PROCEEDINGS

OF THE

SEVENTH MEETING OF THE

NATIONAL SOIL SURVEY COMMITTEE OF CANADA

Held at

THE UNIVERSITY OF ALBERTA, EDMONTON

April 22 - 26, 1968

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Proceedings of the Seventh Meeting of the
National Soil Survey Committee

W. A. Ehrlich - Chairman, N.S.S.C.

Foreword:

The committee and its guests were welcomed by Dr. K. Johns, President of the University of Alberta, Mr. G. Wilson, representative of the Minister of Agriculture of Alberta, and Dr. J. A. Toogood, representative of the Faculty of Agriculture of the University.

The seventh meeting of the National Soil Survey Committee of Canada was held from April 22 to 26 in the Agricultural Building, University of Alberta, Edmonton. The first and last three days were devoted to plenary sessions. On the second day the subcommittees met.

In the taxonomic soil classification minor changes were made in horizon nomenclature, in the Chernozemic, Solonetzic and Gleysolic orders, and major changes in the Podzolic, Brunisolic and Regosolic orders. The Podzolic Order was divided into two orders, the Luvisolic and the Podzolic, each separated from the other on kind of B horizon and degree of base saturation. With the Podzolic soils now are included the Acid Brown Wooded types with Podzolic B horizons formerly in the Brunisolic Order. To the Brunisolic Order which has new names for groups and subgroups were added the Podzo Regosols previously within the Regosolic Order. This removal from the Regosolic Order prompted the modification of some names and definitions of the soils remaining in this order. A major advance in the classification of soils was the adoption of the upper three categories of the Organic Order. This order and the "Histosols" as designated in the United States, which were developed cooperatively on similar concepts, are the first valid classifications of organic soils that have been developed to this degree anywhere in the world. Of utmost significance also was the adoption of the classification for soil families and the criteria for series, types, and phases.

A notable contribution was made in a report on International Soil Correlation in which three systems, the Canadian, United States and World schemes, were compared. Reports on Soils Under Forest, Crop Yield Assessments, and Engineering Applications to Interpretations of Soil Surveys were presented for the first time at a N.S.S.C. meeting. The report on Soils Under Forest provided much useful and interesting information, some of which has direct application to soil classification. The reports on Crop Yield Assessments and on Engineering Applications are interpretive of soil survey data and as such may become of great importance in future planning. However, the lack of data in these fields necessitates more testing before firm recommendations can be made. This reservation also is stated in the report on Climate in Relation to Soil Classification and Interpretation. The subcommittee on Criteria for Landforms was unable to recommend a satisfactory classification for the principal landforms and therefore it will continue on this problem for another term.

A progress report on the Canada Land Inventory provided up-to-date information and within this field an additional report of interest was presented on Biophysical Land Classification. It was pointed out by the speaker on the latter subject that more information from soil surveys than presently supplied is required if it is to be useful for interpretive purposes for Biophysical Land Classification.

The subcommittee on Physical and Chemical Analyses, which has played a useful role since the formation of the N.S.S.C. in 1940, will be discontinued for an indeterminate period.

A report on soil terms is included in the appendix. Although most of these sections were presented in previous proceedings, it was recommended that they be included here in order that all the information be under one cover.

The number of participants at the meeting was the highest on record (84) for a N.S.S.C. meeting and the interest was high throughout. The members of the National Committee were particularly pleased by the contributions made by the forest soil scientists, meteorologists and pedologists who were our guests.

Dr. J. E. McClelland, Principal Correlator, Great Plains Region, U.S.D.A., represented the U.S. Division of Soil Surveys at our meeting. He made many contributions to the discussions for which we owe him a debt of gratitude.

Appreciation and thanks are expressed to Dr. Summers for his excellent address on "Hail" presented to the group at the buffet supper.

Outline of the Canadian System of Soil Classification
for the Order, Great Group, and Subgroup Categories

The establishment of the Luvisolic Order and its addition to the classification system has changed the numbering sequence by one for all orders formerly designated at order 3 or higher. For example, the Podzolic Order formerly numbered 3 is now 4, and the Brunisolic Order previously numbered 4 is now 5.

Subgroups shown with a hyphen after the first two numbers and a virgule before the last number should be used in combination with other subgroups of the same great group not numbered in this manner. The hyphen indicates a missing subgroup number. For example, a Carbonated Rego Black would be numbered 1.32/6 and a Gleyed Calcareous Black would be 1.33/8.

Peaty phases, described in the "Report on the Fifth Meeting of the National Soil Survey Committee of Canada" as peaty subgroups, are defined in the "Report of the Subcommittee on Criteria for Phases" included in these proceedings.

Horizon designations of profile types in the reports on classification make use of the following conventions:

Diagnostic horizons are underlined.
Nondiagnostic horizons that may be present are bracketed.

Order	Great Group	Subgroup	
1. Chernozemic	1.1 Brown (Light Chestnut)	1.11	Orthic Brown
		1.12	Rego Brown
		1.13	Calcareous Brown
		1.14	Eluviated Brown
		1.11-2.11	Solonetzic Brown
		1.14-2.21	Solodic Brown
		1.1-/5	Saline Brown
		1.1-/6	Carbonated Brown
		1.1-/7	Grumic Brown
		1.1-/8	Gleyed Brown
		1.1-/9	Lithic Brown
	1.2 Dark Brown (Dark Chestnut)	1.21	Orthic Dark Brown
		1.22	Rego Dark Brown
		1.23	Calcareous Dark Brown
		1.24	Eluviated Dark Brown
		1.21-2.11	Solonetzic Dark Brown
		1.24-2.21	Solodic Dark Brown
		1.2-/5	Saline Dark Brown
		1.2-/6	Carbonated Dark Brown
		1.2-/7	Grumic Dark Brown
		1.2-/8	Gleyed Dark Brown
		1.2-/9	Lithic Dark Brown

