Forest Soil Types of Nova Scotia

Identification, Description, and Interpretation

NOVA SCOTIA
Natural Resources

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Author:

Kevin Keys, MScF, RPF

Photo Credits:

Eugene Quigley
Peter Neily
Sean Basquill

2007
Nova Scotia Department of Natural Resources
Manual FOR 2007-2

Contacts:

Kevin Keys
Jacques Whitford Ltd.
Dartmouth, NS
902-468-7777
kevin.keys@jacqueswhitford.com

Peter Neily
Forest Management Planning
Nova Scotia Natural Resources
902-893-5692
pdneily@gov.ns.ca

Table of Contents

List of Figures

List of Tables

Acknowledgements

Thanks to Ken Webb, MSc, P.Ag. (Agriculture and Agri-Food Canada, Truro, NS) for his thorough review of this guide.

Any errors found in this document are the sole responsibility of the author.

Introduction

This document is part of the provincial forest ecosystem classification (FEC) project. It describes all currently recognized FEC soil types in the province along with management interpretations, photographs, and correlation with soil survey map units. Although part of a more comprehensive FEC system, this document can be used as a stand alone guide for identifying and interpreting forest soils in Nova Scotia.

Background

In 2000, the Nova Scotia Department of Natural Resources began a long-term project to systematically identify and describe forest ecosystem units in the province. To date, over 1,000 FEC plots have been assessed throughout Nova Scotia. This has resulted in the production of several publications describing regional vegetation types and soil types (Keys *et al*., 2003; Keys and Quigley, 2005; Neily *et al*., 2006; Keys *et al*., 2007; Neily *et al*., 2007). The project will culminate with production of a complete provincial FEC guide in 2009.

FEC Soil Types

There are currently 18 soil types and 4 soil type phases in the provincial FEC system. These units are differentiated based on general features of ecological and/or management related significance (details below). Because more than one soil type can be associated with a given forest cover type, and because different soils can respond differently to management treatments, determination of soil type is recommended for stand-level management purposes.

> Note: *Not all soil types occur everywhere in the province. With time, users of this guide will become familiar with those types found within their region of interest.*

A series of keys have been developed (Figure 1) which enable users to identify different soil types based on:

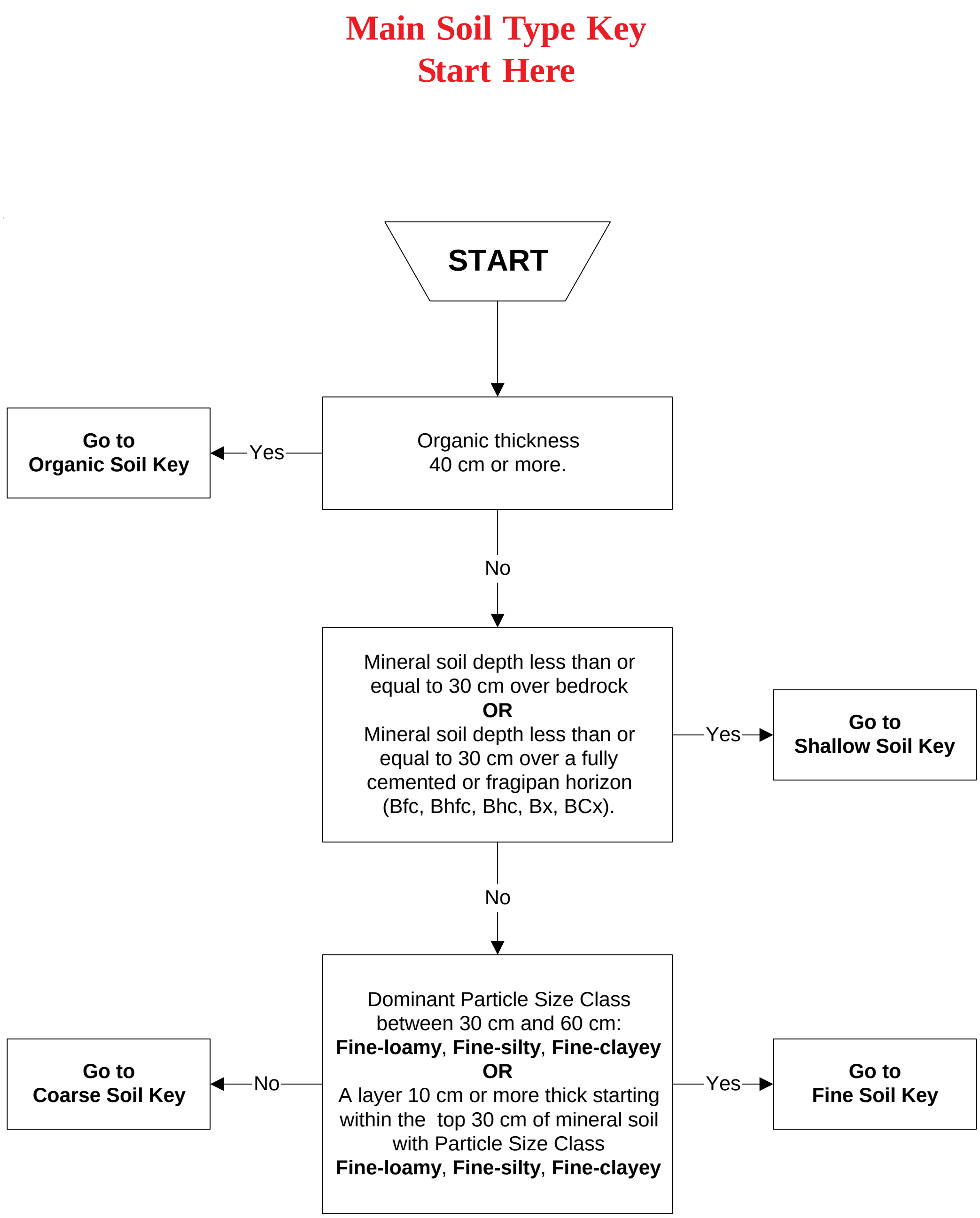
- thickness and type of surface organic horizons
- mineral soil depth
- presence of organically enriched Ah or Ap mineral horizons
- dominant particle size and texture classes within the soil profile
- soil drainage condition
- surface stoniness / coarse fragment content

The soil type keys are hierarchical (starting with the main soil type key), with the user working down through decision points until the soil type is determined. Once a soil type has been keyed out, soil type descriptions can be consulted to verify the decision.

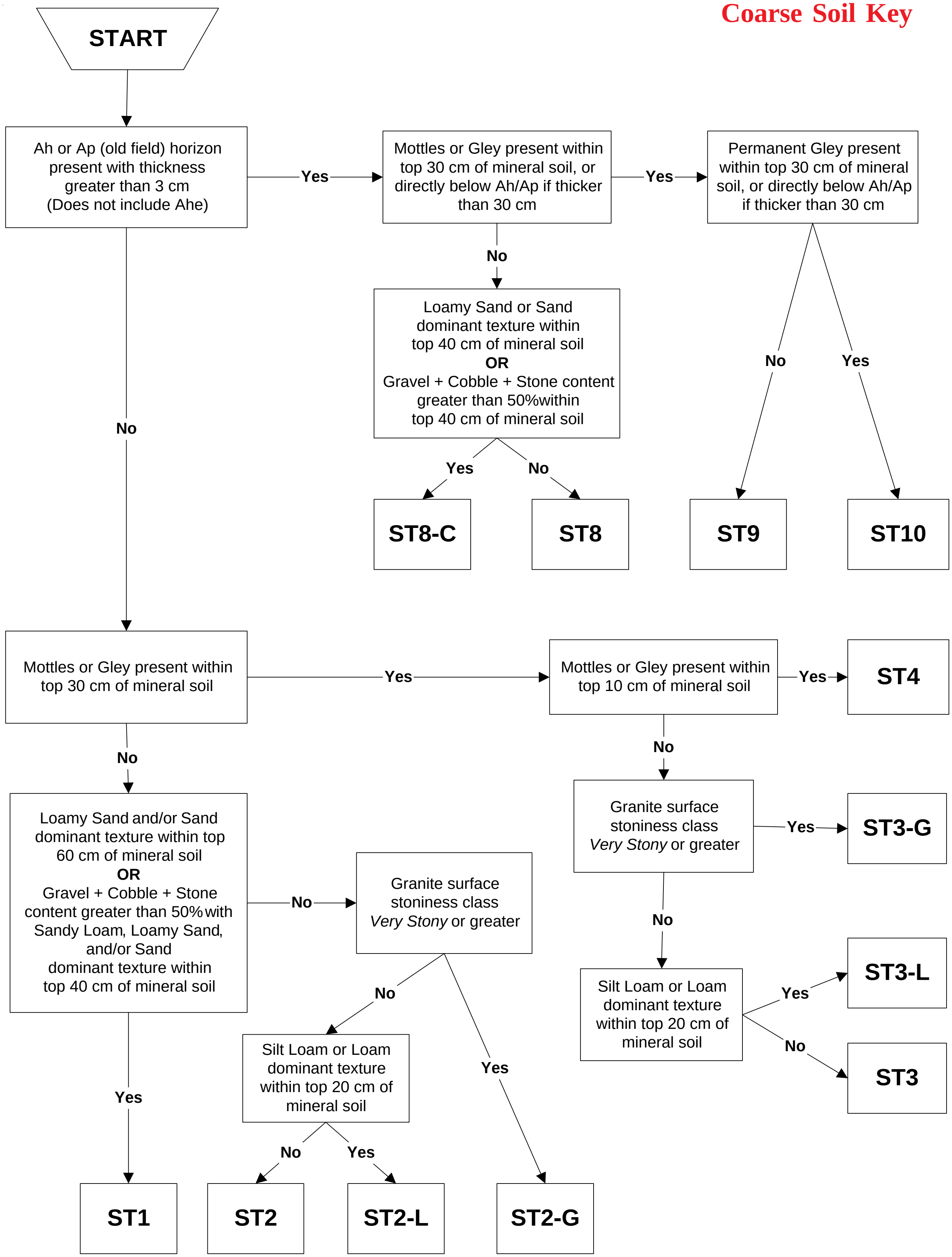
Use of the keys requires digging a small soil pit in an area representative of the forest stand being assessed (see Appendix 3 for details). With experience, soil type assessments generally take less than ten minutes.

