Proposed changes to the soil family taxon within the Canadian System of Soil Classification1

Authors: Warren, C. James, and Saurette, Daniel D.

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ARTICLE

Proposed changes to the soil family taxon within the Canadian System of Soil Classification[1]

C. James Warren and Daniel D. Saurette

Abstract: The soil family was developed in the 1960s as the fourth level of taxa within the hierarchical structure of the Canadian System of Soil Classification. The original aim of the soil family category was to provide a framework for checking and establishing limits for soil series while providing a link between the series and the subgroup level. Its intended use was to define and group numerous soil series based on soil characteristics important for the purpose of applying appropriate management practices. In the current Canadian System of Soil Classification, taxa at the family level represent subdivisions of the subgroups. Classification of mineral soils at the family level is based on properties of the parent materials which include particle size; soil mineralogy; reaction (soil pH); calcareousness; depth to bedrock and permafrost; as well as climactic factors: soil temperature and soil moisture regimes. The soil family particle-size classes were originally intended as a compromise between both agronomic and engineering influences; however, the resulting product has limited functionality because of differences in definitions between engineering and agronomic grain sizes and non-alignment with soil textural classes. Consequently, classification and use of the family taxon have largely been ignored. Some adjustments to the family taxon for mineral soils and terric layers in organic soils are proposed including realignment of classes in the current family particle-size triangle to follow the divisions of the soil textural classes. Minor adjustments to mineralogy classes and depth to bedrock are also proposed.

Key words: pedology, soil texture, particle size, Canadian System of Soil Classification, soil family.

Résumé : Le taxon « famille de sols » a vu le jour dans les années 1960. Il correspond au quatrième échelon dans la taxonomie établie par le Système canadien de classification des sols. L'idée, en créant cette catégorie, était d'avoir un cadre au moyen duquel on pourrait fixer et vérifier les limites des séries de sol tout en formant un pont entre les taxons « série » et « sous-groupe ». La famille de sols devait définir et regrouper de nombreuses séries de sols en fonction de caractéristiques revêtant de l'importance pour l'adoption de bonnes pratiques de gestion. Dans la taxonomie actuelle du Système canadien de classification des sols, la famille correspond à une subdivision du sous-groupe. On classe les sols minéraux en familles d'après les propriétés du matériau originel, ce qui inclus la granulométrie, la minéralogie, la réactivité (pH), la teneur en calcaire, la distance jusqu'au substratum ou au pergélisol, ainsi que des paramètres climatiques comme la température et l'hygrométrie du sol. Au départ, les classes granulométriques de la famille de sols devait constituer un compromis entre les influences agronomiques et techniques, cependant leur utilité est restreinte en raison des divergences entre la définition technique et la définition agronomique de la granulométrie ainsi que du manque d'harmonisation entre les classes de texture des sols. C'est pourquoi on a largement laissé de côté la classification et l'usage du taxon « famille ». Les auteurs y proposent quelques modification pour les sols minéraux et les couches terriques des sols organiques, notamment une restructuration des classes dans le triangle granulométrique actuel des familles d'après la façon dont les classes de texture des sols sont divisées. Ils préconisent également de petits changements aux classes minéralogiques et au calcul de la distance jusqu'au substratum. [Traduit par la Rédaction]

Mots-clés : pédologie, texture des sols, granulométrie, Système canadien de classification des sols, famille de sols.

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C.J. Warren* and D.D. Saurette.* Ontario Ministry of Agriculture Food and Rural Affairs, 1 Stone Road West, 3rd Floor SE, Guelph, ON N1G 4Y2, Canada; School of Environmental Sciences, University of Guelph, Guelph, ON N1G 2W1, Canada.

Corresponding author: C. James Warren (email: jim.warren2@ontario.ca).

