Field Handbook for the Soils of Western Canada

Section 2

Site and Sampling Point Description

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This is one section of a Field Handbook for the Soils of Western Canada.

This section draws on material from the special issue of the Canadian Journal of Soil Science on the Soil of Canada (Volume 91, PP. 671-916).

Full information on the Canadian System of Soil Classification can be found at:

Soil Classification Working Group. 1998. The Canadian System of Soil Classification. 3rd Ed. Research Branch, Agriculture and Agri-Food Canada. Publication 1646. NRC Research Press, Ottawa, Ontario.

The 3rd edition of the CSSC is available on-line at http://sis.agr.gc.ca/cansis/taxa/cssc3/index.html.

The correct citation for this section is:

Pennock, D.J. 2015. Section 2. Site and Sampling Point Description. From: D. Pennock, K. Watson, and P. Sanborn. Field Handbook for the Soils of Western Canada. Canadian Society of Soil Science.

Three other very useful guides available on-line are:

National Wetlands Working Group. 1997. The Canadian Wetland Classification System. 2nd ed. Wetlands Research Centre, University of Waterloo, Waterloo, Canada.

B.C. Ministry of Forests and Range and B.C. Ministry of the Environment. 2010. Field Manual for Describing Terrestrial Ecosystems. 2nd Ed. Research Branch, Ministry of Forests and Range, Victoria B.C. (Available on-line).

Ontario Ministry of Natural Resources. 2011. Field Guide to the Substrates of Ontario.

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2.1 Introduction

A full description of the site that your soil pit is located in is an integral part of any field description of the soil. The site description has several major parts:

1. Identification of the landform that the pit is located in. The landform includes the materials and the form (e.g. hummocky till, level glacio-lacustrine clay). This allows your observation to be meaningfully compared to other observations made on similar landforms. Landforms are also the foundation for the main mapping units used in the provincial surveys in western Canada.
2. The landscape context of the pit. This includes the position of the pit within the slope and its relation to other landscape features (e.g. wetlands, structures, vegetation etc.). Soils typically show a reproducible spatial pattern within the landscape (the soil catena) and it is essential to document the position of the pit within the landscape.
3. Geographical coordinates of the pit. This allows the pit to be located on other spatial products such as maps and remote sensing images. In almost all cases this would involve recording the appropriate coordinates from a geographical positioning system (GPS).

2.2 Selecting a location for your soil pit

At the broadest level, there are two main approaches to selecting a specific point that you are going to make an observation at (which, for simplicity sake, we will call a soil pit). In the first case a sampling plan has been developed (or specified) as part of an assessment – for example, a pre-disturbance assessment prior to a resource extraction facility being constructed. In this case the geographical coordinates are specified beforehand, and the pit is completed where specified.

In the second case, a more general assessment of soil distribution is being made and the selection of the point is at the discretion of the soil surveyor; this is often called the free survey approach. In this case you begin by assessing the landforms present at the site, and selecting a representative site (or sites) within the landform(s). Consider, for example, the catena shown in a cultivated Prairie agricultural landscape in Figure 1.3 of the previous section. The upper convex slope has experienced erosion and is now occupied by Regosolic soils; the lower depression experiences prolonged water saturation and hence the formation of Gleysolic soils. The majority of the slope is occupied by Chernozemic soils with a range of topographically controlled properties. If only a single observation can be made (which was the case for many of the provincial soil surveys) then typically a mid-slope position would be selected for the full pit and soil description. This main pit may be supplemented by several observations made by auger or shallow pits at other positions along the catena.

The best way to represent this is to make a diagram of the slope profile showing the topographical position and landscape context of the pit (Figure 2.1). This should include

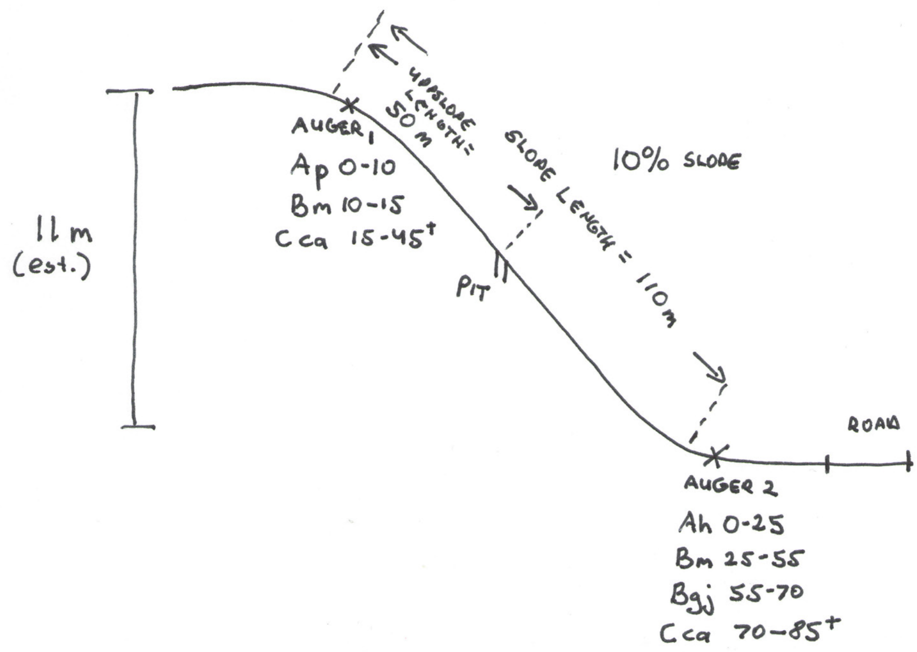


Figure 2.1: Example of a site diagram.

quantitative information on slope length, elevation difference, and distance to other landscape features. Features such as vegetation zones, wetlands, roads, fencelines, landings etc. are very important elements of the landscape. The site description includes further quantitative information on the site such as slope aspect and across-slope or plan context. This is the most effective way to communicate the landscape context of the described point.