Along with soil type keys, a soil texture and particle size key has also been developed to aid field assessment (Figure 2). Explanations of soil-related terms used in this guide are given in Appendix 4.

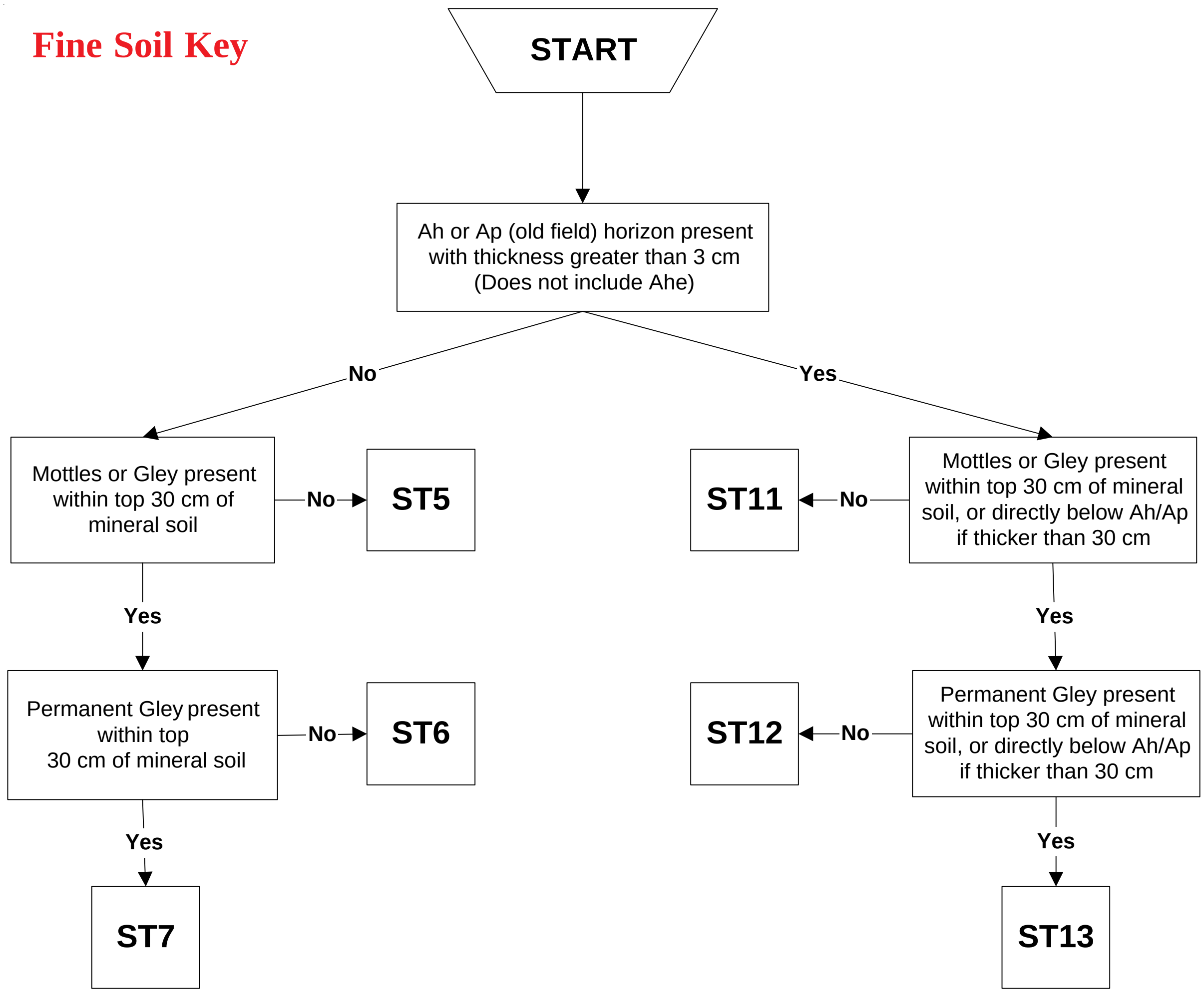
Figure 1. Keys to FEC soil types in Nova Scotia.



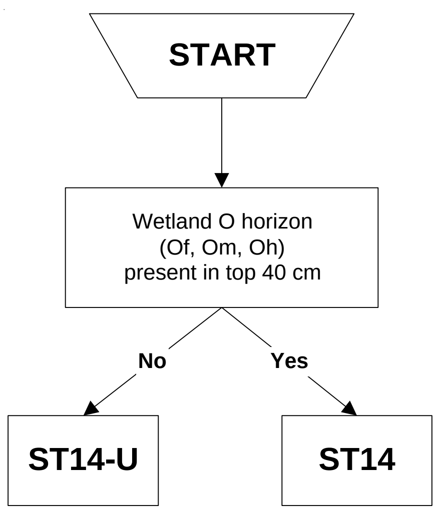
Coarse Soil Key



Fine Soil Key



Organic Soil Key



Shallow Soil Key

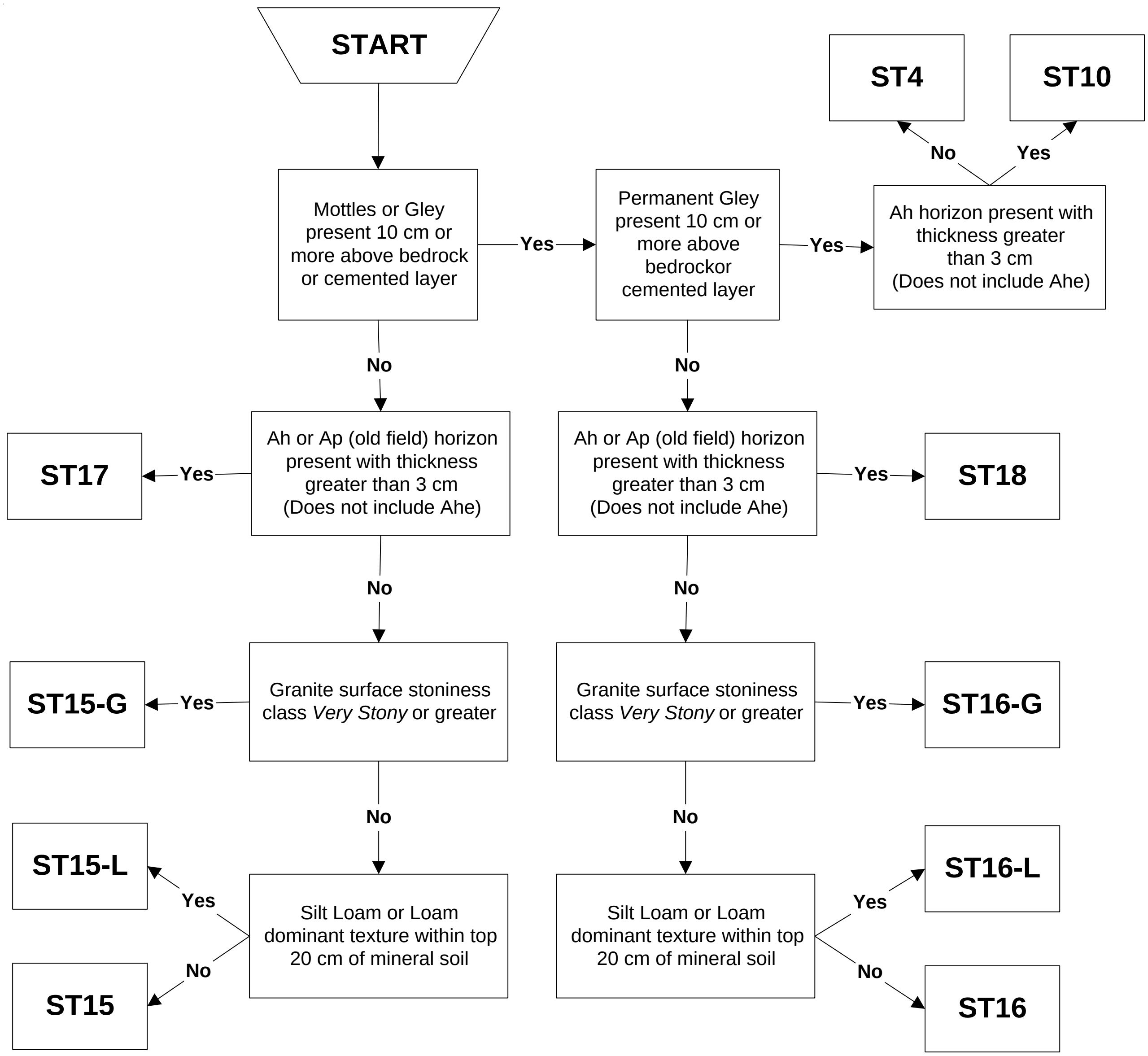
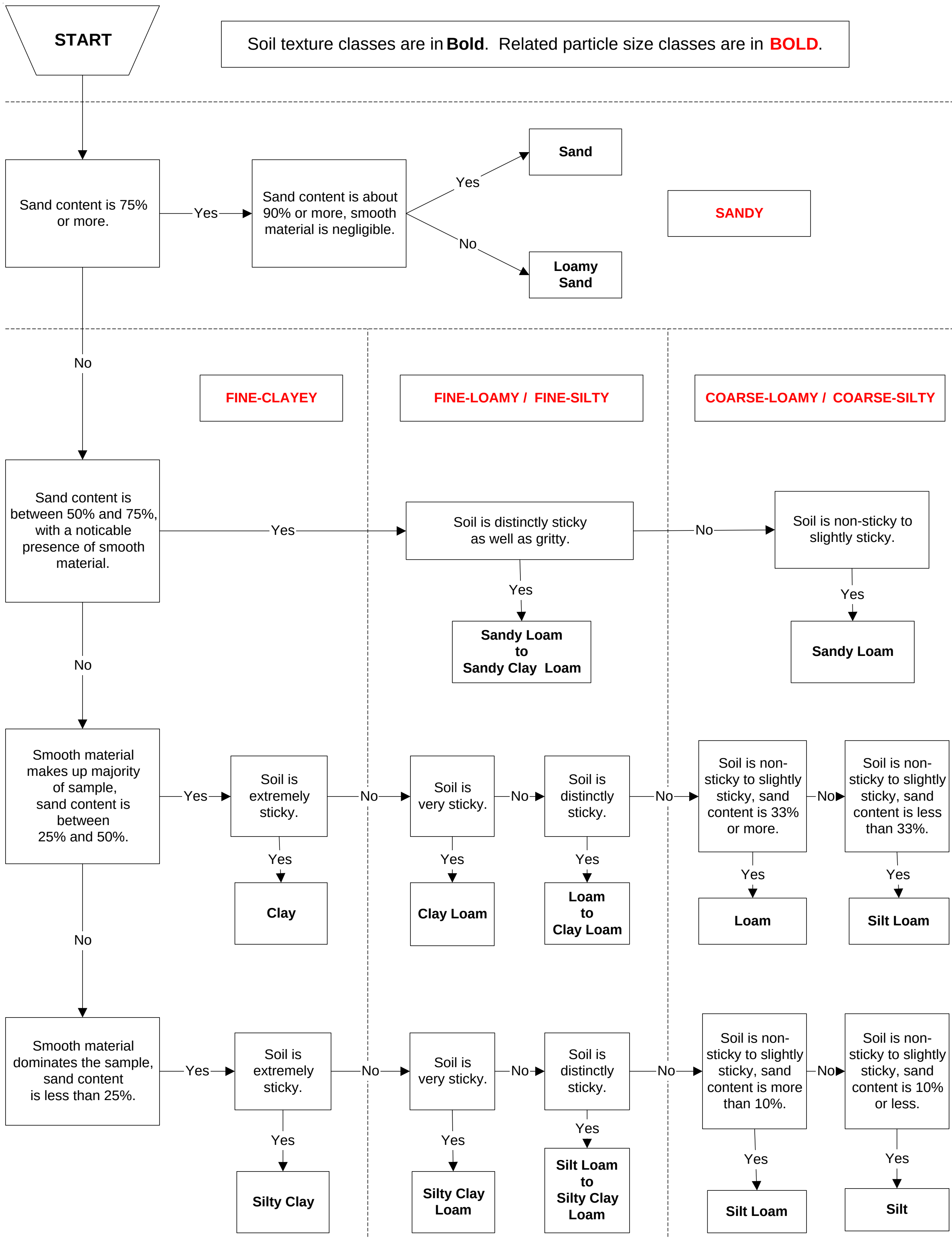