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Introduction

The soil family occupies the fourth taxonomic level within the hierarchical structure of the Canadian System of Soil Classification (CSSC) below subgroups, great groups and orders and above the soil series which is the recommended primary mapping unit in soil maps ranging from survey intensity level 1 (very detailed) to 4 (broad reconnaissance; Coen 1987). The concept of the soil family was first introduced to soil classification in Canada in 1955 as a direct adoption of the family taxonomic level of US Soil Taxonomy at that time (NSSC 1955). It received a formal definition in the Canadian system in the 1963 version; however, pedologists and soil surveyors were solely focused on the three highest taxonomic levels (order, great group and subgroup) at the time (NSSC 1963). Further development of the soil family taxonomic level in the 1960s led to proposed criteria for family classification in 1965 to be used on an evaluation basis by provinces (NSSC 1965) and finally adoption of official terminology and class limits closely resembling those developed for the US Soil Taxonomy in 1968 and updated in 1973 (Broersma 1972; CSSC 1973; Michalyna 1972; NSSC 1968; SCWG 1998). The original aim of the family category was to provide a framework for checking and establishing limits for groups of soil series while providing a link between the series and the subgroup levels. The family category was needed to provide a means of grouping soil series to determine and apply appropriate management practices and was originally defined by Canadian pedologists as 'a group of soil series that are relatively homogeneous with respect to soil-air, soil-water, and plant-root relationships' (NSSC 1963). Inclusion of the family taxon was necessary because the number of individual soil series was far too great to develop management practices for each individual series, and the higher categories are too heterogeneous to be adapted for many management purposes. Even though the soil family provides a useful framework to group soils based on similar moisture, fertility, drainage, parent materials, etc. and has a high potential to group soils based on their characteristics important for crop growth, this taxonomic level remained largely undeveloped (NSSC 1965). Unfortunately, the family category was not adopted as readily as the other taxonomic levels, and as a consequence, application and use of the soil family category have largely been ignored (SCWG 1998).

In the third edition of the CSSC (SCWG 1998), 'taxa at the family level are formed by subdividing subgroups'. Thus, families carry the differentiating criteria of the order, great group and subgroup to which they belong. Families within a subgroup are differentiated based on parent material characteristics, including particle size, mineralogy, calcareousness, reaction and depth and soil climatic factors (SCWG 1998). Soil family criteria differ between mineral and organic soils in the third edition of the CSSC manual (SCWG 1998). Genetic soil factors are adequately addressed at the order, great group and subgroup levels. The criteria for differentiation of soils at the family level generally relate to physical and chemical composition, thickness of the parent materials and climatic factors. Family criteria are applied uniformly across the mineral soil orders while the organic order is addressed separately. Differentiating criteria for mineral soils at the family level as outlined in the CSSC manual (SCWG 1998) are particle size (p. 136); mineralogy (p. 139); depth to lithic and cryic contacts, (p. 139); reaction (p. 139); calcareousness (p. 141); and soil climate (soil temperature regime; and soil moisture regime, p. 141). Differentiating criteria for organic soils at the family level are characteristics of the surface tier (p. 141); reaction (p. 141); soil climate (soil temperature regime and soil moisture regime (p. 141); particle size of any terric layer (p. 144); kind and depth of limnic layers (p. 144); and depth to lithic and (or) cryic contacts (p. 144). Particle-size classes for terric layers within organic profiles are the same as for mineral soils, but the criteria for depth to lithic and (or) cryic contact differ for mineral and organic soils. Discussion here will focus primarily on proposed changes to soil family particle-size classes including particle-size classes of terric layers in organic soils. Minor changes are also proposed to the mineralogy, reaction and calcareous class and depth classes primarily for completeness or to correct perceived omissions.