In many surveys other attributes of the site such as vegetation, land use, surface stoniness etc. will also be noted. This section is focused on those attributes used in the Canadian System of Soil Classification.

2.2 Slope Attributes

A standard set of attributes is used to describe the shape of the slope surrounding the pit.

Slope gradient and slope length are most important for the identification of the landform that you are working in, and the CSSC has some quantitative classes for landform classes based on combinations of slope gradient and length. Slope aspect is also measured for the overall slope.

Slope curvature is most important for the position of the pit within the overall slope. It would typically be assessed on an area approximately 10 m x 10 m around your pit (i.e, 5 m upslope and 5 m downslope, and 5 m in both directions across the slope).

2.2.1 Slope gradient

Slope gradient is the amount of vertical rise over a particular distance or run. It is most usefully expressed as a percent (%slope = (Rise (m)/Run (m))*100). In some cases degrees are still used to describe slope gradient as well.

Slope gradient is most commonly measured with a clinometer. These can be stand-alone instruments or are often included in compasses. There are also very useful clinometer apps for smartphones and other devices. The slope gradient should be measured over the overall slope length (see section 2.2.2 below).

The CSSC uses specified slope classes in its landform classification:

Table 2.1: Slope classes used in the Canadian System of Soil Classification.

Slope Class	Percent Slope	Approximate degrees	Terminology
1	0 – 0.5	0	Level
2	>0.5 – 2	0.3 – 1.1	Nearly level
3	>2 – 5	>1.1 – 3	Very gentle slopes
4	>5 – 10	>3 – 5	Gentle slopes
5	>10 – 15	>5 – 8.5	Moderate Slopes
6	>15 – 30	>8.5 – 16.5	Strong slopes
7	>30 – 45	>16.5 – 24	Very strong slopes
8	>45 – 70	>24 – 35	Extreme slopes
9	>70 – 100	>35 – 45	Steep slopes
10	>100	>45	Very steep slopes

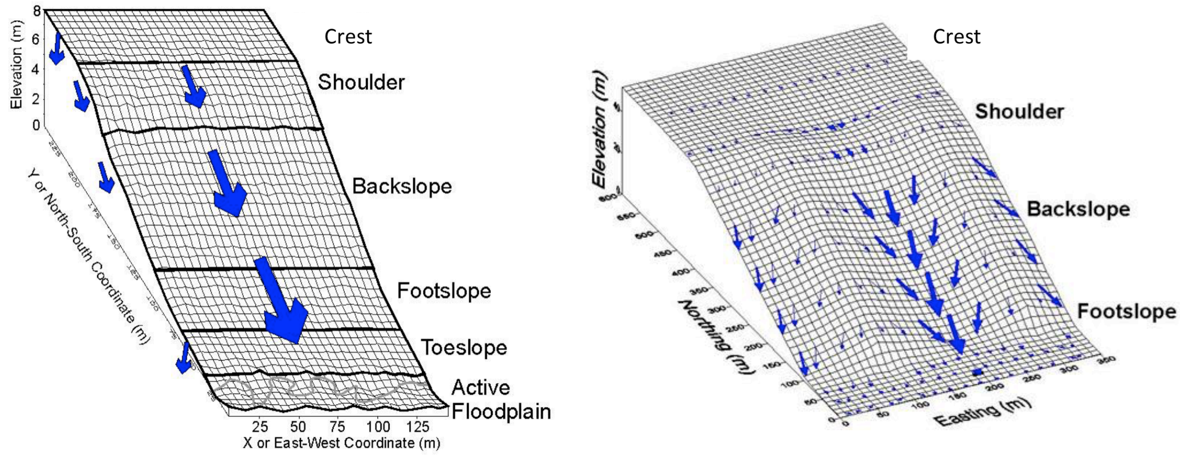
2.2.2 Slope Length

Slope length is measured along the steepest part of the slope, which is the path that water would follow downslope. It is measured with a tape measure or similar device.

Two separate measurements should be made: (see Figure 2.1) the overall slope length and the upslope slope length (downslope length is simply the difference between the two). There is always a degree of arbitrariness to where you judge the break in slope at the top and at the base of the slope to be, but using a site diagram will help to document this. For long slopes you may have to break the slope into several facets and take a slope length and gradient for each segment.

2.2.3 Slope Curvature

The curvature of the slope is a key determinant of the concentration of water downslope and across slope (Figure 2.2). Downslope curvature is termed profile curvature and across-slope curvature is termed plan curvature. Slope curvature classes are not specified in the CSSC.



inclined slope, no plan curvature

inclined slope,
signficant plan curvature

Figure 2.2: Examples of profile or downslope curvature and across-slope or plan curvature. Arrows show direction of surface flow.

Quantitative classifications of profile and plan curvature exist but typically in the field we estimate overall curvature rather than measure it.