Figure 2. Soil texture class and particle size class key.



Soil Texture Key

To use the soil texture key (Figure 2), start by placing a small mass of soil on the middle of your three largest fingers (palm side) and remove any obvious organic material and coarse fragments (rocks).

> Note: *All particles over 2 mm in size are considered coarse fragments and are not not part of the texture assessment. If the sample being assessed has many small coarse fragments, you must mentally disregard these when assessing the sample.*

Next, moisten the sample until it is wet enough to stay in place when inverted (when you turn your hand over), but not so that the sample is runny or excess water is present (see photos below).

Rub the sample between your thumb and fingers to assess relative grittiness and smoothness. All grittiness, no matter how fine, is due to sand content (smoothness is due to both silt and clay). Based on relative grittiness, determine sand content by going down the left hand column of the key until the description matches your sample (Note: percentage values used in this key are not intended to exactly match texture triangle boundaries).

Once you have assessed relative sand content, lift your thumb up and down from the fingers to assess relative stickiness. Only the clay fraction causes stickiness (silt just feels smooth). The more clay in your soil, the stickier it will feel when moist. This assessment only applies when sand content is less than 75%.

Move across the key from left to right (beginning from where you established sand content) until the stickiness description matches your sample. This will lead you to your estimated texture class. Once you have estimated soil texture, look up the associated particle size class (bewteen the dashed lines). See Appendix 4 for more information on soil texture and particle size classes.

Soil sample before moistening.

Soil sample after moistening, ready for texture class determination.

Soil Type Descriptions

Descriptions of each soil type in the provincial FEC system are given below.

ST1: Dry - MCT

Dry, coarse-textured or very gravelly medium-textured soils. Gravel/cobble content in surface horizons is often more than 50%, but may also be absent in sandy outwash or glaciofluvial deposits. Stone and boulder content can be low to high. Drainage is usually well or rapid, but can be moderately well in lower or level slope positions. Profiles generally contain a well developed Ae horizon, and may also contain partially or fully cemented B horizons. Where fully cemented B horizons are found above 30 cm, ST1 soils become ST15 soils.

ST2: Fresh - MCT

Fresh, medium to coarse-textured soils, with near-surface soil texture dominated by sandy loam or coarser textures. Gravel/cobble content is generally low to medium in surface horizons. Stone and boulder content is usually low, but can be high in soils derived from granite or quartzite tills. Drainage is usually well, but can be rapid or moderately well depending on slope position, slope percent, soil depth, and subsoil permeability. Profiles generally contain a well developed Ae horizon, but an Ahe horizon may be present in some soils. Partially or fully cemented B horizons may also be found. Where fully cemented B horizons are found above 30 cm, ST2 soils become ST15 soils.

ST2-G: Fresh - MCT (Granite phase)

ST2-G soils are similar to ST2 soils, but are distinguished by the presence of numerous granite or granodiorite stones and boulders on the surface (surface stoniness class *very stony* or greater). This high surface stoniness is also reflected in high coarse fragment content below the surface.

ST2-L: Fresh - MCT (Loamy phase)

ST2-L soils are similar to ST2 soils, but are distinguished by the presence of surface soil textures dominated by loam and/or silt loam.

ST3: Moist - MCT

Moist, medium to coarse-textured soils, with near-surface soil texture dominated by sandy loam or coarser textures. Gravel/cobble content can vary from low to high, as can stone and boulder content. Drainage is moderately well to imperfect due to slope position (middle, lower, level) and/or restricted vertical drainage in areas of gentle slope. Profiles generally contain an Ae horizon, but an Ahe horizon may be present in some soils. Lower slope seepage potential may be high for soils with restricted vertical drainage.

ST3-G: Moist - MCT (Granite phase)

ST3-G soils are similar to ST3 soils, but are distinguished by the presence of numerous granite or granodiorite stones and boulders on the surface (surface stoniness class *very stony* or greater). This high surface stoniness is also reflected in high coarse fragment content below the surface.

ST3-L: Moist - MCT (Loamy phase)

ST3-L soils are similar to ST3 soils, but are distinguished by the presence of surface soil textures dominated by loam and/or silt loam.

ST4: Wet - MCT

Wet, medium to coarse-textured soils (includes wet shallow soils). Gravel/cobble content can vary from low to high, as can stone and boulder content. Drainage is imperfect to poor due to slope position (lower, level, depression) and/or restricted vertical drainage in areas of gentle slope. Profiles generally contain a mottled or gleyed Ae horizon, but an Ahe horizon (or wet variant) may be present in some soils. Lower slope seepage potential may be high for soils with restricted vertical drainage.

ST5: Fresh - FMT

Fresh to fresh-moist, fine to medium-textured soils. Gravel/cobble content is generally low in surface horizons, and stone and boulder content is usually low. Drainage is usually moderately well, but can be well depending on slope position, slope percent, and soil depth. Profiles generally contain an Ae horizon, but an Ahe or thin Ah horizon are also common. BC and C horizons often contain mottles due to restricted drainage and/or poor aeration in the fine-textured subsoil.

ST6: Moist - FMT

Moist to moist-wet, fine to medium-textured soils. The texture of the A horizon can sometimes be coarser due to inputs from weathered rock. Profiles may also contain coarse-textured horizons below finer surface horizons of different origin. Gravel/cobble content is generally low in surface horizons, and stone and boulder content is usually low. Drainage is moderately well to imperfect due to middle or lower slope position, gentle slope, shallow depth, and/or high clay content in surface horizons. Profiles generally contain an Ae or Ahe horizon, but a thin Ah horizon may be present in some soils. Lower slope seepage potential may be high due to restricted vertical drainage in the fine-textured subsoil.

ST7: Wet - FMT

Wet, fine to medium-textured soils. The texture of the A horizon can sometimes be coarser due to inputs from weathered rock. Profiles may also contain coarse-textured horizons below finer surface horizons of different origin. Gravel/cobble content is generally low in surface horizons, and stone and boulder content is usually low. Drainage is poor due to slope position (lower, level, depression), gentle slope, shallow depth, and/or high overall clay content. Profiles generally contain a mottled or gleyed Ae or Ahe horizon, but a thin Ah horizon may be present in some soils. Lower slope seepage potential may be high due to restricted vertical drainage in the fine-textured subsoil.

ST8: Rich Fresh - MCT

Fresh, medium to coarse-textured soils with significant organic matter enrichment in the A horizon. The Ah/Ap horizon has been formed through mixing by soil fauna or through pasturing/tillage. Gravel/cobble content is generally low to medium in surface horizons, and may be absent in alluvium soils. Stone and boulder content is usually low to medium. Drainage is usually well, but can be moderately well depending on slope position, slope percent, soil depth, and subsoil permeability. Profiles may contain an Ae horizon below the Ah/Ap horizon.

ST8-C: Rich Fresh - MCT (Coarse phase)

ST8-C soils are similar to ST8 soils, but are distinguished by the presence of high sand and/or coarse fragment content. These soils are often associated with coarse alluvium deposits or with colluvium/talus deposits derived from nutrient rich rock (basalt/gabbro).

ST9: Rich Moist - MCT

Moist, medium to coarse-textured soils with significant organic matter enrichment in the A horizon. The Ah/Ap horizon has been formed through mixing by soil fauna, the presence of graminoid species[1], or through pasturing/ tillage. Gravel/cobble content is generally low to medium in surface horizons, and may be absent in alluvium soils. Stone and boulder content is usually low to medium. Drainage is moderately well to imperfect due to slope position (middle, lower, level), restricted vertical drainage in areas of gentle slope, and/or low overall sand content. Profiles may contain an Ae horizon (or mottled variant) below the Ah/Ap horizon. Seepage is often an important contributor to soil fertility in lower slope positions.

ST10: Rich Wet - MCT

Wet, medium to coarse-textured soils with significant organic matter enrichment in the A horizon (includes rich wet shallow soils). The Ah horizon has been formed through mixing by soil fauna and/or the presence of graminoid species. Gravel/cobble content is generally low to medium in surface horizons, and may be absent in alluvium soils. Stone and boulder content is usually low to medium. Drainage is poor due to slope position (lower, level, depression) and/or restricted vertical drainage in areas of gentle slope. Profiles may contain a mottled or gleyed Ae horizon below the Ah horizon. Seepage is often an important contributor to soil fertility in lower slope positions.