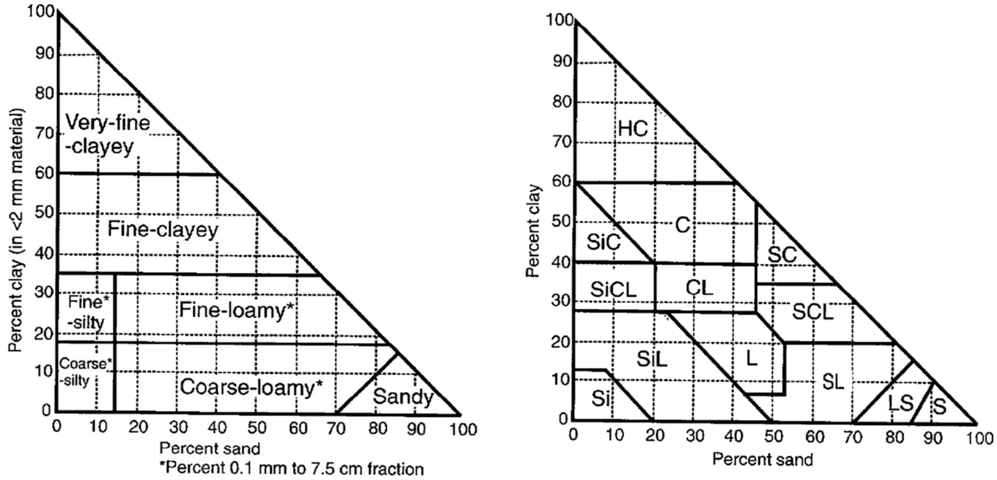
Review of Current Soil Family Taxon

Current soil family particle-size criteria

For the purposes of classification at the family level, as currently defined in the CSSC (SCWG 1998), particle size refers to the whole soil composition including coarse fragments (>2 mm diameter). Family particle size is related to soil texture but differs in that soil texture refers specifically to the composition of the fine earth fraction (i.e. proportion of sand, silt and clay size particles ≤2 mm diameter) and is specific to individual horizons. Family particle size includes the fine earth fraction by mass (≤2 mm diameter) plus coarse fragment (>2 mm diameter) content by volume averaged for the entire control section of the profile. Exceptions are provided for soils with strongly contrasting particle sizes within the control section that affect soil properties which are not captured at higher taxonomic levels (SCWG 1998, p. 138–139). Modifiers for coarse fragment content are applied to soil texture classes for each horizon, but these are not separate texture classes (Day 1983). In practice, family particle size is typically assessed based on the textures within a profile weighted for the thickness of each horizon plus consideration of the overall coarse fragment content.

Within the current version of the CSSC (SCWG 1998), there are 11 classes/categories used to describe particle-size characteristics at the family level. Note however that only seven classes are presented in the family particle-size triangle (Fig. 1; SCWG 1998, p. 136) because the

Fig. 1. Current particles-size classes (left) and soil textural classes (right) based on SCWG (1998).



remaining four classes result due to increased coarse fragment content. These are: clayey-skeletal (includes very fine clayey and fine clayey base classes with ≥35 to <90% coarse fragments by volume), loamy-skeletal (includes coarse-loamy, fine-loamy, coarse-silty and fine-silty classes with ≥35 to <90 % coarse fragments), sandy-skeletal (includes sandy class with ≥35 to <90% coarse fragments) and fragmental (soils composed of ≥90% coarse (>2 mm diameter) fragments). Versions of particle size prior to 1973 had only three primary particle size classes: coarse, medium and fine which followed boundaries to form groups of soil textural classes plus skeletal versions for each and a fragmental group (NSSC 1968). The classes, adopted from US Soil Taxonomy, were originally intended to reflect an equal balance between agronomic and engineering influences (CSSC 1973). For example, the limit of 18% clay between coarse-loamy and fine-loamy classes reflects the change from non-plastic to plastic behaviour with increasing clay content (Handy and Fenton 1977). This is considered by engineers to be an important distinction. Similar breaks related to plastic and liquid behaviour occur at 35% and 60% clay content. There is also a difference between the coarse and fine silty and loamy classes, which relate to capillary rise and available moisture-holding capacity. These breaks were intended to allow groupings of soils with similar responses to management and to some extent, for engineering and related uses (SCWG 1998).

Impracticality of the current soil family particle-size classes

When comparing the current family particle-size classes with soil texture classes (Fig. 1), it quickly becomes evident that the boundaries between many of the family particle-size classes do not coincide with boundaries for textural classes, resulting in particle-size boundaries dividing soil texture classes. Exceptions are the breaks between clay and heavy clay textures corresponding to fine-clayey and very-fine-clayey particle sizes and the boundary between sandy and coarse-loamy particle-size classes coinciding with the boundary between sandy loam and loamy sand textures. There is also a difference between the engineering and agronomic definitions in the grain-size cutoff for sand and silt-sized particles where the cutoff for agronomic applications is typically 0.05 mm diameter while engineering applications use 0.074 mm (SSDS 2017; Schoeneberger et al. 2012). There are also differences between engineering and pedological definitions for subdivisions (fine, medium and coarse) of gravel (USDA 1987; Schoeneberger et al. 2012).

Although the current family particle-size classes were intended as a compromise to incorporate engineering criteria at the family level (CSSC 1973), different classification systems exist worldwide which are used for different applications (Garcia-Gaines and Frankenstein 2015), and sometimes there is no direct relationship between systems. Whereas pedologists are more concerned with the control section, engineers focus primarily on parent materials and materials below (Pawluk 1970). In fact, regulations require that topsoil (A horizon materials) must be stripped and stockpiled from sites prior to construction activities of interest to engineers. Engineering properties of the solum are consequently of little use in practice.

The utility of the current particle-size triangle was based on the premise that analytical data such as sand, silt and clay content (including values for the 0.074 mm division between sand and silt) and coarse fragment content were collected and readily available (i.e., published soil survey reports) in addition to agronomic attributes required for classification at the series level. Soil survey maps and reports are often lacking engineering test data such as Atterberg and plasticly indexes, particle-size distributions according to unified and or A.A.S.H.O.

Fig. 2. Proposed particle-size triangle for soils with <35% coarse fragments by volume. *Very fine sand is included with coarse-loamy particle-size class.