The basic curvature classes are convex, concave, and straight. Convex surfaces are bowed outwards and concave surfaces are bowed inwards; straight surfaces show no significant curvature. If you have trouble visualizing this take a piece of paper in your two hands and move your hands together so that the paper rounds towards you (convex) and then round it away from you (concave).

Profile curvature classes are typically grouped into different slope profile classes or slope position classes (Figure 2.2 and 2.3, Table 2.2).

Table 2.2: Profile curvature classes.

Crest or summit	Uppermost portion of a hill which is generally convex in all direction
Shoulder	Convex profile with a gentler slope towards the crest and a steeper slope grained towards the base of the slope
Backslope	Straight profile with a more-or-less constant gradient.
Footslope	Concave profile with a steeper slope towards the summit and a gentler slope towards the base of the slope
Toeslope	Gentler slope extending from the bottom of the footslope
Depression	A feature that is concave in all direction (i.e., that water would pond in)
Level	A straight, low slope gradient segment that is not adjacent to any slope

Plan curvature is assessed along an axis that is perpendicular to the slope profile axis (or, more simply, across slope rather than down slope). Three main classes are used:

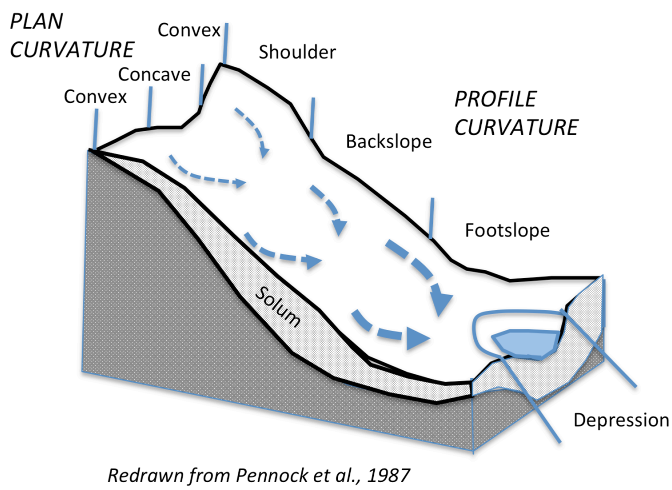
Table 2.3: Plan curvature classes.

Divergent	The across-slope curvature is bowed up; water flow would diverge (or be shed) from the position.
Convergent	The across-slope curvature is bowed inwards; water flowing across slope with converge (or concentrate into) the position.
Straight	There is no significant across-slope curvature and water would run straight downslope.

We combine the two types of curvature by listing the plan curvature class first and the profile curvature class second: e.g. divergent shoulder (abbreviated as DSH), straight backslope (SBS), or convergent footslope (CFS). The terms divergent and convergent are used in place of convex and concave because a (for example) concave shoulder seems inherently confusing.

Notes on the use of curvature classes:

- **Remember that you are assessing a 10 m x 10 m area surrounding your soil pit for curvature, not the overall slope.**
- Not all classes occur in all landforms. For example, an undulating landscape with very gentle slopes and a slope length of 20 m may only have straight shoulder and straight backslopes present. In hummocky surface forms, crests and toeslopes are rarely present.
- Level and near-level slopes often have very subtle curvature associated with them, which may be evident when water ponds on the surface (e.g. at snowmelt) but is difficult to discern otherwise. A segmentation of level landforms into level (no water movement on the surface), sloping (slow water movement on surface), and depressional (water collects on the surface) may be useful.
- Crests and level profile classes would often not be modified by the inclusion of plan modifiers.



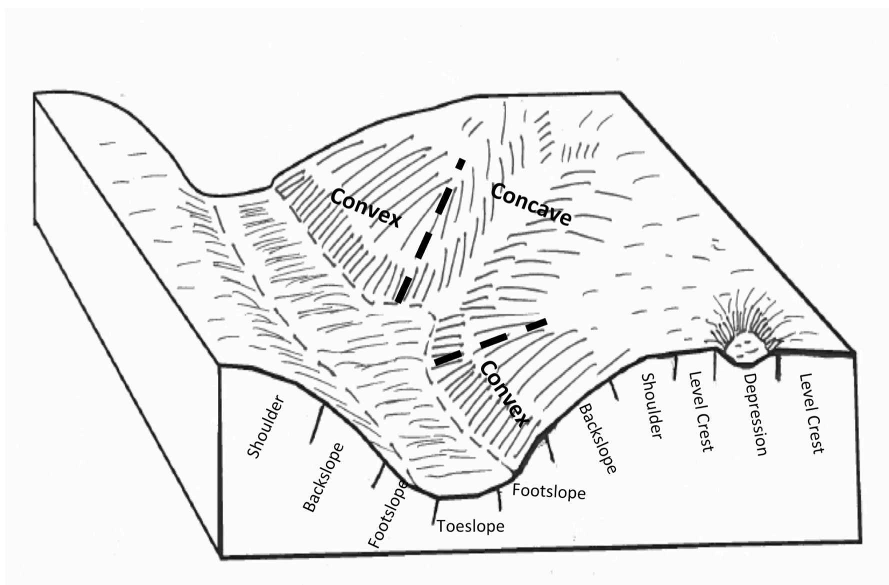


Figure 2.3: Examples of profile and plan classes in hummocky till and in a river valley.

2.2.4 Slope segments in mountainous terrain

Material in this section is drawn from: B.C. Ministry of Forests and Range and B.C. Ministry of the Environment. 2010. Field Manual for Describing Terrestrial Ecosystems. 2nd Ed. Research Branch, Ministry of Forests and Range, Victoria B.C. (Available on-line).