ST11: Rich Fresh - FMT

Fresh to fresh-moist, fine to medium-textured soils with significant organic matter enrichment in the A horizon. The Ah/Ap horizon has been formed through mixing by soil fauna or through pasturing/tillage. Gravel/cobble content is generally low in surface horizons, and may be absent in alluvium soils. Stone and boulder content is usually low. Drainage is usually moderately well, but can be well depending on slope position, slope percent, and soil depth. Profiles may contain an Ae horizon below the Ah/Ap horizon, and BC and C horizons often contain mottles due to restricted drainage and/or poor aeration in the fine-textured subsoil.

ST12: Rich Moist - FMT

Moist to moist-wet, fine to medium-textured soils with significant organic matter enrichment in the A horizon.

1. Graminoid species includes grasses, sedges, and rushes.

The Ah/Ap horizon has been formed through mixing by soil fauna, the presence of graminoid species, or through pasturing/tillage. Gravel/cobble content is generally low in surface horizons, and may be absent in alluvium soils. Stone and boulder content is usually low. Drainage is generally imperfect due to slope position (middle, lower, level), gentle slope, restricted vertical drainage, and/or high clay content in surface horizons. Profiles may contain an Ae horizon (or mottled variant) below the Ah/Ap horizon. Seepage is often an important contributor to soil fertility in lower slope positions.

ST13: Rich Wet - FMT

Wet, fine to medium-textured soils with significant organic matter enrichment in the A horizon. The Ah horizon has been formed through mixing by soil fauna and/or the presence of graminoid species. Gravel/cobble content is generally low in surface horizons, and may be absent in alluvium soils. Stone and boulder content is usually low. Drainage is poor due to slope position (lower, level, depression), restricted vertical drainage, and/or high clay content in surface horizons. Profiles may contain a mottled or gleyed Ae horizon below the Ah horizon. Seepage is often an important contributor to soil fertility in lower slope positions.

ST14: Organic

Soils with thick organic layers mainly derived from vegetation associated with very wet sites (dominantly O horizon types). Mineral soil (if reached) can be of variable texture and coarse fragment content can be low to high. Drainage is poor to very poor due to level or depression slope position and/or shallow depth to horizons with restricted vertical flow.

ST14-U: Organic (Upland phase)

Soils with thick organic layers currently derived from vegetation associated with upland sites (thick LFH horizons). O horizons may be found below the thick LFH layer, and stones or boulders may be intermixed with organic horizons where these soils have developed on stony sites. Mineral soil (if reached) can be of variable texture and coarse fragment content can be low to high. Drainage is generally imperfect due to slope position (lower, level) and/or shallow depth to horizons with restricted vertical flow.

ST15: Dry Shallow - MCT

Dry to fresh, medium to coarse-textured, shallow soils over cemented/fragipan horizons or near-surface bedrock (including exposed bedrock). Gravel/cobble content can vary from low to high, as can stone and boulder content. Drainage is usually rapid or well, but can be moderately well depending on slope position. Profiles generally contain an Ae horizon, but an Ahe horizon may be present in some soils.

ST15-G: Dry Shallow - MCT (Granite phase)

ST15-G soils are similar to ST15 soils, but are distinguished by the presence of numerous granite or granodiorite stones and boulders on the surface (surface stoniness class *very stony* or greater). This high surface stoniness is also reflected in high coarse fragment content below the surface.

ST15-L: Dry Shallow - MCT (Loamy phase)

ST15-L soils are similar to ST15 soils, but are distinguished by the presence of surface soil textures dominated by loam and/or silt loam.

ST16: Moist Shallow - MCT

Moist, medium to coarse-textured, shallow soils over cemented/fragipan horizons or near-surface bedrock (including exposed bedrock). Gravel/cobble content can vary from low to high, as can stone and boulder content. Drainage is moderately well to imperfect due to slope position. Profiles generally contain an Ae or mottled Ae horizon, but an Ahe horizon (or mottled variant) may be present in some soils.

ST16-G: Moist Shallow - MCT (Granite phase)

ST16-G soils are similar to ST16 soils, but are distinguished by the presence of numerous granite or granodiorite stones and boulders on the surface (surface stoniness class *very stony* or greater). This high surface stoniness is also reflected in high coarse fragment content below the surface.

ST16-L: Moist Shallow - MCT (Loamy phase)

ST16-L soils are similar to ST16 soils, but are distinguished by the presence of surface soil textures dominated by loam and/or silt loam.

ST17: Rich Dry Shallow - MCT

Dry to fresh, medium to coarse-textured, shallow soils with significant organic matter enrichment in the A horizon. The Ah/Ap horizon has been formed through mixing by soil fauna or through pasturing. Enhanced fertility in these shallow soils is often a result of inputs from nutrient rich bedrock (basalt/gabbro). Gravel/cobble content can vary from low to high, as can stone and boulder content. Drainage is usually rapid to well, but can be moderately well depending on slope position. These soils are usually associated with near-surface bedrock, but they can also occur with cemented or fragipan soils.

ST18: Rich Moist Shallow - MCT

Moist, medium to coarse-textured, shallow soils with significant organic matter enrichment in the A horizon. The Ah/Ap horizon has been formed through mixing by soil fauna or through pasturing. Enhanced fertility in these shallow soils is often a result of inputs from nutrient rich bedrock (basalt/gabbro). Gravel/cobble content can vary from low to high, as can stone and boulder content. Drainage is moderately well to imperfect due to slope position. These soils are usually associated with near-surface bedrock, but they can also occur with cemented or fragipan soils.

Soil Type Matrix

Relationships between FEC soil types can be shown using a matrix table (Figure 3). This allows users to see which soils are related to each other by their texture, drainage, fertility, and depth.

Figure 3. FEC soil type matrix.

Dominant Moisture Condition	Medium to Coarse Textured				Fine to Medium Textured		Organic
	Typic	**Rich**	**Shallow**	**Shallow/ Rich**	**Typic**	**Rich**	**Typic**
Dry	**ST1**		(ST15-G) **ST15** (ST15-L)				
Fresh	(ST2-G) **ST2** (ST2-L)	(ST8-C) **ST8**		**ST17**	**ST5**	**ST11**	
Moist	(ST3-G) **ST3** (ST3-L)	**ST9**	(ST16-G) **ST16** (ST16-L)	**ST18**	**ST6**	**ST12**	**ST14-U**
Wet	**ST4**	**ST10**	**ST4**	**ST10**	**ST7**	**ST13**	**ST14**

By design, the soil type matrix can be used to predict how different soils will react or change with changing site conditions.

For example:

- During and shortly after a significant rain event, a well drained (fresh) ST2 soil will react to machine traffic like a moist ST3 soil or a wet ST4 soil until such time as excess water has drained away.

- An old field white spruce stand found on a mapped ST6 soil will likely now be dominated by ST12 soil because of the presence of an Ap horzon.

- An ST2-L soil located in an area known to be shallow to slate bedrock will transition into ST15-L or ST16-L soils where this bedrock is close to the surface.

Soil Type Photographs

The following series of photographs show examples of FEC soil types along with some diagnostic features.

> Note: *Forest soil morphology is inherently variable, not all soils encountered will match these photographs. Users of this guide should rely on information contained in the soil type keys and descriptions when determining soil type in the field.*

ST1

Rapidly drained ST1 soil with sand and high gravel/ cobble content.

ST2

Well drained ST2 soil with sandy loam mineral soil and broken Ae horizon (greyish-white).

ST2-L

Well drained ST2-L soil with silt loam / loam mineral soil and thin Ae horizon.

ST3

Imperfectly drained ST3 soil with sandy loam mineral soil, well developed Ae horizon, and mottles in lower horizons.

ST3-L

Imperfectly drained ST3-L soil with loam mineral soil and mottles in lower horizons.

ST4

Poorly drained ST4 soil with near surface mottling and thick moss layer.

ST5

Well drained ST5 soil with reddish coloured lower horizons high in clay.

ST6

Imperfectly drained ST6 soil with a thin Ahe horizon and faint mottles above reddish coloured horizons high in clay.

ST7

Poorly drained ST7 soil with near surface prominent mottles (gley conditions) and high clay content.

ST8

Well drained ST8 soil with brown (organically enriched) Ah horizon above reddish-brown B horizons.

ST8-C

Stony alluvium deposit with sandy Ah horizon.

ST9

Imperfectly drained ST9 soil with Ah horizon above mottled C horizons (alluvium deposit).

ST10

Poorly drained ST10 soil with dark, wet Ah horizon below black organic horizon.

ST11

Moderately well drained ST11 soil with well developed Ah horizon and SiL - SiCL texture. Dark spots in lower horizons are from weathered rock fragments (shale).

ST12

Imperfectly drained ST12 soil with thick Ah horizon and mottled B and BC horizons high in clay.

ST13

Poorly drained ST13 soil with prominent mottling (gley conditions) below Ah horizon.

ST14

Very poorly drained ST14 soil derived from sphagnum moss.

ST14-U

Imperfectly drained upland organic ST14-U soil with mineral soil below.

ST15

Rapidly drained ST15 soil shallow to bedrock.

ST16

Imperfectly drained ST16 soil with mottled horizons above bedrock.

ST17 / ST18

Rich shallow soils over basalt bedrock. Where these soils are well drained, they are classed as ST17 soils. Imperfectly drained (mottled) soils are classed as ST18 soils. In both cases, a well developed Ah horizon is present.

Granite Phase

Examples of very stony surface conditions associated with granite phase soil types.

Soil Survey Correlation

Unlike larger provinces in Canada, most soils in Nova Scotia have been mapped at the soil series or soil association level (see Appendix 2). Only in northern Cape Breton are there large areas of essentially unsurveyed soils in the province.

Based on survey descriptions, a table has been created which correlates soil survey units with probable FEC soil types (Table 1). This allows use of soil survey maps to predict which soil types will be found in a given area - information which can then be used for planning purposes.

> Note: *Soil survey maps are not absolutely accurate. Users can expect to find inclusions of other soil units and/or a range of drainage conditions within any mapped polygon, especially if the polygon is large. As a result, predicted soil types should be verified at the stand level before implementing management prescriptions. A more detailed list of probable soil types associated with each soil survey unit can be found in Appendix 1.*

Table 1. Probable FEC soil types associated with mapped soil survey units in Nova Scotia. Only soil units which are reasonably expected to support forest cover are included in this list.