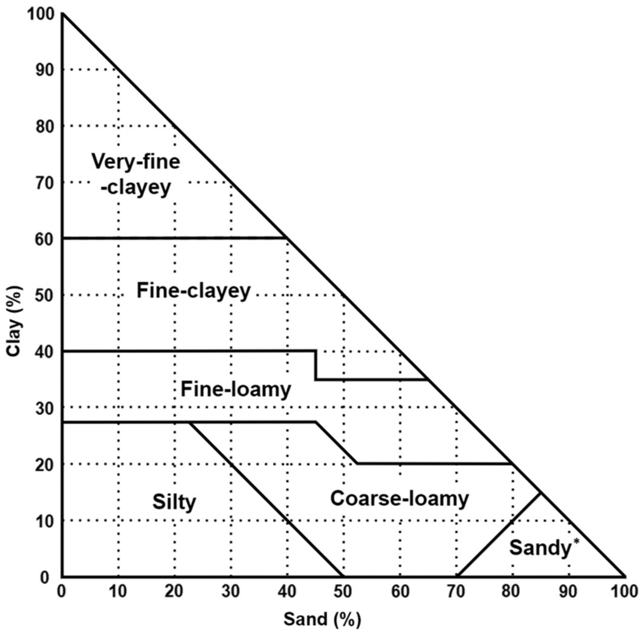
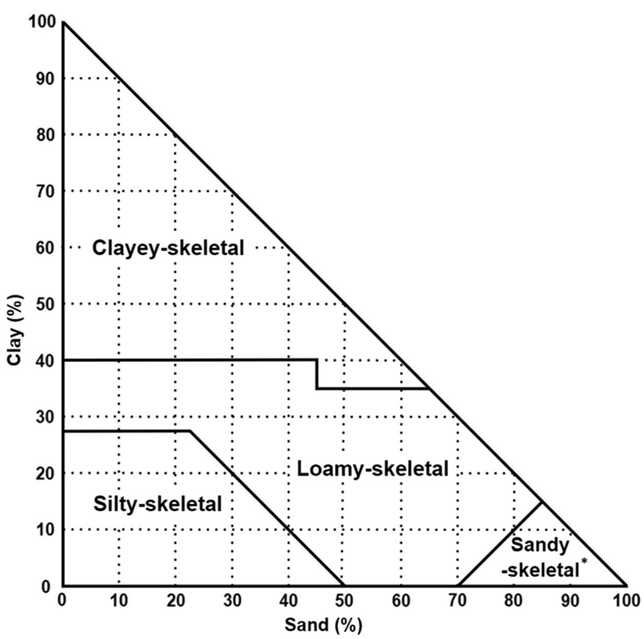
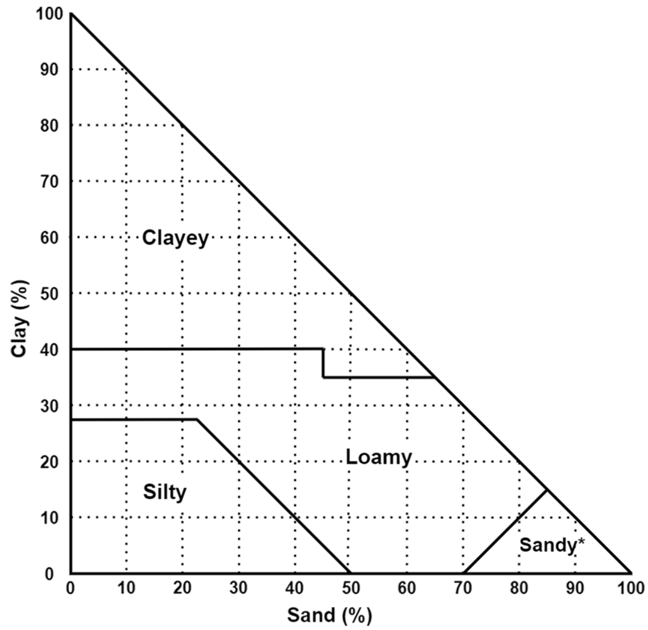


Fig. 3. Proposed particle-size triangle for soil with ≥35% to <90% coarse fragments by volume (i.e., skeletal soils). *Very fine sandy-skeletal is included with loamy-skeletal particle-size class.



systems which are not commonly used by agronomists, and therefore these reports are of limited direct utility to engineers without additional interpretations or assumptions. Data required for particle-size classes are for the most part lacking and definitely absent in older soil survey reports before the advent of the soil family

Fig. 4. Proposed particle-size triangle describing terric layers within organic soils. *Very fine sand is included with the loamy particle-size class.



class. Grain-size distributions expressed as a graph also afford more useful information for engineers than do particle-size classes, and because such interpretations are multi-disciplinary, they should be handled separately (Pawluk 1970). Although there were some indifference and reluctance among soil survey committee members at the time to adopt family criteria, it was recognized that there was a need to sort and group soil series to point out discrepancies in the criteria used for soil series (CDA 1970).

