Appendix B

The Canadian System of Soil Classification (CSSC)

Canadian efforts at soil classification began in 1914 with the partial mapping of Ontario's soils by A. J. Galbraith. Efforts to develop a taxonomic system spread countrywide, anchored by universities in each province. Regional differences in soil classification emerged, further confused by a lack of specific soil details. By 1936, only 1.7% of Canadian soil had been surveyed (15 million hectares).

Canadian scientists needed a taxonomic system based on observable and measurable properties in soils specific to Canada. This meant a departure from Marbut's 1938 U.S. classification. Canada's first taxonomic system was introduced in 1955, splitting away from the soil classification effort in the United States and the Fourth Approximation stage. Classification work progressed through the Canada Soil Survey Committee after 1970 and was replaced by the Expert Committee on Soil Survey in 1978, all under Agriculture Canada.

The Canadian System of Soil Classification (CSSC) provides taxa for all soils presently recognized in Canada and is adapted to Canada's expanses of forest, tundra, prairie, frozen ground, and colder climates. As in the U.S. Soil Taxonomy system, the CSSC classifications are based on observable and measurable properties found in real soils rather than idealized soils that may result from the interactions of genetic processes. The system is flexible in that its framework can accept new findings and information in step with progressive developments in the soil sciences.

Categories of Classification in the CSSC

Categorical levels are at the heart of a taxonomic system. These categories are based on soil profile properties organized at five levels, nested in a hierarchical pattern to permit generalization at several levels of detail. Each level is referred to as a category of classification. The levels in the CSSC are briefly described here, as adapted from *The Canadian Soil Classification System*, 2nd ed., Publication 1646 (Ottawa: Supply and Services Canada, 1987), p. 16.

- *Order*: Each of nine soil orders has pedon properties that reflect the soil environment and effects of active soil-forming processes.
- *Great Group*: Subdivisions of each order reflect differences in the dominant processes or other major contributing processes. As an example, in Luvic Gleysols (great group name followed by order) the dominant process is gleying—reduction of iron and other minerals—resulting from poor drainage under either grass or forest cover with Aeg and Btg horizons (see Table 1).
- *Subgroup*: Subgroups are differentiated by the content and arrangement of horizons that indicate the relation of the soil to a great group or order or the subtle transition toward soils of another order.
- *Family*: This is a subdivision of a subgroup. Parent material characteristics such as texture and mineralogy, soil climatic factors, and soil reactions are important.
- *Series*: Detailed features of the pedon differentiate subdivisions of the family—the essential soil-sampling unit. Pedon horizons fall within a narrow range of color, texture, structure, consistence, porosity, moisture, chemical reaction, thickness, and composition.

Soil Horizons in the CSSC

Soil horizons are named and standardized as diagnostic in the classification process. Several mineral and organic horizons and layers are used in the CSSC. Three mineral horizons are recognized by capital letter designation, followed by lowercase suffixes for further description. Principal soil-mineral horizons and suffixes are presented in Table 1.

Four organic horizons are identified in the Canadian classification system. *O* is further defined through subhorizon designations. Note that for organic soils, such layers are identified as *tiers*. These organic horizons are detailed in Table 2.

The Nine Soil Orders of the CSSC

The nine orders of the CSSC, and related great groups, are summarized in Table 3 with a general description of properties, related Great Groups, an estimated percentage of land area for the soil order, a fertility assessment, and any applicable Soil Taxonomy equivalent.

Figure 1 is a generalized map of the distribution of principal soil orders in relation to physiographical regions in Canada. This grouping allows you to easily compare soils across Canada. A summary of the nine soil orders appears in Table 3. Please consult the *National Atlas of Canada*, 5th edition, for a detailed map of Canadian soils (http://atlas.gc.ca/).

The *Soil Landscapes of Canada* (SLC) site at http://sis.agr.gc.ca/cansis/nsdb/slc/intro.html is most useful! Here you will find a wonderful assortment of landscape and soil profile photographs, arranged geographically across Canada from east to west. The site also has an interactive GIS on-line mapping application. Version 2.2 SLC Component Mapping (December 1996) is operational and involves the CSSC and the Canadian Land Resource

Table 1 Three Mineral Horizons and Mineral Horizon Suffixes Used in the CSSC

Symbol	Mineral Horizon Description
A	Forms at or near the surface; experiences *eluviation*, or leaching, of finer particles or minerals. Several subdivisions are identified, with the surface usually darker and richer in organic content than lower horizons (*Ah*); or a paler, lighter zone below that reflects removal of organic matter with clays and oxides of aluminum and iron leached (removed) to lower horizons (*Ae*).
B	Experiences *illuviation*, a depositional process, as demonstrated by accumulations of clays (*Bt*), sesquioxides of aluminum or iron, and possibly an enrichment of organic debris (*Bh*), and the development of soil structure. Coloration is important in denoting whether hydrolysis, reduction, or oxidation processes are operational for the assignment of a descriptive suffix.
C	Exhibits little effect from pedogenic processes operating in the *A* and *B* horizons, except the process of gleysation associated with poor drainage and the reduction of iron, denoted (*Cg*), and the accumulation of calcium and magnesium carbonates (*Cca*) and more soluble salts (*Cs*) and (*Csa*).