Soil Type 1	Soil Type 2	Soil Type 2L
Canning	Berwick	Barney
Cornwallis	Bridgetown	Bridgewater
Digby	Cobequid	Bryden
Hebert	Farmville	Glenmont
LaHave	Folly	Hopewell
Medway	Gibraltar	Kirkhill
Nictaux	Halifax	Kirkmount
Somerset	Hansford	Morristown
Torbrook	Merigomish	Pelton
Truro	Mersey	Rawdon
	Perch Lake	Rossway
	Portapique	
	Pugwash	
	Rodney	
	RML*	
	Shulie	
	Thom	
	Tormentine	
	Westbrook	
	Woodville	
	Wyvern	
	Yarmouth	

* RML = Rough Mountain Land

Table 1. Continued...

Soil Type 3	Soil Type 3L	Soil Type 4
Annapolis	Riverport	Arichat
Avonport	Roxville	Aspotogan
Bayswater		Economy
Comeau		Masstown
Danesville		Meteghan
Debert		Middlewood
Deerfield		Millar
Kentville		Pitman
Kingsport		Roseway
Liverpool		Seely
Mira		Tiddville
Springhill		

Soil Type 5	Soil Type 6	Soil Type 7
Elmsdale	Diligence	Joggins
Falmouth	Fash	Kingsville
Wolfville	Hantsport	Lawrencetown
Woodbourne	Middleton	Mahone
	Millbrook	
	Queens	

Soil Type 8	Soil Type 9	Soil Type 10
Cumberland	Bridgeville	Chaswood
Gulliver	Cherryfield	
Mossman		
Stewiacke		

Soil Type 14	Soil Type 15	Soil Type 16
Castley	Port Hebert	Lydgate
Organic	Rockland	
Peat		
Swamp		

Management Interpretations

Management interpretations related to soil compaction hazard, rutting hazard, erosion hazard, frost heave hazard, windthrow hazard, and sensitivity to forest floor loss have been made for all FEC soil types. All hazards considered are influenced (to varying degrees) by soil texture, soil moisture content, soil organic matter content, soil depth, and stoniness - the same features used to delineate soil types in the FEC system. Based on the condition of each soil type feature (and its relative importance), overall susceptibility ratings for each hazard type were assigned, ranging from low to very high (Table 2).

Soil hazard ratings are meant to alert users to the potential for soil damage or negative off-site impacts when conducting harvesting and site preparation treatments. These ratings should be considered when deciding on (i) harvesting system and equipment, (ii) site preparation method and equipment, (iii) timing of operations, (iv) trail and road layout, and (v) the need for on-site or off-site mitigation measures.

In general:

Low (L) hazard means there is a minor risk of damage or negative impacts under normal operating conditions.

Moderate (M) hazard means caution should be exercised as there is potential for some damage or negative impacts under normal operating conditions.

High (H) hazard means there is a potential for significant damage or negative impacts under normal operating conditions. These hazards need to be addressed in the planning process.

Very High (VH) hazard means there is potential for severe damage or negative impacts under normal operating conditions. These hazards need to be addressed in the planning process.

More information on avoiding soil and site damage can be found in Sutherland (2005) and Keys and Quigley (2005).

> Note: *Soils with low hazard ratings can still be susceptible to damage under certain circumstances. Hazard ratings in Table 2 reflect "usual" susceptibility, based on general conditions of each soil type.*

Compaction Hazard (CP)

Soil compaction from machines can reduce site quality by increasing soil bulk density, reducing soil aeration, altering water flow, and changing soil temperature regimes (Racey *et al*., 1989; Krause, 1998). The main soil factors influencing compaction hazard are moisture content, texture, and (to a lesser extent) organic matter content and coarse fragment content.

In general, *compaction hazard increases* as:

soil moisture content increases: soil aggregates are less stable as soil moisture increases;

soil texture becomes finer: because of particle size distributions, fine to medium-textured soils are more easily compacted than coarse-textured soils;

soil organic matter content decreases: the compressibility of soil at a given moisture content increases as organic matter content decreases (Krause, 1998).

coarse fragment content decreases: high coarse fragment content can reduce the impact of compaction (Childs and Flint, 1990).

Rutting Hazard (RT)

Soil rutting from machines reduces site quality mainly through alteration of water flows and exposure of less fertile subsurface horizons. Loss of soil structure and porosity in rutted (puddled) soils is also of concern. The main soil factors influencing rutting hazard are moisture content, texture, and organic matter content.

In general, *rutting hazard increases* as:

soil moisture content increases: soil bearing capacity decreases with increasing moisture content;

soil texture becomes finer: when wet, silty and clayey soils have lower shear strength than sandy soils;

soil organic matter content increases: organic matter contributes to reduced bearing capacity in soils.

In most cases, soils which are susceptible to rutting are also susceptible to compaction. Also, rutting in surface horizons often leads to compaction of deeper soil layers.

Soils with high compaction and rutting hazards are best travelled when frozen or during summer dry periods. When moist, these sensitive soils can be damaged with even one or two vehicle passes (McNabb, 1999; Keys and Quigley, 2005). To minimize damage, treatment plans should minimize the need for machine travel and traffic damage should be focused on fewer trails which are located and designed to withstand high use.

Frozen Soils: To prevent machine traffic damage, mineral soils need to be frozen to a depth of 15 cm or more and organic soils to a depth of 50 cm or more (Sutherland, 2005). For many areas in Nova Scotia, this condition is not often achieved, or is only achieved for short periods of time. To avoid serious site damage during winter operations, adequate frost penetration should be confirmed before operations begin. In some cases, management techniques can be used to promote frost penetration (Sutherland, 2005).

Dry Soils: Fine to medium textured (high hazard) soils remain moist for long periods after summer rain events and, depending on weather patterns, may never reach a truly dry condition. However, when (or if) these soils do become dry, managers should take advantage of these short-lived conditions by directing additional resources to these sites while conditions are favourable.

Erosion Hazard (E1/E2)

Soil erosion reduces site quality through loss of fertile topsoil. Stream water quality and aquatic habitat can also be severely impacted by erosion deposits, both on and off-site. The main soil factors influencing erosion hazard are moisture content, texture, organic matter content, and depth - factors related to a soil's ability to absorb and/or store water. The main site factors affecting erosion hazard are presence of surface organic horizons, degree of slope, and slope length.

In general, *erosion hazard increases* as:

soil moisture content increases: soils with high inherent moisture are less able to store additional water;

soil texture becomes finer: soils high in silt and fine sand are more prone to erosion because these particle sizes are mobile and can easily clog pore space, reducing infiltration capacity. Also, soil permeability generally decreases as soil texture becomes finer.

s*oil organic matter content decreases*: organic matter contributes to soil aggregate strength and porosity, weak aggregates are more likely to breakdown and clog pore space, reducing infiltration capacity. Also, organic matter has a high moisture absorption capacity - the lower the organic matter content, the lower the water storage capacity of the soil;

soil depth decreases: shallow soils are less able to store water.

With respect to site factors, the presence of intact surface organic horizons can significantly reduce erosion potential by absorbing the impact of rain and by increasing the water storage capacity of the soil.

All things being equal, the steeper and longer the slope, the greater the potential for erosion on a given site (Racey *et al*., 1989). Therefore, two erosion hazard ratings are given: one for slopes 10% or less (E1) and one for slopes greater than 10% (E2).

All soil types which have fine to medium-textured surface horizons are susceptible to erosion. Soils which are also moist and/or shallow are even more at risk. However, the presence of a well developed Ah/Ap horizon can reduce ersoion hazard, if soil structure is maintained. In this guide, wet soils are given lower hazard ratings because these soils tend to be on level or depression slope positions.

To avoid erosion on high hazard sites, forest floor organic layers should be kept intact and compaction and rutting should be minimized. Compaction can increase erosion hazard by reducing infiltration capacity. Rutting can produce artificial flow channels leading to erosion.

Frost Heave Hazard (FH)

Frost heave can result in poor growth or mortality of planting stock and natural regeneration. The main soil factors influencing frost heave hazard are moisture content, texture, and pore structure which influences soil water tension (Beckingham *et al*., 1996). Soils with low macro-pore percentages readily move water through capillary action, raising the likelihood of frost heave.

In general, *frost heave hazard increases* as:

soil moisture content increases: moisture is necessary for frost action;

soil texture becomes finer: fine-textured soils tend to have less macro-pore space than coarse-textured soils;

soil organic matter content decreases: organic matter contributes to soil structure and macro-porosity.

To reduce the occurrence of frost heave on high hazard sites, forest floor organic layers should be kept intact (Racey *et al*., 1989) and soil compaction should be minimized. Forest floor horizons can ameliorate temperature and moisture conditions which contribute to frost formation. Soil compaction reduces the percentage of macro-pores which contributes to frost heave hazard.

Windthrow Hazard (WT)

Windthrow hazard is often more related to stand and species characteristics than to soil limitations. Many tree species (eg. spruce and fir) are shallow rooted even when found on deep soils. Stand density, overall tree health, and relative exposure to winds are also important factors.

The main soil factor influencing windthrow hazard is potential rooting depth, which is related to soil moisture content, soil texture, and overall soil depth. Ratings in Table 2 refer only to soil-related windthrow hazard. Users must consider all factors listed above when assessing overall windthrow hazard for a given site.

In general, *windthrow hazard increases* as:

soil moisture content increases: high or fluctuating water tables do not allow for deep or stable rooting;

soil texture becomes finer or coarser: fine-textured soils tend to become more massive in structure with depth, thereby reducing potential rooting depth. Also, clayey soils lack shear strength, particularly when wet. Sandy soils, although usually deep, lack cohesiveness making them more susceptible to windthrow than loamy soils (Zelazny *et al*., 1989).

soil depth decreases: naturally shallow soils do not allow deep rooting regardless of species type.

Forest Floor Loss (FL)

This hazard refers to the potential for serious decreases in micro-site fertility (nutrient and moisture availability) when surface organic horizons are removed or redistributed on a site. Forest floor horizons are an important source of nutrients, especially for tree seedlings. Forest floor horizons also regulate moisture supply and temperature extremes near the soil surface. The main factors influencing sensitivity to forest floor loss are soil moisture content, soil texture, soil organic matter content, and overall soil depth.