Soil survey reports, with some exceptions, provide profile descriptions with soil texture classes for individual horizons with only some original data for grain-size analyses (percentages of sand, silt and clay). In Canada, some data related to engineering properties have been included in soil survey reports; however, they are often limited to single pedons for soil series with extensive areal distribution (e.g., Presant and Wicklund 1971; Coen and Holland 1976; Eilers and Halstead 1981; Luttmerding 1981; Wang and Rees 1983; Kingston and Presant 1989; Lamontagne et al. 2014) and are only available for a limited number of published soil surveys. Whereas textural classes see immediate use in classification at the series level, grouping of soil series into soil families for the purpose of applying management practices may only be considered sometime later. Any analytical data collected at the time of sampling may have been lost, or the original textural data may have been estimated from hand texturing. The result being that the current particle-size classes are difficult to accurately assess, particularly when based on older pedological data without additional data

Table 1. Modifiers applied to texture classes based on coarse fragment (>2 mm diameter) shape and size.

Coarse Fragment Class	Definition – Size Range	Adjective (modifier for texture classes)
Rounded, subrounded angular or irregular shapes		
Gravel	>2 mm (0.2 cm)–7.5 cm diameter	Gravelly
Fine Gravel	>0.2 cm–0.5 cm diameter	Fine Gravelly[a]
Medium Gravel	>0.5 cm–2.0 cm diameter	Medium Gravelly[a]
Coarse Gravel	>2.0 cm–7.5 cm diameter	Coarse Gravelly[a]
Cobble	>7.5 cm–25 cm diameter	Cobbly
Stone	>25 cm–60 cm diameter	Stony
Boulder	>60 cm diameter	Bouldery
Flat shapes		
Channer	>0.2 cm–15 cm long	Channery
Flagstone	>15 cm–38 cm long	Flaggy
Stone	>38 cm–60 cm long	Stony
Boulder	>60 cm long	Bouldery

[a]May be used as a texture modifier in cases where the dominant (>50%) size diameter for gravel is known.

Table 2. Summary of proposed soil family particle-size classes.

Particle-size Class	Description
Coarse Fragment Content <35% by volume	
Very-fine-clayey	fine earth (<2 mm) fraction has ≥60% clay by mass[a] (HC)
Fine-clayey	fine earth (<2 mm) fraction includes SiC, C and SC
Silty	fine earth (<2 mm) fraction includes Si and SiL
Fine-loamy	fine earth (<2 mm) fraction includes SiCL, CL, and SCL
Coarse-loamy (including vfS and LvfS)	fine earth (<2 mm) fraction includes all sub-fractions of SL, L, plus LvfS and vfS
Sandy (excluding vfS and LvfS)	fine earth (<2 mm) fraction includes all sub-fractions of sands and loamy sands exclusive of loamy very fine sand (LvfS) and very fine sand (vfS)
Coarse Fragment Content ≥35% by volume	
Clayey-skeletal	<90% & ≥35% fragments >2 mm by volume: with fine earth (<2 mm) defined as clayey particle-size class (fine or very-fine-clayey)
Silty-skeletal	<90% & ≥35% coarse fragments (>2 mm) by volume: with fine earth (<2 mm) defined as silty particle-size class
Loamy-skeletal	<90% & ≥35% fragments >2 mm by volume: with fine earth (<2 mm) defined as loamy particle-size class (fine and coarse-loamy including very fine sand[b])
Sandy-skeletal	<90% & ≥35% coarse fragments (>2 mm) by volume: with fine earth (<2 mm) defined as sandy particle-size class (exclusive of very fine sand[b])
Fragmental	≥90% coarse fragments (>2 mm) by volume with insufficient fine earth to fill <1 mm interstices

[a]Carbonates of clay-size fraction are not considered clay but are treated as silt.
[b]Whole soil profiles dominated by coarse, medium and fine sand or loamy coarse sand, loamy sand or loamy fine sand texture classes are categorized as sandy or sandy-skeletal particle sizes. Profiles dominated by very fine sand or loamy very fine sand texture classes are categorized as coarse-loamy or loamy-skeletal particle-size classes.

required for classification at the family level typically not collected initially. Consequently, the family classification has largely been ignored in the past, and agronomic management practices have been applied with little formalized guidance towards grouping of soils for targeting proposed management practices which was the original intent of the family taxon. Use of family classes to group soil series for application of appropriate management practices would have a benefit of streamlining and efficiently targeting field trials to help identify and target soils which may have been overlooked in the past or alternatively avoid duplication of research efforts on soils that are similar. This would also aid in identifying soils with similar properties at the family level for application of appropriate management practices targeting specific soils.