Symbol	Horizon Suffix Description
b	A buried soil horizon.
c	Irreversible cementation of a pedogenic horizon, e.g., cemented by $CaCO_3$.
ca	Lime accumulation of at least 10 cm thickness that exceeds in concentration that of the unenriched parent material by at least 5%.
cc	Irreversible cemented concretions, typically in pellet form.
e	Used with *A* mineral horizons (*Ae*) to denote eluviation of clay, Fe, Al, or organic matter.
f	Enriched principally with illuvial iron and aluminum combined with organic matter, reddish in upper portions and yellowish at depth, determined through specific criteria. Used with *B* horizons alone.
g	Gray to blue colors, prominent mottling, or both, produced by intense chemical reduction. Various applications to *A*, *B*, and *C* horizons.
h	Enriched with organic matter: accumulation in place or biological mixing (*Ah*) or subsurface enrichment through illuviation (*Bh*).
j	A modifier suffix for *e*, *f*, *g*, *n*, and *t* to denote limited change or failure to meet specified criteria denoted by that letter.
k	Presence of carbonates as indicated by visible effervescence with dilute hydrochloric acid (HCl).
m	Used with *B* horizons slightly altered by hydrolysis, oxidation, or solution, or all three to denote a change in color or structure.
n	Accumulation of exchangeable calcium (Ca) in ratio to exchangeable sodium (Na) that is 10 or less, with the following characteristics: prismatic or columnar structure, dark coatings on ped surfaces, and hard consistence when dry. Used with *B* horizons alone.
p	*A* or *O* horizons disturbed by cultivation, logging, and habitation. May be used when plowing intrudes on previous *B* horizons.
s	Presence of salts, including gypsum, visible as crystals or veins or surface crusts of salt crystals, and by lowered crop yields. Usually with *C* but may appear with any horizon and lowercase suffixes.
sa	A secondary enrichment of salts more soluble than Ca or Mg carbonates, exceeding unenriched parent material, in a horizon at least 10 cm thick.
t	Illuvial enrichment of the *B* horizon with silicate clay that must exceed in overlying *Ae* horizon by 3% to 20%, depending on the clay content of the *Ae* horizon.
u	Markedly disrupted by physical or faunal processes other than cryoturbation.
x	Fragipan formation—a loamy subsurface horizon of high bulk density and very low organic content. When dry, it has a hard consistence and seems to be cemented.
y	Affected by cryoturbation (frost action) with disrupted and broken horizons and incorporation of materials from other horizons. Application to *A*, *B*, and *C* horizons and in combination with other suffixes.
z	A frozen layer.

Network (CLRN). The component mapping involves a GIS model consisting of layers that include the major characteristics of soil and land for all of Canada. You can select a spatial area and a variety of attributes to display on the map (drainage class, soil type, rooting depth, local surface form, slope, and vegetation cover, among others).

Table 2 Four Organic Horizons Used in the CSSC

Symbol	Description
O	Organic materials, mainly mosses, rushes, and woody materials
L	Mainly discernible leaves, twigs, and woody materials
F	Partially decomposed, somewhat recognizable L materials
H	Indiscernible organic materials

O is further defined through subhorizon designations:

Of	Readily identifiable fibric materials
Om	Mesic materials of intermediate decomposition
Oh	Humic material at an advanced stage of decomposition—low fiber, high bulk density