Slope segments are much longer in mountainous terrain. The B.C. handbook cited above uses the following site position classification for these slopes:

Table 2.4: Slope position in major uplands or mountainous terrain (typically with total slope lengths > 300 m)

Apex	The uppermost portion of the mountain. Surface shape is often convex.
Face	A vertical rock wall with steep, exposed bedrock.
Upper slope	The generally convex, upper portion of a mountain slope immediately below the apex or, if present, the rock face.
Middle slope	The area of a mountain between the upper slope and the lower slope where the general slope profile is neither distinctly concave nor complex.
Lower slope	The area near the base of a mountain slope where the broad slope profile is generally concave.
Valley floor	The lower part of the valley system, more or less horizontal in cross section, and bounded on both sides by mountain slopes. Valley floors generally have level to moderate slopes.
Plain	The area in which gravitational forces and confinement of water bodies by mountainous topography are not major factors. Plains may occur at any elevation and plateaus are considered as elevated plains.

These segments are illustrated in Figure 2.4

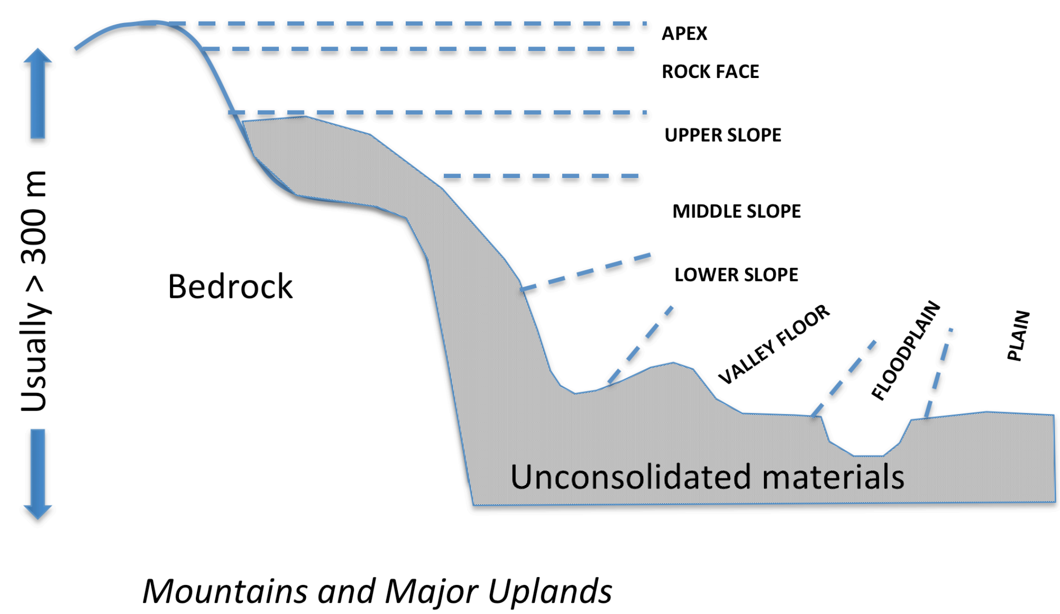


Figure 2.4: Slope classes in mountainous terrain.

Within each of these segments, the slope segments covered in section 2.2.3 will commonly occur. Therefore the site position description would first document the position with the overall slope, and then the position within that segment: Lower slope, divergent backslope for example.

2.2.5 Microtopography

Microtopography refers to surface variability within the 10 m x 10 m sampling site that your pit is located in. In most sites there is no significant microtopography (i.e., a smooth surface) but in some cases significant microtopography can occur. The following classes are used in the CSSC:

Table 2.5: Classification for Microtopography

Smooth	Few or no mounds; surface profile of sampling site is horizontal or inclined.
Micromounded	Mounds are <0.3 m high.
Slightly mounded	Mounds are 0.3 to 1 m high, and > 7 m apart.
Moderately mounded	Mounds are 0.3 to 1 m high, and 3 to 7 m apart.
Strongly mounded	Mounds are 0.3 to 1 m high, and 1 to 3 m apart.
Severely mounded	Mounds are 0.3 to 1 m high, and 0.3 to 1 m apart.
Extremely mounded	Mounds are > 1 m high, and > 3 m apart.
Ultramounded	Mounds are > 1 m high, and < 3 m apart.

2.2.6 Slope Aspect

Aspect is the direction that a slope faces, and can be an important control on the amount of solar radiation received. It is measured for the whole slope (e.g. the slope that the slope length and gradient are measured on) and is measured with a compass sighting downhill.

Aspect is not measurable for slopes with gradients less than 0.5%. For slopes with gradients greater than this, record the aspect in degrees (with true north = 360^{o}).

2.3 Landform Description

The term landform is used in the Canadian System of Soil Classification to classify the parent material and associated surface form that the sampling point is located in.

2.3.1 Surface Forms of Mineral Parent Materials

The 3rd edition of the CSSC contains a landform classification that emphasizes the form of the material (e.g. level surface) rather than the geomorphological origin of the surface (e.g. level floodplain).

Simple Slopes:

Simple slopes are smooth, regular features unbroken by knolls or depressions (Figure 2.5 a). They differ in terms of slope gradient.

