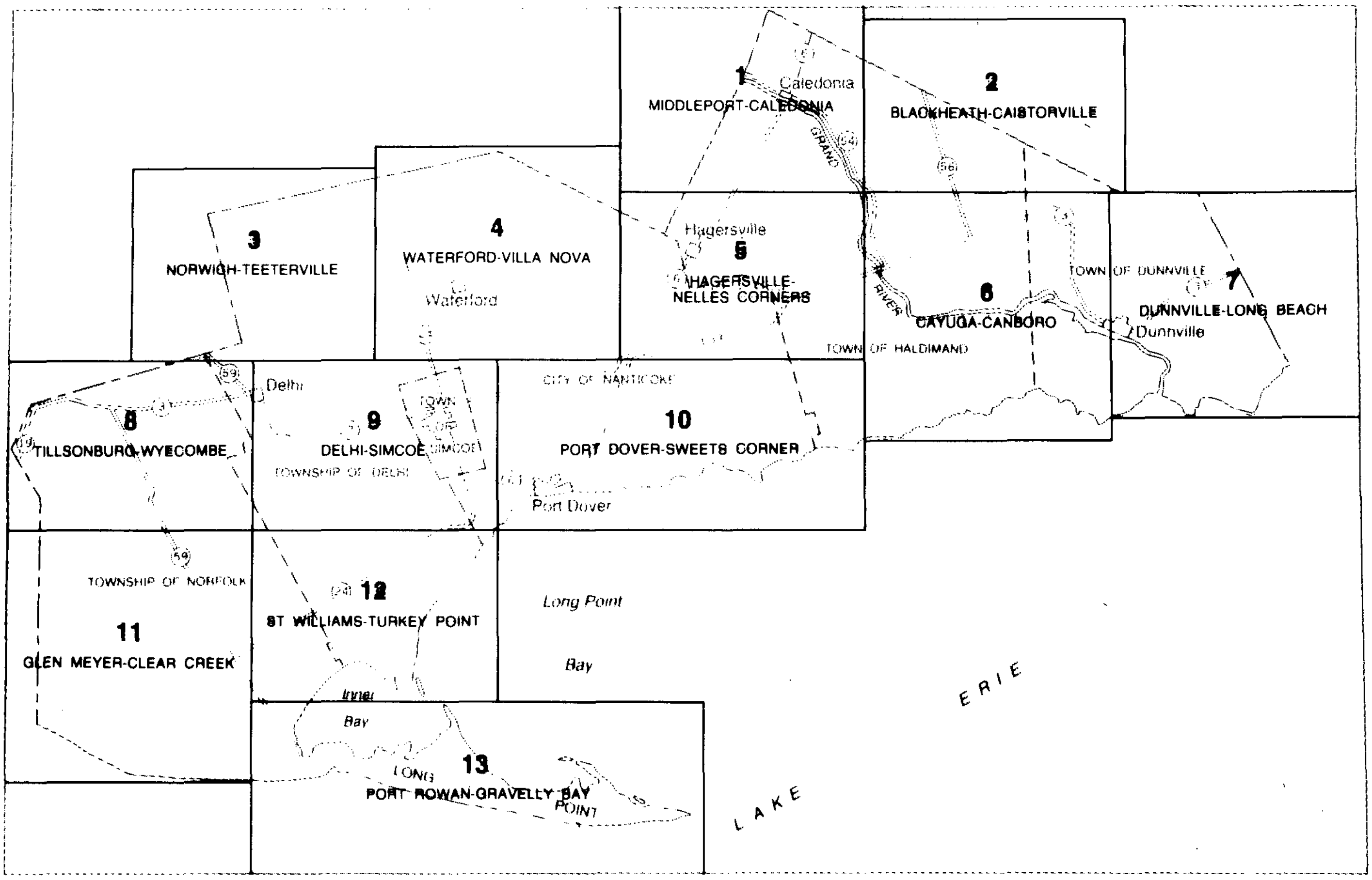
**Uppercase symbols represent severe limitations (e.g. C).*
Lowercase symbols represent moderate limitations (e.g. c).
Absence of symbol represents slight or no limitation.
For each soil, limitation symbols are listed in descending order of severity in the soil limitations column.