Another disadvantage of the current family classification is the use of long attribute-based family names,

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Table 3. Summary of soil texture class modifiers and family particle-size classes based on coarse fragment content.

Coarse Fragment Content (by Volume)	Texture Class Modifier (Applied to Individual Horizons)	Family Particle-size Class (Applied to Whole Soil Profile)
0%–15%	no modifier	
15%–35%	gravelly cobbly stony	Base class[a] i.e., very-fine-clayey, fine-clayey, fine-loamy, coarse-loamy, silty, sandy (see Fig. 2)
35%–60%	very gravelly very cobbly very stony	Combined base class[b] + '-skeletal' i.e., clayey-skeletal, loamy-skeletal, silty-skeletal, sandy-skeletal (see Fig. 3)
60%–90%	extremely gravelly extremely cobbly extremely stony	
>90%	no modifier. Use fragment-size class name of dominant coarse fragment, (i.e., gravel, cobbles, stones, boulders: see Table 2)	fragmental

[a]Base family class refers to the six individual particle-size classes based on grain-size analyses in the absence of coarse fragments as shown in Fig. 2.
[b]Combined base class refers to the four skeletal particle-size classes as shown in Fig. 3.

making their application very cumbersome. Although the attributes are highly descriptive, assignment of a common soil series name to designate each family has been recommended for convenience and brevity (SCWG 1998, p. 144). Adoption of a series name (e.g., Breton family in place of Orthic Gray Luvisol, fine-loamy, mixed, neutral, cold, subhumid family) for the family name based on a series that is most representative (i.e. greatest areal extent) or oldest or most recognized name within a given soil family class would be most appropriate. Formalized adoption of common series names in place of attribute-based names would help facilitate more widespread application and ease of use.

Proposed Revisions to the Soil Family Taxon

Particle-size classes

Proposed changes to soil particle-size classes are summarized in Figs. 2, 3 and 4. The modified 'Base' particle-size triangle (Fig. 2) is similar to s-type particle sizes used in Forest Ecosystem Classification (Sims et al. 1989) which align with soil texture (fine earth) classes. This triangle (Fig. 2) is proposed to replace the particle-size triangle on Figure 41, left side (p. 136) of CSSC (SCWG 1998). These new proposed particle-size classes are based on percentages by weight of clay, silt and sand using 0.05 mm (50 μm) as the division between sand and silt grain sizes. An exception is that very fine sand textures are lumped with the coarse-loamy particle class rather than the sandy particle-size class. Soils containing coarse fragments of all sizes >2 mm diameter exceeding 35% by volume (approximately 50% by mass) and classified as 'skeletal' are summarized in a new figure (Fig. 3), while those soils with ≥90% coarse fragments of all sizes >2 mm diameter by volume are classed as fragmental. Coarse fragments as defined within certain size and shape ranges are shown in Table 1 (Day 1983). To maintain consistency, the proposed particle-size class names and those for 'skeletal' and fragmental classes are the same as the current version of the CSSC (SCWG 1998), except that the boundaries have been shifted to coincide with soil texture boundaries (Fig. 3).

Textural and engineering soil classification systems are not directly translatable because the latter are not based purely on texture (grain size) but also use plasticity data which is reflected in clay mineralogy. It is unlikely that a precise translation between textural and engineering classifications will ever be made because their purposes differ (Handy and Fenton 1977). Engineering classifications are directed towards variations in soil behaviour relevant to engineering, and textural classifications are more concerned with pedological description. Consequently, soil data required for engineering purposes should be collected and handled separately and in addition to pedological data.

The distinction between coarse-silty and fine-silty particle-size classes has been combined in favour of a larger single silty particle-size class that encompasses silt and silt loam textures. The distinction between coarse and fine silty particle-size classes relates to differences in support strength and to a lesser extent moisture-holding capacity (Handy and Fenton 1977).

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Table 4. Strongly contrasting particle sizes.

	Fragmental	Sandy-skeletal	Loamy-skeletal	Silty-skeletal	Clayey-skeletal	Sandy	Silty	Loamy[b]		Clayey[b]				
								Coarse-loamy	Fine-loamy	Fine-clayey	Very-fine-clayey	Cindery	Ashy	Thixotrophic
	Row over Column[c]													
Fragmental			X[a]	X	X		X	X	X	X	X			X
Sandy-skeletal				X	X		X	X	X	X	X	X		X
Loamy-skeletal	X[c]									X	X		X	X
Silty-skeletal	X									X	X		X	X
Clayey-skeletal	X	X				X								
Sandy	X			X	X		X		X	X	X	X		X
Loamy	X	X				X				X	X	X	X	X
Silty	X	X				X				X	X	X	X	X
Clayey	X	X	X	X		X	X	X	X					
Cindery													X	

[a]Recognized combinations are designated by an X at an intersect.
[b]The broader underlined term (i.e. loamy or clayey) may be used in place of specific terms if desired.
[c]Example: Loamy-skeletal over fragmental (X at the intersect).