In general, *forest floor loss sensitivity increases* as:

soil moisture content becomes too dry or too wet: in drier soils, loss of forest floor horizons can lead to dessication near the surface. In wet soils, loss of forest floor horizons means a loss of nutrient supply and rooting medium, since mineral horizons are often too wet for root access;

soil texture becomes coarser: coarse-textured soils lack the moisture and nutrient holding capacities of medium and fine-textured soils.

soil organic matter decreases: lack of soil organic matter means decreased moisture and nutrient holding capacities, as well as reduced nutrient sources.

soil depth decreases: shallow soils do not have the same nutrient and moisture resources as deeper soils, all other things being equal.

To avoid damaging sites which are sensitive to forest floor loss, mineral soil exposure should be kept to a minimum during all treatment operations.

Planning Considerations

Managers, harvest contractors, and woodlot owners can use soil type information to promote sustainable forest management and reduce the likelihood of long-term site damage from management treatments.

Soil type information can be used for both pre-treatment and operational planning. It is recommended the following steps be followed:

1. Use soil survey maps together with information in Table 1and Appendix 1 to predict which soil types are likely associated with planned treatment blocks.

2. Use Table 2 to determine the hazards (and opportunities) associated with each predicted soil type and integrate this information into preliminary management prescriptions aimed at minimizing soil damage.

3. Verify soil types on-site using soil type keys and adjust management prescriptions as needed (this step can be carried out before step 2 if feasible).

4. Use the soil type matrix (Figure 3) and Table 2 to predict how damage hazards may change with changing moisture conditions. Use this information to establish operational protocols aimed at mimimizing potential soil damage once treatments begin.

5. Document effective planning procedures, operational protocols, and hazard mitigation measures for use on other sites with similar soil types.

Table 2. Hazard ratings for FEC soil types.

CP = Compaction hazard, RT = Rutting hazard, E1 = Erosion hazard (slope 10% or less), E2 = Erosion hazard (slope more than 10%), FH = Frost Heave hazard, WT = Windthrow hazard, FL = Forest Floor Loss hazard.

Soil Type	CP	RT	E1	E2	FH	WT	FL
ST1	L	L	L	L-M	L	L-M	VH
ST2	L-M	L	L	M	L	L-M	H
ST2-G	L	L	L	L-M	L	L	VH
ST2-L	M	L-M	M	M-H	L-M	L-M	M
ST3	M-H	M	M	M-H	L-M	M	M
ST3-G	M	M	M	M-H	L-M	L-M	M-H
ST3-L	H	H	M-H	H	M-H	M	M
ST4	H	H	L-M	-	H	H	H
ST5	M	M	M	H	M	L-M	L-M
ST6	H	H	M-H	VH	H	H	M
ST7	VH	VH	L-M	-	VH	VH	H
ST8	L-M	L-M	L	L-M	L-M	L	L
ST8-C	L	L	L	L-M	L	L-M	L-M
ST9	M-H	H	L-M	M-H	L-M	M	L
ST10	H	VH	L	-	M-H	H	L-M
ST11	M	M	L-M	M-H	L-M	L-M	L
ST12	VH	VH	M	H	M-H	H	L
ST13	VH	VH	L	-	H	VH	L-M
ST14	L	VH	-	-	-	VH	-
ST14-U	L	H-VH	-	-	-	H-VH	-
ST15	L-M	L	H	VH	L	VH	VH
ST15-G	L	L	H	VH	L	H	VH
ST15-L	M	L-M	VH	VH	L	VH	H
ST16	M-H	M-H	H	VH	M-H	VH	H
ST16-G	M	M	H	VH	M	H	VH
ST16-L	H	H	VH	VH	H	VH	H
ST17	L-M	L-M	H	VH	L-M	H-VH	M
ST18	M-H	H	VH	VH	M-H	VH	M

Notes: For erosion and frost heave hazards, ratings assume exposed mineral soil. Where well developed forest floors remain intact, ratings can be reduced.

Dashes mean ratings are not applicable.

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Appendix 1.

List of Probable Soil Types Associated with Nova Scotia Soil Survey Units

Soil Name	Likely FEC Soil Type (in order of probability)				
Annapolis	3	3L	9	3G	16
Arichat	4	14			
Aspotogan	4	14			
Avonport	3	2	6	1	
Barney	2L	3L	5	6	
Bayswater	3	3G	16	16G	14U
Berwick	2	2L	8		
Bridgetown	2	2L	8	2G	15
Bridgeville	9	12	10	13	
Bridgewater	2L	8	2		
Bryden	2L	2	3L	3	
Canning	1	2	15		
Castley	14	4			
Chaswood	10	13	14		
Cherryfield	9	8			
Cobequid	2	2L	8		
Comeau	3	16	4	6	
Cornwallis	1	2	15		
Cumberland	8	8C	9		
Danesville	3	3L	9		
Debert	3	16	3L		
Deerfield	3	3L	9		
Digby	1	2	15		
Diligence	6	3L	7		
Economy	4	14			
Elmsdale	5	2L	6	3L	
Falmouth	5	11			
Farmville	2	2L	2G	1	
Fash	6	7	12	13	
Folly	2	3	16		
Gibraltar	2	2G	1	15	15G
Glenmont	2L	8	2	17	
Gulliver	8	8C	2L		
Halifax	2	2L			
Hansford	2	2L	3	3L	
Hantsport	6	3L	12	7	
Hebert	1	2	15		
Hopewell	2L	8	8C	15L	17
Joggins	7	14	13	6	
Kentville	3	3L	2	2L	8
Kingsport	3	16	6		
Kingsville	7	14	13		
Kirkhill	2L	2	8	3L	1

Appendix 1. Continued...

Kirkmount	2L	8	2		
LaHave	1	2	15		
Lawrencetown	7	13	14		
Liverpool	3	3L	9		
Lydgate	16	16G	3	3G	
Mahone	7	4	14	13	
Masstown	4	14	3	10	
Medway	1	2	15		
Merigomish	2	2L			
Mersey	2	2L	8		
Meteghan	4	14			
Middleton	6	12	3L		
Middlewood	4	10	14		
Millar	4	14	10		
Millbrook	6	3L	12	9	
Mira	3	3L	9	4	
Morristown	2L	8	2	5	
Mossman	8	9			
Nictaux	1	15	2		
Organic	14	4			
Peat	14	4			
Pelton	2L	8	2		
Perch Lake	2	2L	8		
Pitman	4	14	10		
Port Hebert	15	15G	2	2G	1
Portapique	2	1	15		
Pugwash	2	2L	3	3L	16
Queens	6	7	12	13	
Rawdon	2L	8	2		
Riverport	3L	9	3	16L	
Rockland	15	2	15G	2G	
Rodney	2	2L			
Roseway	4	14			
Rossway	2L	8	17	8C	15L
RML	2	3	4	14	15
Roxville	3L	9	18	16L	
Seely	4	14	10		
Shulie	2	2L	3	3L	16
Somerset	1	2	15		
Springhill	3	3L	16		
Stewiacke	8	9	11	12	8C
Swamp	14	4	10		
Thom	2	2L	8		
Tiddville	4	10	14		
Torbrook	1	2	15		

Appendix 1. Continued...

Tormentine	2	2L			
Truro	1	2	15		
Westbrook	2	2L	8		
Wolfville	5	2L	11	8	6
Woodbourne	5	2L	6	3L	8
Woodville	2	2L	3	3L	16
Wyvern	2	2G	1	8	
Yarmouth	2	2L	8		

Notes: Soil survey units are listed in alphabetical order and include only those units which are reasonably expected to support forest cover.

Where drainage class is included in soil survey units (Colchester and Pictou County soil surveys), users can refer to the soil type matrix (Figure 3) to adjust predicted soil types based on drainage.

Soil surveys cannot account for changes in soil characteristics caused by previous management or use. In particular, old field sites with Ap horizons can be associated with many different soil units. Where sites of interest are known to be old fields, users can refer to the soil type matrix (Figure 3) to adjust predicted soil types based on increased richness ratings.

RML = Rough Mountain Land. This represents a large, essentially unsurveyed, section of Northern Cape Breton which may contain several different soil types.

Due to inherent variability in soil morphology, soil type should be confirmed at the stand level before implementing management prescriptions.

Appendix 2.

Chronological List of Nova Scotia Soil Surveys

Cann, D.B., Hilchey, J.D., and Smith, G.R. 1954. Soil survey of Hants County, Nova Scotia. Nova Scotia Soil Survey Report No. 5. Can. Dept. of Agric. 65pp. (plus map).

Cann, D.B. and Hilchey, J.D. 1954. Soil survey of Antigonish County, Nova Scotia. Nova Scotia Soil Survey Report No. 6. Can. Dept. of Agric. 54pp. (plus maps).

Cann, D.B. and Hilchey, J.D. 1958. Soil survey of Lunenburg County, Nova Scotia. Nova Scotia Soil Survey Report No. 7. Can. Dept. of Agric. 48pp. (plus maps).

Cann, D.B. and Hilchey, J.D. 1959. Soil survey of Queens County, Nova Scotia. Nova Scotia Soil Survey Report No. 8. Can. Dept. of Agric. 48pp. (plus maps).

Hilchey, J.D., Cann, D.B., and MacDougall, J.I. 1960. Soil survey of Yarmouth County, Nova Scotia. Nova Scotia Soil Survey Report No. 9. Can. Dept. of Agric. 47pp. (plus maps).

MacDougall, J.I., Cann, D.B., and Hilchey, J.D. 1961. Soil survey of Shelburne County, Nova Scotia. Nova Scotia Soil Survey Report No. 10. Can. Dept. of Agric. 38pp. (plus maps).

Hilchey, J.D., Cann, D.B., and MacDougall, J.I. 1962. Soil survey of Digby County, Nova Scotia. Nova Scotia Soil Survey Report No. 11. Can. Dept. of Agric. 58pp. (plus maps).

Cann, D.B., MacDougall, J.I., and Hilchey, J.D. 1963. Soil survey of Cape Breton Island, Nova Scotia. Nova Scotia Soil Survey Report No. 12. Can. Dept. of Agric. 85pp. (plus maps).

MacDougall, J.I., Cann, D.B., and Hilchey, J.D. 1963. Soil survey of Halifax County, Nova Scotia. Nova Scotia Soil Survey Report No. 13. Can. Dept. of Agric. 53pp. (plus maps).

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Webb, K.T. 1990. Soils of Pictou County, Nova Scotia. Nova Scotia Soil Survey Report No. 18. Research Branch, Agric. Can. 183pp. (plus maps).