Level – A flat or very gently sloping, unidirectional surface with a generally constant slope not broken by marked hills and depressions. Slopes are generally less than 2%. Level surfaces are most commonly associated with the beds of glacial lakes are have glacio-lacustrine clays and silts.

Inclined – A sloping, unidirectional surface with a generally constant slope not broken by marked irregularities in the slope profile. Slopes can be between 2-70%. Inclined slopes are associated with terrace scarps, floodplains, and escarpments. They are also common in the river valleys at the southern parts of Saskatchewan and Alberta where the glacial sediments become very thin and the long bedrock-controlled slopes are the dominant form.

Steep – Erosional slopes, greater than 70%, on both consolidated and unconsolidated materials. Commonly associated with mountain slopes and walls of deeply incised river valleys.

Fan –A fan-shaped form similar to a segment of a cone and possessing a perceptible gradient from the apex to the toe. Fans form at the break in slope in valleys, where channels emerge from steeper slopes and abruptly deposit their sediments (Figure 2.5 b). The channel migrates over the surface of the fan over time, extending the fan shape. Fan sediments are typically gravelly and sandy fluvial sediments.

The great majority of landforms in western Canada are associated with depositional of glacial sediments during the retreat of the Wisconsinan glaciers. The mode of deposition of these sediments often results in curved and rounded surface forms. In areas where curved glacial sediments are superimposed on long bedrock-controlled slopes, and we would use descriptors such as inclined hummocky to describe these surfaces.

Complex slopes:

The next two categories (undulating and rolling; Figure 2.5 c) are both wave-like in form but differ in slope length and slope gradient. Both are associated most commonly with glacio-lacustrine silts and sands and glacio-fluvial sands, but undulating and rolling till landforms also occur.

Undulating – A very regular sequence of gentle slopes that extend from rounded, sometimes confined concavities to broad, rounded convexities producing a wavelike pattern of local relief. Slope length is generally less than 0.8 km and the dominant gradient of slopes is 2-5%.

Rolling – A very regular sequence of moderate slopes extending from rounded, concave depressions to broad, rounded convexities producing a wavelike pattern of moderate relief. Slope length is often 1.6 km or greater and gradients greater than 5%.

Hummocky – A very complex sequence of slopes extending from rounded depressions of various sizes to irregular, conical knolls or knobs (Figure 2.5 d). The depressions are often occupied by wetlands. Slopes have a great range between 5-70% and are typically short in length (20 to 50 m). The majority of hummocky landforms are underlain by till, but hummocky glacio-fluvial and glacio-lacustrine landforms also occur. Parent materials in hummocky landscapes often show considerable short-range variability and inclusions of other sediments (e.g. inclusions of sand layers in a till landform) are very common.

Terraced – Terraces have steep scarp faces and horizontal or gently inclined surfaces (treads) below the scarp (Figure 2.5 e). Terraces are associated with floodplains of rivers where the river has progressively incised new channels into its previous floodplain or into the bed of a glacial lake. They occur in many river valleys in Alberta. They often have medium to coarse sandy and gravelly fluvial sediments associated with them. Terraces are well expressed in the interior valleys of British Columbia, where they more commonly occur in fine-textured glacio-lacustrine sediments.

Ridged – A long, narrow elevation of the surface, usually sharp crested with steep sides (Figure 2.5 f). The ridges may be parallel, subparallel, or intersecting. Ridged landscapes are associated with particular glacio-depositional features such as eskers and some forms of drumlins, but are not common in western Canada.

The CSSC has two further classes for mineral parent materials that pertain to the thickness of a surface layer of sediment overtop of second layer of sediments or, in some cases, bedrock. In both cases the form of the surface is related to the genesis of the underlying material, not the surficial material.

Veneer – Unconsolidated materials too thin to mask the minor irregularities of the underlying surface. A veneer ranges from10 cm to 1 m in thickness and possesses no form typical of the materials' genesis. Veneers of glacio-lacustrine sediments overlying hummocky till surfaces are very common, and veneers of wind-blown silts or sands over a variety of surfaces also occur.

Blanket – A mantle of unconsolidated materials that is thick enough to mask minor irregularities in the underlying unit but still conforms to the general underlying topography. These are common where thin glacial sediments overlie long bedrock-controlled slopes such as in Southern Saskatchewan and Alberta.