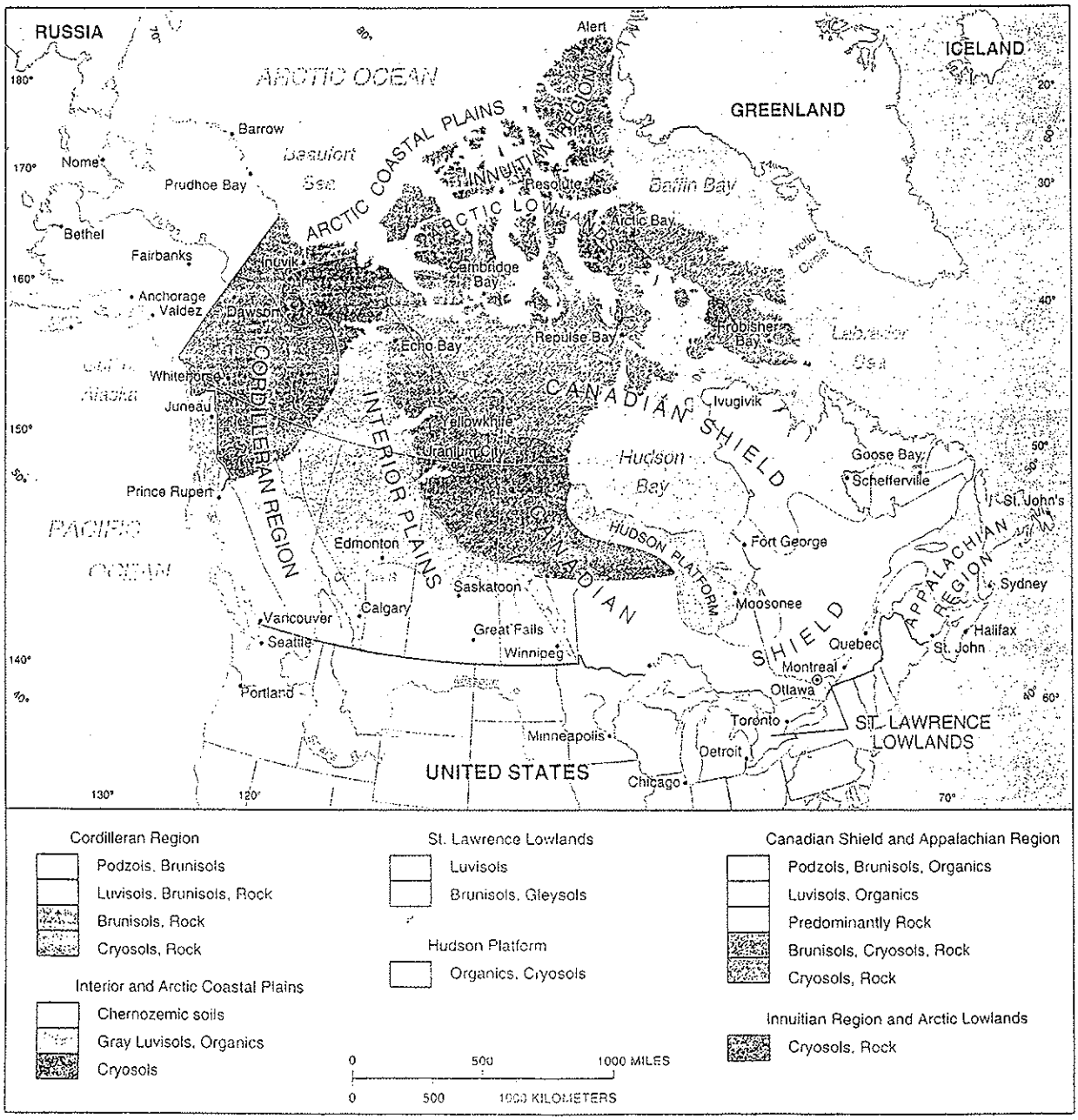

FIGURE 1 Soil orders of Canada.
Principal soil regions of the Canadian System of Soil Classification (CSSC) as related to major physiographic regions. [After maps prepared by the Land Resources Research Institute, Geological Survey of Canada, and the Canadian Soil Survey Committee.]