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More information on soil survey in Canada is available on-line from Agriculture and Agr-Food Canada at: http://sis.agr.gc.ca/cansis/

Appendix 3.

Soil Type Field Assessment

Use of the soil type keys requires digging a small soil pit in an area *representative* of the forest stand being assessed. Attention must be paid to slope position and micro-topography, as well as signs of local disturbance.

> Note: *Soil pits do not need to be as large as those shown in the soil type photographs - those pits were used for data collection and research purposes. To key out soil types, pits only need to be large enough to expose and assess the soil to a depth of 50-60 cm, approximately two shovel head depths.*

The soil type keys are hierarchical, with the user working down through decision points until the soil type is determined.

Starting with the main soil type key, the user determines if the soil is an organic soil or a shallow/cemented mineral soil. If either of these cases are found unexpectedly, it is recommended verification be made with a second soil pit (see Appendix 4 for more information on cemented and fragipan soils). Organic soils are further divided based on whether they are associated with wetland or upland vegetation (Note: wetland organic soils are by far the most common type).

If the soil is not organic or shallow/cemented, the next decision point determines what the dominant particle size class is for the soil. This dictates whether the soil is considered fine or coarse. Dominant particle size is achieved if a minimum of 50% of the thickness range being assessed (30-60 cm) contains one or more of the particle size classes listed. Alternatively, the soil is also considered fine when a minimum 10 cm fine soil layer is found near the surface, regardless of the dominant particle size class below (Note: these fine over coarse layered soils are not common).

After being directed to the coarse, fine, or shallow mineral soil keys, the next decision points determine whether the A horizon has been significantly enriched with organic matter (either naturally or through human actions) and whether there are mottles or gley present near the surface (related to drainage conditions).

Lastly, some soil types require an assessment of coarse fragment content, dominant surface soil texture, and/or surface stoniness for final determination.

Once a soil type has been keyed out, the user should consult the appropriate soil description to verify the decision. If the description does not fit, the soil type should be re-assessed.

Appendix 4.

Soil Terminology

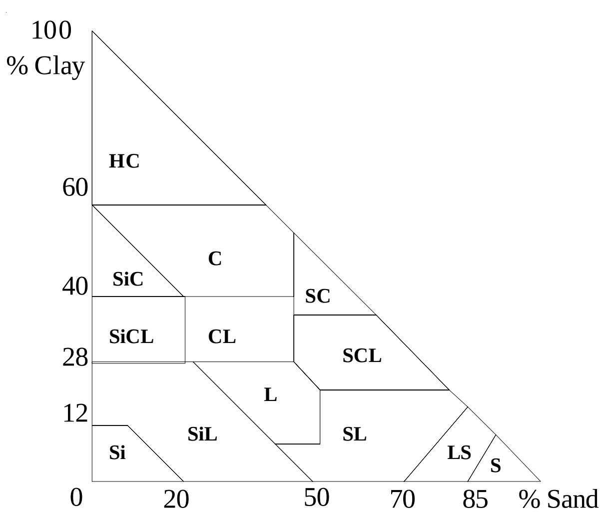
In describing soils, this guide generally follows the terminology and conventions outlined in *The Canadian System of Soil Classification* (Soil Classification Working Group, 1998) and The Canadian Soil Information System (CanSIS) *Manual for Describing Soils in the Field* (ECSS, 1983). Reference should be made to these publications when more detailed information on soil terms is sought.

1. Soil Texture and Family Particle Size Class

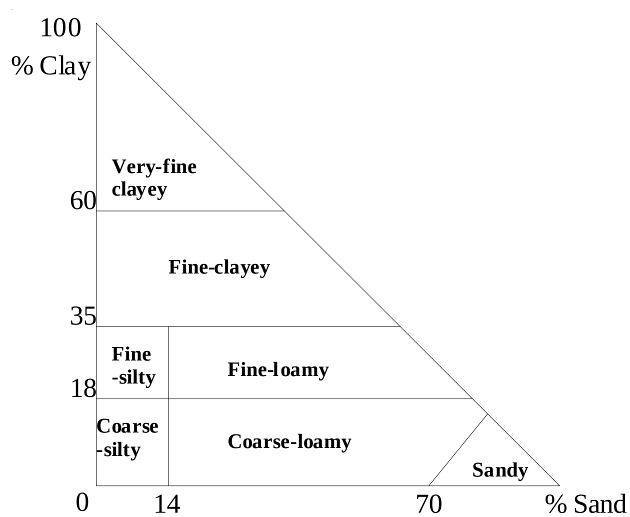
Soil texture refers to the percentage distribution of sand, silt, and clay in a soil (sand ranges in size from 0.05 - 2.0 mm, silt from 0.002-0.05 mm, and clay < 0.002 mm). In the field, soil texture can be described using texture classes which have specific ranges of sand, silt, and clay. Texture class relationships are shown using a texture triangle which has % sand as the horizontal axis and % clay as the vertical axis (% silt is inferred based on the levels of sand and clay). Particle size is a broader term which refers to the grain size distribution of the whole soil and which is usually applied to a specific section of the soil which may include several horizons (see diagrams below).

Both classifications are used in this guide to allow differentiation of soil types based on features of management and ecological significance. For example, the boundary between coarse-loamy and fine-loamy particle size classes roughly coincides with clay percentages associated with high plasticity and compaction hazard (Curran, 2001). However, these units are too broad for other interpretations such as erosion and frost heave hazards.

Soil Texture Class Triangle



Family Particle Size Class Triangle



HC = Heavy Clay	SC = Sandy Clay	SCL = Sandy Clay Loam	L= Loam	S = Sand
SiC = Silty Clay	SiCL = Silty Clay Loam	Si = Silt	SL = Sandy Loam	
C = Clay	CL = Clay Loam	SiL = Silt Loam	LS = Loamy Sand	

General Texture Groupings:

Fine-Textured	Medium-Textured	Coarse-Textured
Heavy Clay	Silt	Sandy Loam
Silty Clay	Silt Loam	Loamy Sand
Clay	Loam	Sand
Sandy Clay	Sandy Clay Loam	
Silty Clay Loam		
Clay Loam		

2. Mottles and Gleying

Iron is a common element in soils. Oxidized iron is responsible for much of the red, orange, and yellow colours associated with well aerated soils. In wet soils, which are poorly aerated, iron undergoes chemical reactions which can result in significant changes in soil colour. Wet soils dominated by anaerobic (low oxygen) chemical reactions are known as *gleyed* soils.

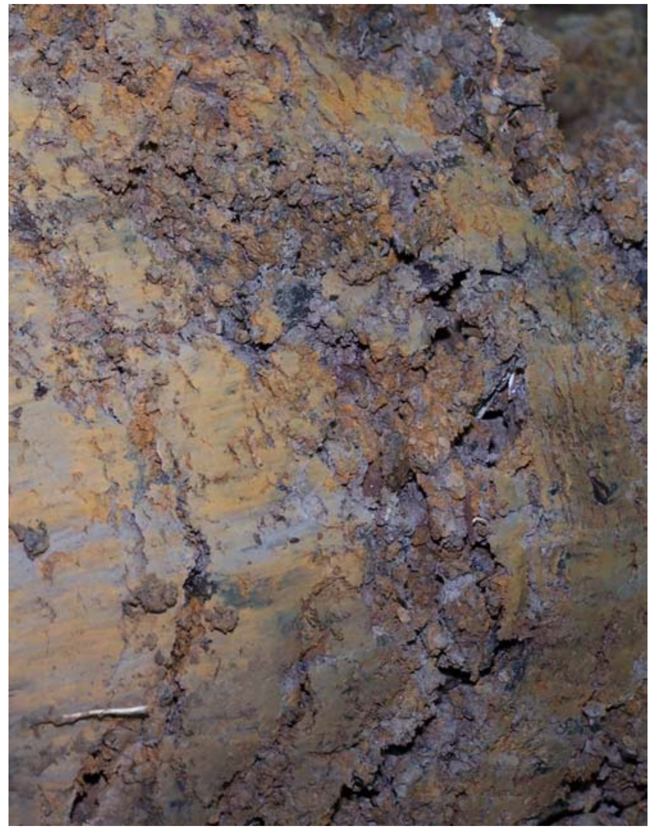
Colour changes associated with gleying depend on the length of time under anaerobic (reducing) conditions, and on the original soil colour.

Non-red soils: Soils which are not derived from reddish parent materials tend to turn greyish, or even bluish-grey, under long-term gleying conditions. However, under partial gleying, these soils do not change colour completely, instead they usually contain orange or reddish *mottles*. Mottles are areas of contrasting colour against an overall background colour, and are produced when pockets of reduced soil iron become oxidized as air re-enters a soil. Faint to distinct mottles indicate regular water table fluctuation (for example, during and after spring snow melt). Prominent mottles indicate irregular or short duration water table fluctuations, where air only occasionally re-enters a soil. Non-red soils with prominent mottles are considered to be fully gleyed soils (see photos on page 41).

Red soils: For reasons not fully understood, soils derived from reddish parent materials do not undergo full colour change when gleyed. Instead, these soils tend to have a "bleached" look and may contain greyish, brownish, or yellowish-red mottles. In some reddish soils, black manganese mottles can also be found in the poorly aerated subsoil. Partially gleyed red soils may be identified by the presence of mottles near the surface of the soil (see photos on page 41).

> Note: *Mottling in soils is not always associated with imperfect or poor drainage. Other factors may cause these colour patterns (eg. the presence of weathered coarse fragments, or the physical mixing of soil horizons). The presence of drainage-related mottles should be in keeping with other indicators of potential drainage problems such as slope position, high clay content, etc.*

Photographs:	**Top Left:**	**Close up of faint to distinct mottles (drainage related).**
	Top Right:	**Close up of distinct to prominent mottles (drainage related).**
	Bottom Left:	**Poorly drained soil with fully gleyed (blue-grey) lower horizon.**
	Bottom Right:	**Poorly drained (gleyed) soil derived from reddish parent material.**



3. Mineral Soil Horizons

Mineral soil horizons are described using various letter combinations. Capital letters are used to symbolize main soil horizons (A, B, C), and lower case letters (suffixes) are used to describe horizon features. Explanations of the more common soil horizon descriptors are given below.