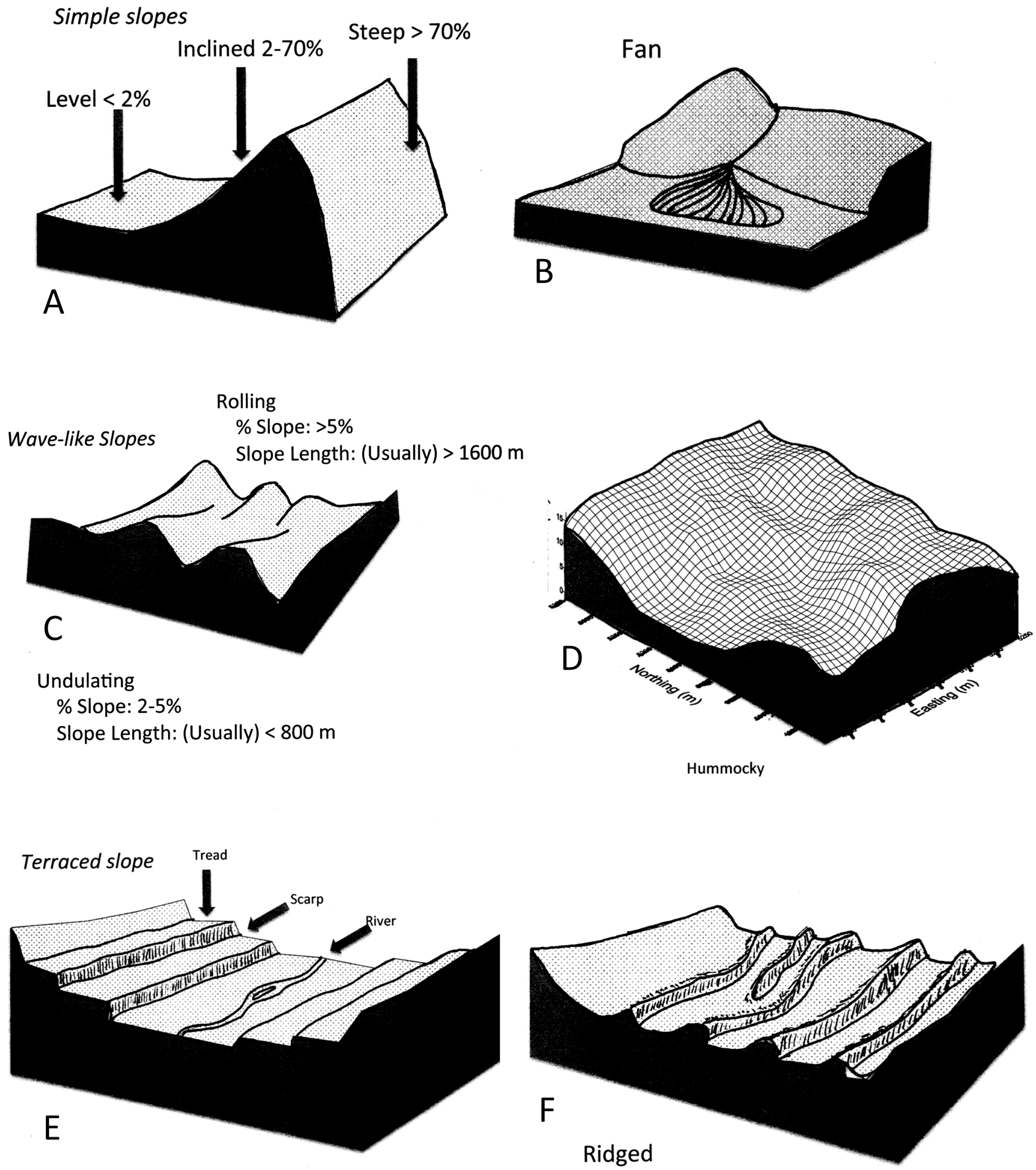


Figure 2.5: Block diagrams of major surface forms used in landform classification (re-drawn from Ontario Institute of Pedology originals).

2.3.2 Surface forms of Organic materials

Organic materials build vertically upwards from the original mineral soil surface and, when thick enough, create distinctive surface forms that may be unrelated to the surface form of the underlying mineral surface.

The CSSC has a very basic classification of organic surface forms. A much more comprehensive system (including cross-sections of major forms) be found on-line in:

National Wetlands Working Group. 1997. The Canadian Wetland Classification System. 2nd ed. Wetlands Research Centre, University of Waterloo, Waterloo, Canada.

Blanket – The mantle of organic materials is thick enough to mask minor irregularities in the underlying mineral surface but still conforms to the general underlying topography.

Bowl – A bog or fen that occupies concave-shaped depressions.

Domed– A bog with an elevated, convex central area that may be considerably higher than the margin. Domes may be abrupt, gently sloping, or have a steeped surface. The domes may have a frozen core. Domed bogs include palsas, peat mounds, and raised bogs.

Floating – A level organic surface floating within a pond or lake.

Horizontal – A fen or bog surface not broken by marked elevations or depressions.

Plateau – Bogs with an elevated, flat central area only slightly higher than the margin.

Ribbed – Fens with a pattern of parallel or reticulate low ridges.

Sloping – Fen or bog surfaces with a generally constant slope not broken by marked irregularities.

Note on surface forms for the Folisol great group: The Folisol great group encompasses organic soils that form in wet, forested landscapes concentrated along the central and southern west coast and islands of British Columbia (see Fig. 1 in Fox and Tarnocai, 2011). The thickness of the Folisols is often not thick enough to mask the underlying mineral or bedrock surface.

2.3.3 Description of Mineral Materials

Note: There is a simple field key for the recognition of parent materials at the end of this section.

Anthropogenic – Materials that have been moved from their original location by humans or that have been substantially disrupted by human activity such that the original mode of deposition is irrelevant. This would include materials associated with mine exploitation, waste disposal and construction sites.

Colluvial – Materials moved by slope processes. The texture of the material will be very similar to the source material on the slope, and hence can be almost any texture. Colluvial deposits in mountains will often have a high percentage of gravel and boulder-sized material and will be poorly sorted.

Eolian – Materials transported by wind. Sediments typically consist of medium to fine sand and coarse silt particle sizes, are well sorted, poorly compacted. Deposits of wind blown silt are called loess.

Fluvial – Materials have been transported by water and deposited by flowing water. Sediments typically consist of gravel and sand with minor fractions of silt and rarely clay. The gravels may be rounded and contain interstitial sand. Fluvial sediments are commonly moderately to well sorted and display stratification (bedding), but massive, nonsorted fluvial gravels do occur. Glacio-fluvial sediments were deposited by river systems associated with the Pleistocene ice sheets.