Table 3 Nine Orders of the Canadian System of Soil Classification

Order Great Group	Characteristics*	Fertility
Chernozemic (Russian, *chernozem*) Brown (more moist) Dark brown Black Dark gray (less moist) (38 subgroups)	Well to imperfectly drained soils of the steppe-grassland-forest transition, Southern Alberta, Saskatchewan, Manitoba, Okanagan Valley, BC, Palouse Prairie, BC. Accumulation of organic matter in surface horizons. Most frozen during some winter months with soil-moisture deficits in the summer. A diagnostic **Ah** is typical (although **Ahe**, **Ap** are present) at least 10 cm thick or 15 cm if disturbed by cultivation. Mean annual temperature > 0°C and usually < 5.5°C. (5.1%, 470,000 km^2; Soil Taxon. = Mollisols.)	High; wheat-growing
Solonetzic (Russian, *solonetz*) Solonetz Solodized Solonetz Solod (27 subgroups)	Solonetz denotes saline or alkaline soils. Well to imperfectly drained mineral soils developed under grasses in semiarid to subhumid climates. Limited areas of central and north-central Alberta. Noted for a **B** horizon that is very hard when dry but swells to a sticky, low-permeability mass when wet. A saline **C** horizon reflects nature of parent materials. (0.8%, 73,700 km^2; Soil Taxon. = Natric horizon of Mollisols and Alfisols.)	Variable (medium) about 50% cultivated, remainder in pasture
Luvisolic Gray brown Luvisol Gray Luvisol (18 subgroups)	Eluviation-illuviation processes produce a light-colored **Ae** horizon and a diagnostic **Bt** horizon. Soils of mixed deciduous–coniferous forests. Major occurrence is the St. Lawrence lowland. Luvisols do not have a solonetzic B horizon, evidence of Gleysolic order and gleying, or organics less than in the Organic order. Permafrost within 1 m of surface and 2 m if soils are cryoturbated. (10.3%, 950,000 km^2; Soil Taxon. = Boralfs, Udalfs—suborders of Alfisols.)	High
Podzolic (Russian, *podzol*) Humic Ferro-humic Podzol Humo-ferric Podzol (25 subgroups)	Soils of coniferous forests and sometimes heath, leaching of overlying horizons occurs in moist, cool to cold climates. Iron, aluminum and organic matter from **L**, **F**, and **H** horizons are redeposited in podzolic **B** horizon. A diagnostic **Bh**, **Bhf**, or **Bf** is present depending on great group. Dominant in western British Columbia, Ontario, and Québec. (22.6%, 2,083,000 km^2; Soil Taxon. = Spodosols, some Inceptisols.)	Low to medium depending on acidity
Brunisolic (French, "brown") Melanic Brunisol Eutric Brunisol Sombric Brunisol Dystric Brunisol (18 subgroups)	Sufficiently developed to distinguish from Regosolic order. Soils under forest cover with brownish **Bm** horizons, although various colors are possible. Also, can be with mixed forest, shrubs and grass. Diagnostic **Bm**, **Bfj**, thin **Bf**, or **Btj** horizons differentiate from soils of other orders. Well to imperfectly drained. Lack the podzolic **B** horizon of podzols although surrounded by them in St. Lawrence lowland. (8.8%, 811,000 km^2; Soil Taxon. = Inceptisols, some Psamments [Aquents in Entisols].)	Medium (variable)
Regosolic (Greek, *rhegos*) Regosol Humic Regosol (8 subgroups)	Weakly developed limited soils, the result of any number of factors: young materials; fresh alluvial deposits; material instability; mass-wasted slopes; or dry, cold climatic conditions. Lack solonetzic, illuvial, or podzolic **B** horizons. Lack permafrost within 1 m of surface, or 2 m if cryoturbated. May have **L**, **F**, **H**, or **O** horizons, or an **Ah** horizon if less than 10 cm thick. Buried horizons possible. Dominant in Northwest Territories and northern Yukon, now designated as Cryosols under CSSC. (1.3%, 120,000 km^2; Soil Taxon. = Entisols.)	Low (variable)
Gleysolic (Russian, *glei*) Luvic Gleysol Humic Gleysol Gleysol (13 subgroups)	Defined on the basis of color and mottling that results from chronic reducing conditions inherent in poorly drained mineral soils under wet conditions. High water table and long periods of water saturation. Rather than continuous they appear spotty within other soil orders and occasionally may dominate an area. A diagnostic **Bg** horizon is present. (1.9%, 175,000 km^2; Soil Taxon. = Various aquic suborders, a reducing moisture regime.)	High to medium
Organic Fibrisol Mesisol Humisol Folisol (31 subgroups)	Peat, bog, and muck soils, largely composed of organic material. Most water-saturated for prolonged periods. Are widespread in association with poorly to very poorly drained depressions, although Folisols are found under upland forest environments. Exceed 17% organic carbon and 30% organic matter overall. (4.2%, 387,000 km^2; Soil Taxon. = Histosols.)	High to medium given drainage, available nutrients
Cryosolic (Greek, *kyros*) Turbic Cryosol Static Cryosol Organic Cryosol (15 subgroups)	Dominate the northern third of Canada, with permafrost closer to the surface and composed of mineral and organic soil deposits. Generally found north of the treeline, or in fine-textured soils in subarctic forest, or in some organic soils in boreal forests. **Ah** horizon lacking or thin. Cryoturbation (frost action) common, often denoted by patterned ground circles, polygons, and stripes. Subgroups based on degree of cryoturbation and the nature of mineral or organic soil material. (45%, 4,150,000 km^2; Soil Taxon. = Cryoquepts, Inceptisols, and pergelic temperature regime in several suborders.)	Not applicable

*Estimated percentage and square kilometers of Canada's land area and Soil Taxonomy equivalent are given in parentheses.