REFERENCES

1. Ontario Soil Survey. 1928. *Soil map of Norfolk County.* Ontario Agricultural College and Dominion Dept. of Agriculture.
2. Ontario Soil Survey. 1935. *Soil map of Haldimand County.* Ontario Agricultural College and Dominion Dept. of Agriculture.
3. Chapman, L.J. and D.F. Putnam. 1966. *Physiography of Southern Ontario.* University of Toronto press, Toronto.
4. Feenstra, B.H. 1974. *Quaternary geology of the Dunnville area, Southern Ontario.* Ont. Div. Mines, Prelim. map P.981, scale 1:50,000.
5. Barnett, P.J. 1978. *Quaternary geology of the Simcoe area.* Ont. Div. Mines, Geoscience Rept. 162, scale 1:50,000.
6. Chanasyk, V. (Ed.) 1970. *The Haldimand-Norfolk Environmental Appraisal.* Ont. Min. of Treasury, Economics and Intergovernmental Affairs.
7. Telford, P.G. and G.A. Tarrant. 1972. *Paleozoic geology of Dunnville Area, Southern Ontario.* Ont. Div. Mines, Prelim. Map P.988, scale 1:50,000.
8. Hewitt, D.F. and M.A. Vos. 1972. *The limestone industry of Ontario.* Ont. Div. Mines, IMR11.
9. Fahselt, D., P. Maycock, G. Winder and C. Campbell. 1979. *The Oriskany sandstone outcrop and associated natural features, a unique occurrence in Canada.* Canadian Field Naturalist 93(1):28-40.
10. Cowan, W.R. 1972. *Pleistocene geology of the Brantford area, Southern Ontario.* Ont. Dept. Mines, IMR37.
11. Feenstra, B.H. 1975. *Quaternary geology of the Grimsby area, Southern Ontario.* Ont. Div. Mines, Prelim. Map P.993, scale 1:50,000.
12. Feenstra, B.H. 1972b. *Quaternary geology of the Welland area, Southern Ontario.* Ont. Div. Mines, Prelim. Map P.796, scale 1:50,000.
13. Barnett, P.J. 1982. *Quaternary geology of the Tillsonburg area, Southern Ontario.* Ont. Geol. Survey Rept. 220.
14. Brown, D.M., G.A. McKay and L.J. Chapman. 1968. *The climate of southern Ontario.* Climatological studies No. 5, Met. Branch, Ont. Dept. of Transport.
15. Munn, R.E. *et al.* 1972. *"Atmospheric inventory and air pollution analysis", in the Haldimand-Norfolk Environmental Appraisal* (Ed. V. Chanasyk). Ont. Min. of Treasury, Economics and Intergovernmental Affairs.
16. Dorney, R.S. *et al.* 1972. *"Historical Ecology", in the Haldimand-Norfolk Environmental Appraisal* (Ed. V. Chanasyk). Ont. Min. of Treasury, Economics and Intergovernmental Affairs.
17. Maycock, P.F. 1963. *The phytosociology of the deciduous forests of extreme southern Ontario.* Can. J. Botany, Vol. 41, pp. 379-438.
18. Heffernan, Susan E. and B.D. Ralph. 1978. *Vegetation of Long Point, Ontario.* Report to Canadian Wildlife Section, Ontario Region, under contract no. KL110-80014.
19. Taylor, E.P. and R.K. Jones. 1980. *Soil interpretations for forest land management in the Regional Municipality of Haldimand-Norfolk.* Ont. Inst. of Pedology, unpublished.
20. Mapping Systems Working Group. 1981. *A soil mapping system for Canada:* revised. Land Resource Research Inst., Contribution No. 142, Agriculture Canada, Ottawa, 94 pp.
21. Canada Soil Survey Committee, Subcommittee on Soil Classification. 1978. *The Canadian system of soil classification.* Can. Dept. Agric., Publ. 1646. Supply and Services Canada, Ottawa, Ont. 164 pp.
22. Environment Canada. 1976. *Land capability for agriculture.* Canada Land Inventory; A preliminary report. Lands Directorate.
23. Environment Canada. 1972. *Canada Land Inventory soil capability classification for agriculture.* Report No. 2.