Lacustrine – Materials transported by water and deposited in lakes. Sediments generally consist of stratified fine sand, silt, and clay deposited on the lake bed or moderately well sorted and stratified sand and coarser materials that are beach and other near-shore sediments that were transported and deposited by wave action. Glacio-lacustrine sediments were deposited in lakes associated with the Pleistocene ice sheets.

Till (or Diamict or Morainal) – Materials transported beneath, beside, on, within, and in front of a glacier and not modified by any intermediate agent (i.e., wind, water, or slope processes). Till generally consists of nonstratified, poorly sorted material and contains a heterogeneous mixture of particle sizes, often in a mixture of gravel, sand, silt, and clay. Textures are typically in the loam range (e.g. loam, clay loam, sandy clay loam).

Note on terminology: Glacial sedimentologists use the term diamict to describe these sediments; till is an older but still very common term; morainal is used in many soil surveys, but is an obsolete term for describing sediments.

Saprolite – Weathered rock containing a high proportion of residual silts and clays formed by alteration, chiefly by chemical weathering. They are uncommon in Canada.

Marine – Materials that have settled from suspension in salt or brackish water bodies or have accumulated at their margins through shoreline processes such as wave action. They consist of unconsolidated deposits of clay, silt, sand, or gravel that are well to moderately well sorted and well stratified to moderately stratified (and that may contain shells).

Bedrock-- Clastic materials that are tightly packed or indurated.

2.3.4 Description of Organic Materials

The CSSC has a basic classification of organic materials. A much more comprehensive system is (and available on-line in):

National Wetlands Working Group. 1997. The Canadian Wetland Classification System. 2^{nd} ed. Wetlands Research Centre, University of Waterloo, Waterloo, Canada.

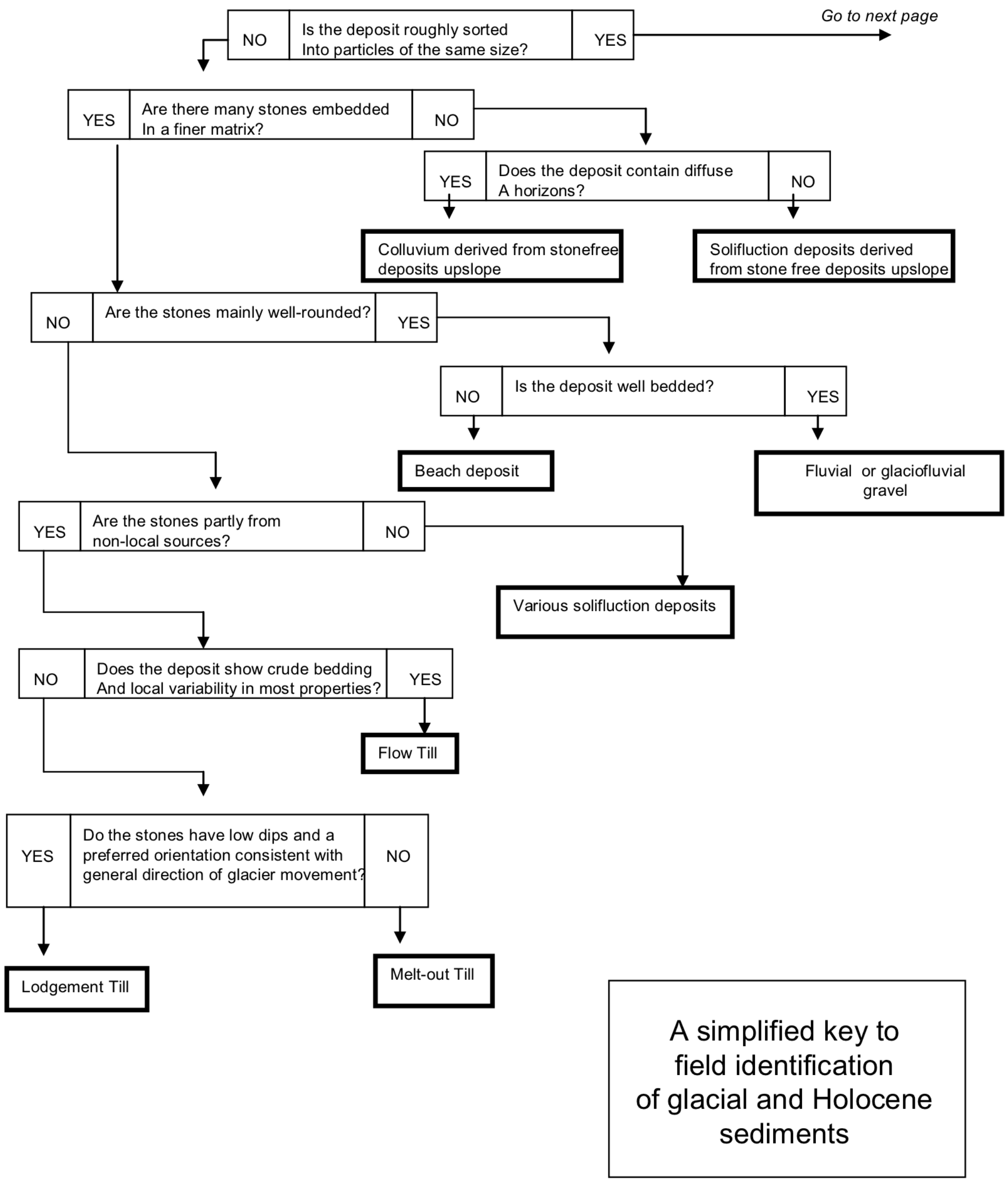
Bog – Organic materials composed of acid, weakly to moderately decomposed *Sphagnum* moss and woody remains of shrubs. The surface of the bog is typically slightly elevated or level with surrounding terrain. The uppermost organic materials only receive water from precipitation (termed ombrotrophic or "cloud-fed") and hence are bogs are nutrient poor.