Although the occurrence of pure silty materials (coarse-silty particle size) may be more common in the United States, they seem to be rare in the Canadian landscape, thus not warranting more than a single particle-size class. This reduces the number of 'base' particle-size classes (coarse fragment contents <35% by volume) from 7 to 6. Similarly, proposed particle-size classes for soils with coarse fragment contents ≥35% by volume (Fig. 3) also have boundaries coinciding with soil texture boundaries retaining particle-size class names from the current version of the CSSC. A new silty-skeletal class is proposed, and although rare, it is included for completeness (Fig. 3). Figure 4 provides the particle-size classes used to described terric layers found in organic soils. All 10 proposed family particle-size classes are summarized in Table 2. Table 3 provides a summary of proposed family particle-size classes along with corresponding modifiers used for soil texture classes for horizon descriptions which are based on coarse fragment content by volume.

Classification of soils with two or more parent materials in the control section with strongly contrasting particle-size classes must also be revised. Table 4 provides a listing of terms for particle-size classes for soils having strongly contrasting layers. The difference from the prior table (SCWG 1998, p. 139) is the combination of coarse-silty and fine-silty particle size columns into a single silty class and addition of the silty-skeletal class. The minimum significant thickness of a strongly contrasting layer is 15 cm, and the transition between layers is less that 12 cm thick as per the current version (SCWG 1998). Table 4 herein should be substituted for table 1 on page 139 of the CSSC for consistency with the proposed changes.

Mineralogy classes in mineral soils

A minor change/addition to table 2 Key to Mineralogy Classes (p. 140) of the current version of the CSSC (SCWG 1998) is to add a 'Mixed' class under 'Classes applied to soil families of any particle-size class' (SCWG 1998, p. 140, table 2). This class is proposed as a mixed mineralogy class which is by far the most common mineralogy class compared with those currently listed yet was not included in previous versions.

Reaction classes in mineral soils

Table 5 is proposed as an amendment to reaction classes for mineral soils substituting for the current listing of pH reaction classes on page 141 of the current version of the CSSC (SCWG 1998). The amended table adds the more detailed reaction classes as reported in Day (1983) to aid in clarity for the reader.

Calcareousness classes in mineral soils

A minor change to family calcareousness classes is the addition of a non-calcareous class corresponding to acid and neutral pH classes (Table 6). This additional

Table 5. Soil family reaction classes and corresponding field pH ranges.

Soil Family Criteria		Field pH Ranges[a]	
Class	pH of the C horizon	Class	pH
Acid	<5.5	Extremely Acid	≤4.5
		Very Strongly Acid	4.6–5.0
		Strongly Acid	5.1–5.5
Neutral	5.5–7.4	Moderately Acid	5.6–6.0
		Slightly Acid	6.1–6.5
		Neutral	6.6–7.3
Alkaline	>7.4	Mildly Alkaline	7.4–7.8
		Moderately Alkaline	7.9–8.4
		Strongly Alkaline	≥8.5

[a]Adapted from Day (1983).

Table 6. Soil family calcareous classes and corresponding field calcareous class ranges.

Soil Family Criteria		Field Calcareous Ranges[a]	
Class (for pH>7.4)	$CaCO_3$ Equivalent (%)	Class	$CaCO_3$ Equivalent (%)
Non-calcareous (acid and neutral)	<1%	Weakly calcareous	<5
Weakly calcareous	1%–6%		
		Moderately calcareous	5%–15%
Strongly calcareous	>6%–40%	Strongly calcareous	15%–25%
		Very strongly calcareous	25%–40%
Extremely calcareous	>40%	Extremely calcareous	>40%

[a]Adapted from Day (1983). Note that the class break at the upper end of the range for weakly calcareous does not align between the soil family system and the field classes.

calcareous class is proposed for completeness and to be substituted for the current list on page 141 in the current version of the CSSC (SCWG 1998).