24. McBride, R.A. 1983. *Agronomic and engineering soil interpretations from water retention data.* Unpublished PH.D. thesis, U. of Guelph.
25. Hoffman, D.W. and C.J. Acton. 1974. *Soils of Northumberland County.* Report No. 42, Ontario Soil Survey.
26. Agriculture Canada. 1981. *Climate and soil requirements for economically important crops in Canada.* Prepared by P.A. Dubé under DSS Contract 01 SW 01528-6-0238 for Research Branch, Agriculture Canada.
27. Cressman, D. and M. Hoffman. 1983. *Soil rating system specialty crops in southwestern Ontario.* Prepared under Ont. Inst. of Pedology Contract for Ontario Hydro. Unpublished.
28. Wischmeier, W.H. and D.D. Smith. 1978. *Predicting rainfall erosion losses — a guide to conservation planning.* U.S. Dept. of Agriculture, Agr. Handbook No. 537.
29. van Vliet, L.J.P., G.J. Wall and W.T. Dickinson. 1976. *Effects of agricultural land use on potential sheet erosion losses in southern Ontario.* Can. J. Soil Sci. 56:443-451.
30. van Vliet, L.J.P. and G.J. Wall. 1979. *Comparison of predicted and measured sheet and rill erosion in southern Ontario.* Can. J. Soil Sci. 59:211-213.
31. Wall, G.J., W.T. Dickinson and J. Greuel. 1983. *Rainfall erosion indices for Canada east of the Rocky Mountains.* Can. J. Soil Sci. 63:271-280.
32. Hayes, W.A. 1972. *Designing wind erosion control systems in the Midwest Region.* RTSC - Agron. Tech. Note L1-9, Soil Cons. Serv. U.S.D.A., Lincoln, Nebr.
33. Lyles, L. 1975. *Possible effects of wind erosion on soil productivity.* J. Soil and Water Cons. Nov.-Dec. pp. 279-283.
34. Irwin, R.W. 1970. *Drainage benefits.* Agdex 555. Ont. Dept. of Agriculture and Food, Toronto.
35. Chisholm, P.S. 1981. *Hydrologic classification of Ontario soils.* Proc. 13th Drainage Engineers Conference, Eng. Tech. Pub. 126-58, School of Engineering, U. of Guelph.
36. Desjardins, R. *The impact of obstacles on farm operations.* Resource Economics Branch, Alberta Agriculture.
37. Paul, C.L. and J. DeVries, 1979. *Prediction of soil strength from hydrologic and mechanical properties,* Can. J. Soil Sci. 59:301-311.
38. Mackintosh, E.E. and J. van der Hulst. 1978. *Soil drainage classes and soil water table relations in medium- and coarse-textured soils in Southern Ontario.* Can. J. Soil Sci. 58:287-301.
39. Irwin, R.W. and P.S. Chisholm. 1984. *Soil drainage for agricultural productivity.* Proc. summer meeting Am. Soc. Agric. Eng., U. of Tennessee, Knoxville: 84-2052.
40. Sheard, R.W. 1982. *Soil plant relations: grain corn response to tile drainage and nitrogen.* Progress Rept., Dept. of Land Res. Sci. and Ont. Inst. of Pedology, U. of Guelph: 53-57.

41. Soil Conservation Service, United States Dept. of Agriculture. 1964. *National Engineering Handbook, Sec. 4: Hydrology.*
42. Chisholm, P.S., A. Baytalan and R.W. Irwin. 1980. *Soil classification for agricultural drainage - southern Ontario.* Tech. Rept. 126-54, School of Engineering, U. of Guelph.
43. Robson, J.D. and A.J. Thomasson. 1977. *Soil water regimes.* Soil Survey of England and Wales. Tech. Monograph No. 11.
44. Irwin, R.W. 1984. *Drainage guide for Ontario*, Pub. 29 (revised), Ont. Min. of Agriculture and Food, Toronto.

KEY MAP OF HALDIMAND-NORFOLK



Index of Soil Maps Available for the Regional Municipality of Haldimand-Norfolk.