Fen – Slightly acid to neutral organic materials composed primarily of well-decomposed sedges and brown mosses with inclusions of partially decayed stems of shrubs. They form in close association with groundwater that has moved through mineral soils and hence is richer in dissolved minerals than bogs.

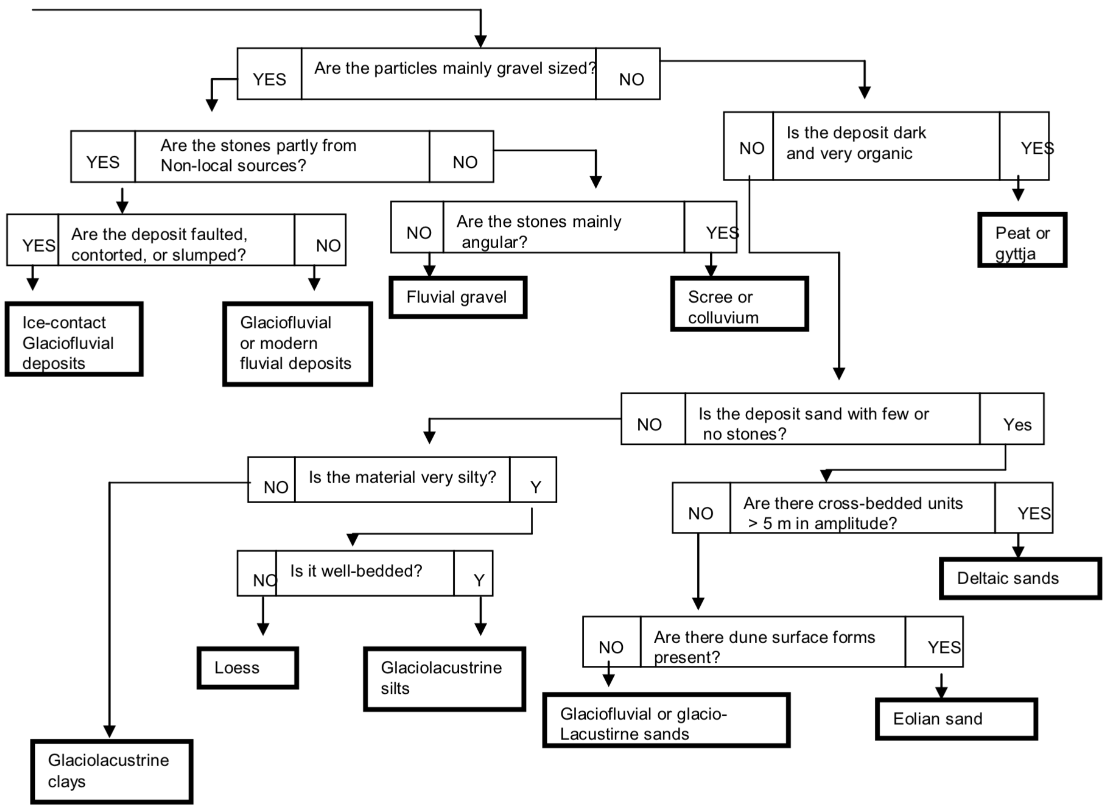
Swamp – Swamps are composed of neutral to slightly alkaline, well-decomposed woody peats. They form in contact with nutrient-rich groundwater and often have slow-moving water flowing through them. Surface vegetation includes trees (generally over 30% cover), shrubs, and forbs and the surface is typically 20 cm or more above the average summer groundwater level. Both organic and mineral (where organic materials are less than 40 cm thick) soils are found in swamps.

Marsh – Marshes are composed of neutral to slightly alkaline, well-decomposed peats with inclusions of mineral materials ("muck"). They are typically rich in nutrients. Water levels in marshes fluctuate dramatically due to tides, seasonal flooding, and changes in groundwater discharge. Both organic and mineral (where organic materials are less than 40 cm thick) soils are found in marshes.

Key to Parent Material



Adapted and simplified from Catt, J. A. 1986.
Soils and Quaternary Geology. Clarendon Press, Oxford.



Are the particles mainly gravel sized?
YES
NO
Are the stones partly from Non-local sources?
YES
NO
Is the deposit dark and very organic
NO
YES
Are the deposit faulted, contorted, or slumped?
YES
NO
Are the stones mainly angular?
NO
YES
Peat or gyttja
Ice-contact Glaciofluvial deposits
Glaciofluvial or modern fluvial deposits
Fluvial gravel
Scree or colluvium
Is the deposit sand with few or no stones?
NO
Yes
Is the material very silty?
NO
Y
Are there cross-bedded units > 5 m in amplitude?
NO
YES
Deltaic sands
Is it well-bedded?
NO
Y
Loess
Glaciolacustrine silts
Are there dune surface forms present?
NO
YES
Glaciofluvial or glacio-Lacustirne sands
Eolian sand
Glaciolacustrine clays