A Horizon: Mineral horizon formed at or near the surface of the soil, generally immediately beneath the forest floor. It is usually formed:

(i) by leaching or loss of iron and aluminum, clay, and organic matter content to form an **Ae** horizon,
(ii) by accumulation of partially decomposed organic matter from the forest floor to form an **Ah** horizon,
(iii) by a combination of leaching and organic matter accumulation to form an **Ahe** horizon, or
(iv) by incorporation of organic matter through cultivation (or other human disturbance) to form an **Ap** horizon.

B Horizon: Mineral horizon characterized by enrichment of material lost from the A horizon above, and/or through transformations (chemical reactions) within the horizon itself.

C Horizon: Mineral horizon relatively unaffected by the soil formation processes active in the A and B horizons above. A transition horizon between the B and C horizons (and one which has features of both) is called a **BC** horizon.

Mineral horizon descriptors:

b Indicates a buried horizon.

c Used with **B** or **BC** horizon, it denotes a naturally cemented horizon.

e Used with **A** horizon only, it denotes a horizon that has been leached of iron and aluminum, clay, and organic matter (alone or in combination), resulting in a horizon with a greyish-white colour (or pinkish colour in red soils).

f Used with **B** horizon only, it denotes an accumulation of iron and aluminum from the A horizon above. The increased iron content is evident by a change in soil colour.

g Used with **A, B,** or **C** horizon, it denotes a horizon characterized by gley colours, prominent mottling, or both, indicating permanent or prolonged reducing conditions.

h Used with **A** or **B** horizon, it denotes an accumulation of organic matter by various processes. In the A horizon, the accumulation is through physical means (mixing); in the B horizon, the accumulation is through chemical means (solution deposit). In both cases, accumulation is indicated by a change in soil colour.

j Used as a modifier, when placed to the right of another suffix it denotes a weak expression of the horizon characteristic. For example, **Bfgj** denotes a Bf horizon with partial gleying.

m Used with **B** horizon only, it denotes a horizon mainly formed through in-place weathering with minor accumulation of materials from the A horizon above.

p Used with **A** horizon only, it denotes a surface horizon disturbed by human activities (eg. cultivation, logging, habitation).

t Used with **B** horizon only, it denotes an accumulation of clay from the A horizon above.

x A dense, compact horizon of fragipan character.

Well developed cemented and fragipan horizons (**Bfc**, **Bhfc**, **Bhc**, **Bx**, **BCx**) act as barriers to rooting and restrict or reduce the vertical flow of water. In this guide, these soils are considered equal to shallow soils over bedrock (when encountered at less than 30 cm in depth).

Cemented and fragipan horizons strongly resist penetration with a shovel, and are almost rock-like in their consistence. Cemented horizons are generally associated with well drained, sandy, and/or gravelly soils. Fragipan horizons are loamy, dense, and frequently show bleached fracture planes. In both cases, these horizons are found below more friable or loose surface horizons.

Well developed **Ah** and **Ap** horizons can be identified based on several features:

Increased organic matter in Ah/Ap horizons gives the soil a more brownish or blackish colour compared to horizons below. This is in contrast to the leached, light colours found in Ae horizons, or the mixed colours found in Ahe horizons.

Ah/Ap horizons often have a high percentage of fine roots because of the availability of nutrients in these horizons. This is in contrast to the low rooting levels found in most Ae horizons.

Ah/Ap horizons often have a distinctive granular structure (rounded aggregations of soil particles) due to earthworm activity, and worms may also be visible during sampling.

4. Organic Horizons

Organic horizons are divided into four main types:

L (Litter): An upland organic horizon consisting of relatively fresh organic material in which entire original structures are discernible (eg. leaves, needles, twigs).

F (Fermented): An upland organic horizon comprised of more-or-less disintegrated plant residues, but which is still identifiable as to origin (even though decomposition is very apparent). Fine rooting is often abundant in this horizon because of the release of nutrients during decomposition.

H (Humus): An upland organic horizon dominated by fine substances in which the organic materials are no longer identifiable as to origin. Fine rooting is common, but often less so than in the F horizon.

O (Organic): Horizons developed mainly from sphagnum mosses, rushes, and other plant material associated with wetland ecosystems. They are divided into fibric (**Of**), mesic (**Om**), and humic (**Oh**) horizons, depending on the level of decomposition.

5. Soil Parent Material

Soils can develop from a variety of parent material types, the characteristics of which influence soil development and site quality. Parent material types found in Nova Scotia are described below.

Glacial till: Unstratified deposits of sand, silt, clay, and rock which have been released from glacier ice. Types of glacial till include: *basal till* (laid down and compacted at the base of an advancing glacier) and *ablation till* (loose till deposited as a glacier receded). Some glacial deposits also have recognizable landform features such as *drumlins*.

Glaciofluvial: Glacial deposits which were partly or wholly stratified by glacial meltwater. Many glacio-fluvial deposits have distinguishable landforms (such as *eskers*) and are often high in sand and gravel.

Alluvium: Sediments deposited by streams and rivers (flood plains, deltas, etc.) - these deposits are younger than glacial deposits. Alluvium sediments can range in texture from fine to coarse (with or without rock).

Lacustrine: Sediments deposited in quiet waters (lakes and ponds) which may or may not have been directly associated with glaciers. These deposits tend to be high in silt and clay and generally do not contain rock.

Organic: Built up plant debris which does not easily decompose because of high moisture and low soil temperatures, or which is underlain by bedrock.

Bedrock: Near-surface bedrock which has been weathered in place.

Marine: Sediments of variable texture deposited in salt or brackish waters which are now above sea level. These deposits generally do not contain rock.

Aeolian: Material deposited by wind action. Aeolian deposits are usually high in silt and fine sand and may show internal structures such as cross-bedding..

Colluvium: Generally unstratified deposits of sand, silt, clay, and rock which have reached their position by gravity-induced movement.

6. Drainage

Soil drainage class reflects the length of time it takes water to be removed from a soil in relation to supply. Several factors affect drainage class, including: (i) slope position, (ii) slope percent and aspect, (iii) soil texture, (iv) depth to impermeable layer, (v) coarse fragment content, and (vi) abundance and type of vegetation (evapotranspiration). Drainage classes used in this guide are described below.

Rapid: Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is permeable, or laterally if vertical flow is restricted. The water source is precipitation. Soils are free from any evidence of mottling or gleying throughout the profile.

Well: Water is removed from the soil readily, but not rapidly. Excess water flows downward if underlying material is permeable, or laterally if vertical flow is restricted. The water source is precipitation. Soils are usually free from mottling in the upper 1m, but may be mottled below this depth.

Moderately Well: Water is removed from the soil somewhat slowly in relation to supply - due to low permeability and lack of slope, shallow water table, seepage inputs, or some combination of these. The water source is precipitation in medium to fine-textured soils, and precipitation and seepage flow in coarse-textured soils. Moderately well drained soils are commonly mottled in the lower B and C horizons.

Imperfect: Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Excess water moves slowly downward if precipitation is the major supply. If seepage water or groundwater (or both) is the main source, the flow rate may vary but the soil remains wet for a significant part of the growing season. Imperfectly drained soils are commonly mottled in the B and C horizons. The Ae horizon (if present) may also be mottled.

Poor: Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time (when not frozen). Seepage inputs or groundwater flow (or both), in addition to precipitation, are the main water sources. There may also be a perched water table with precipitation exceeding evapotranspiration. Gleyed soils and organic soils predominate.

Very Poor: Water is removed from the soil so slowly that the water table remains at or near the surface for the greater part of the time (when the soil is not frozen). Groundwater flow and seepage inputs are the major water sources. Precipitation is less important, except where there is a perched water table with precipitation exceeding evapotranspiration. Organic soils and gleyed soils predominate.

7. Seepage

Seepage is the input of soil water from upper slope positions to lower slope positions through lateral subsurface flow. Seepage water runs along the top of massive, compacted, or cemented subsoil horizons (or bedrock) and can be an important source of moisture and nutrients in some soils.

8. Moisture Regime

Moisture regime represents average moisture availability for plant growth. It is assessed by integrating moisture supply (as related to climate) with soil drainage and moisture holding capacities. Moisture regime units have been included with soil type names to indicate general moisture conditions associated with each soil type.

In general, dry moisture regimes are associated with moderate to severe moisture deficits; fresh moisture regimes with slight to moderate moisture deficits; moist moisture regimes with little to no moisture deficits; and wet moisture regimes with excess moisture during the growing season.

9. Coarse Fragments

Coarse fragments (CF) are rock fragments found in the soil which are larger than 2 mm in size. Abundance classes used in this guide are: Low (< 20%), Moderate (20-40%), and High (> 40%). Size classes include:

Gravel:	Rounded/Angular	0.2 - 7.5 cm diameter	**Stone:**	Rounded/Angular	26 - 60 cm diameter
	Flat	0.2 - 15 cm long		Flat	39 - 60 cm long
Cobble:	Rounded/Angular	7.5 - 25 cm diameter	**Boulder:**	Rounded/Angular	>60 cm diameter
	Flat	15 - 38 cm long		Flat	>60 cm long

10. Surface Stoniness

Stoniness describes the percentage area of a site covered by exposed stones and boulders (minimum 25 cm in diameter or length). Stoniness classes are (adapted from ECSS, 1983):

Class	Distance (m) Between Stones Stones 25 cm	Stones 60 cm	Stones 120 cm
Non-stony	> 25	>60	>120
Slightly stony	8 - 25	20 - 60	37 - 120
Moderately stony	1 - 8	3 - 20	6 - 37
Very stony	0.5 - 1	1 - 3	2 - 6
Exceedingly stony	0.1 - 0.5	0.2 - 1	0.5 - 2
Excessively stony	<0.1	<0.2	<0.5

11. Slope Position

Slope position describes the relative topographic position of a site within the landscape. Position classes are illustrated and described below (adapted from ECSS, 1983):

A. Crest: The generally convex upper-most portion of a hill, it is usually convex in all directions with no distinct aspect (direction of slope).

B. Upper: The upper portion of a hill immediately below the crest - it has a convex surface profile with a specific aspect.

C. Middle: The area of a hill between the upper slope and lower slope with a specific aspect.

D. Lower: The area toward the base of a hill with a specific aspect.

E. Toe: The area below the lower slope usually demarcated by an abrupt leveling of the slope.

F. Depression: An area that is concave in all directions, generally at the foot of a hill or in a level area.

G. Level: Any level area not immediately adjacent to a hill. The surface profile is generally horizontal with no aspect. Level areas can be lower or upper elevations.