Depth classes in mineral soils

Table 7 provides a comparison between current and proposed depth classes for lithic and permafrost (cryic) contacts for mineral soils. Proposed additions are the inclusion of non-lithic and non-cryic classes for soils with lithic contacts or permafrost contacts at >100 cm depth. These new criteria are proposed for completeness but may be omitted from many descriptions. There are no changes proposed for lithic and permafrost for organic soils. It is proposed that the depth of the lithic and cryic contacts between very shallow and extremely shallow be changed from <20 cm to <25 cm for consistency with other world soil classification systems and inclusion of the Leptosolic order to the CSSC (see Warren et al. In press). It is also proposed for the time being that the extremely shallow lithic criteria be applied as necessary only as a phase to very shallow lithic families. Otherwise, because of the hierarchical structure of the CSSC, assignment of separate series names would necessitate differentiation at the series level for soil belonging to extremely shallow vs. very shallow families. This is recommended in an effort to minimize unnecessary proliferation of soil series names.

All cryic criteria need only be applied in the case of extremely cold and very cold soil temperature regimes. Otherwise, a non-cryic class is implied and not explicitly used as it is redundant for all temperature regimes warmer than very cold and therefore omitted from most family class names.

Implications for acceptance of the proposed revisions

Adoption of the proposed family particle classes would align with particle-size classes which are currently used in Forest Ecosystem Classification (CFEC 2010) and other classification systems in Canada (Sims et al. 1989). Adoption of proposed particle-size criteria will also facilitate use of historical soil survey data published prior to the introduction of the soil family taxon in the 1960s for classification of these soils at the family level. This would facilitate a means of grouping soils with similar properties at the family level for application of appropriate management practices targeting specific soils which

Table 7. Soil family depth classes for mineral soils (lithic and cryic).

EXISTING[a]		PROPOSED	
Class	Depth (cm)	Class	Depth (cm)
Lithic			
Extremely shallow lithic	<20	Extremely shallow lithic[b]	<25
Very shallow lithic	20–50	Very shallow lithic	25–50
Shallow lithic	>50–100	Shallow lithic	>50–100
		Non-lithic	>100
Permafrost			
Extremely shallow cryic	<20	Extremely shallow cryic[c]	<25
Very shallow cryic	20–50	Very shallow cryic[c]	25–50
Shallow cryic	>50–100	Shallow cryic[c]	>50–100
		Non-cryic[c]	>100

[a]CSSC (SCWG 1998, p. 139).
[b]Extremely shallow lithic to be applied as necessary as a phase to very shallow lithic soil series, otherwise assignment of a separate series name is required to differentiate series belonging to extremely shallow vs. very shallow families.
[c]Applied only in the case of extremely cold and very cold soil temperature regimes (SCWG 1998, p. 142, table 3); otherwise a non-cryic class is implied and omitted from the family classification as it is redundant for all warmer temperature regimes (i.e. cold, cool and mild).

was the original intent of implementing the soil family taxon. Use of family classes to group soil series data for application of appropriate management practices would have a benefit of targeting field trials to develop management practices for soils which may have been overlooked in the past or alternatively avoid duplication of research efforts on soils with similar properties. The proposed changes will also separate engineering properties from pedological properties. Engineering data should be included in future soil survey reports; however, it should be collected and tabulated specific to engineering uses separate from pedological classification.

Recommendations

The following recommendations are based on the above discussion:

1. Adopt the revised soil particle-size classes as outlined in Figs. 2, 3 and 4 and summarized in Table 2 to replace the current versions of the soil family particles-size classes in the CSSC (SCWG 1998). These proposed changes align the family soil particle-size classes with soil texture classes. Adoption of these modifications will facilitate broader adoption and utility of the soil family class through retro-classification based on soil series data from pre-1960 soil survey data as well as new and future pedological surveys. Substitute Table 4 herein for table 1 on p. 139 of the CSSC (SCWG 1998).
2. Explicitly include 'Mixed' as a mineralogy class for all particle-size classes to facilitate clarity and completeness.
3. Explicitly include 'non-calcareous' as a calcareousness class for acid and neutral pH reactions to facilitate clarity and completeness. Substitute Tables 5 and 6 herein for lists on p. 141 of the CSSC (SCWG 1998).
4. Explicitly include 'non-lithic' as a depth to bedrock class for soils with lithic contacts >100 cm to facilitate clarity and completeness. Substitute Table 7 for the list on page 139 of the current CSSC (SCWG 1998).
5. Substitute Table 1 herein for table 9 on page 157 of the CSSC (SCWG 1998).
6. Add Table 3 herein to Chapter 17 of the CSSC (SCWG 1998, p. 157).
7. Formalize the assignment of a 'Family Name' based on a series name within each family group to abbreviate the current attribute-based family descriptor names. The assigned family name should be based on the soil series name that is most representative (i.e. greatest areal extent) or oldest or most recognized series name within each given soil family class (e.g. Breton family).

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