Order	Great Group	Subgroup	
	1.3 Black	1.31	Orthic Black
		1.32	Rego Black
		1.33	Calcareous Black
		1.34	Eluviated Black
		1.31-2.12	Solonetzic Black
		1.34-2.22	Solodic Black
		1.3-/5	Saline Black
		1.3-/6	Carbonated Black
		1.3-/7	Grumic Black
		1.3-/8	Gleyed Black
		1.3-/9	Lithic Black
	1.4 Dark Gray	1.41	Orthic Dark Gray
		1.42	Rego Dark Gray
		1.43	Calcareous Dark Gray
		1.41-2.12	Solonetzic Dark Gray
		1.41-2.22	Solodic Dark Gray
		1.4-/5	Saline Dark Gray
		1.4-/6	Carbonated Dark Gray
		1.4-/7	Grumic Dark Gray
		1.4-/8	Gleyed Dark Gray
		1.4-/9	Lithic Dark Gray
2. Solonetzic	2.1 Solonetz	2.11	Brown Solonetz
		2.12	Black Solonetz
		2.13	Gray Solonetz
		2.14	Alkaline Solonetz
		2.1-/8	Gleyed Solonetz
		2.1-/9	Lithic Solonetz
	2.2 Solod	2.21	Brown Solod
		2.22	Black Solod
		2.23	Gray Solod
		2.2-/8	Gleyed Solod
		2.2-/9	Lithic Solod
3. Luvisolic	3.1 Gray Brown Luvisol (Gray Brown Podzolic)	3.11	Orthic Gray Brown Luvisol
		3.12	Brunisolic Gray Brown Luvisol
		3.13	Bisequa Gray Brown Luvisol
		3.1-/8	Gleyed Gray Brown Luvisol
		3.1-/9	Lithic Gray Brown Luvisol
	3.2 Gray Wooded (Gray Luvisol)	3.21	Orthic Gray Wooded
		3.22	Dark Gray Wooded
		3.2-/3	Brunisolic Gray Wooded
		3.2-/4	Bisequa Gray Wooded
		3.2-/8	Gleyed Gray Wooded
		3.21-2.23	Solodic Gray Wooded
		3.22-2.23	Solodic Dark Gray Wooded
		3.2-/9	Lithic Gray Wooded

Order	Great Group	Subgroup	
4. Podzolic	4.1 Humic Podzol	4.11	Orthic Humic Podzol
		4.12	Placic Humic Podzol
		4.1-/8	Gleyed Humic Podzol
		4.1-/9	Lithic Humic Podzol
	4.2 Ferro-Humic Podzol	4.21	Orthic Ferro-Humic Podzol
		4.22	Mini Ferro-Humic Podzol
		4.23	Sombric Ferro-Humic Podzol
		4.2-/4	Placic Ferro-Humic Podzol
		4.2-/8	Gleyed Ferro-Humic Podzol
		4.2-/9	Lithic Ferro-Humic Podzol
	4.3 Humo-Ferric Podzol	4.31	Orthic Humo-Ferric Podzol
		4.32	Mini Humo-Ferric Podzol
		4.33	Sombric Humo-Ferric Podzol
		4.3-/4	Placic Humo-Ferric Podzol
		4.3-/5	Bisequa Humo-Ferric Podzol
		4.3-/7	Cryic Humo-Ferric Podzol
		4.3-/8	Gleyed Humo-Ferric Podzol
		4.3-/9	Lithic Humo-Ferric Podzol
5. Brunisolic	5.1 Melanic Brunisol (Brown Forest)	5.11	Orthic Melanic Brunisol
		5.12	Degraded Melanic Brunisol
		5.1-/8	Gleyed Melanic Brunisol
		5.1-/9	Lithic Melanic Brunisol
	5.2 Eutric Brunisol (Brown Wooded)	5.21	Orthic Eutric Brunisol
		5.22	Degraded Eutric Brunisol
		5.23	Alpine Eutric Brunisol
		5.2-/7	Cryic Eutric Brunisol
		5.2-/8	Gleyed Eutric Brunisol
		5.2-/9	Lithic Eutric Brunisol
	5.3 Sombric Brunisol (Acid Brown Forest)	5.31	Orthic Sombric Brunisol
		5.31/8	Gleyed Sombric Brunisol
		5.31/9	Lithic Sombric Brunisol
	5.4 Dystric Brunisol (Acid Brown Wooded)	5.41	Orthic Dystric Brunisol
		5.42	Degraded Dystric Brunisol
		5.43	Alpine Dystric Brunisol
		5.4-/7	Cryic Dystric Brunisol
		5.4-/8	Gleyed Dystric Brunisol
		5.4-/9	Lithic Dystric Brunisol
6. Regosolic	6.1 Regosol	6.11	Orthic Regosol
		6.12	Cumulic Regosol
		6.1-/5	Saline Regosol
		6.1-/7	Cryic Regosol
		6.1-/8	Gleyed Regosol
		6.1-/9	Lithic Regosol

Order	Great Group	Subgroup	
7. Gleysolic	7.1 Humic Gleysol	7.11	Orthic Humic Gleysol
		7.12	Rego Humic Gleysol
		7.13	Fera Humic Gleysol
		7.1-/5	Saline Humic Gleysol
		7.1-/6	Carbonated Humic Gleysol
		7.1-/7	Cryic Humic Gleysol
		7.1-/9	Lithic Humic Gleysol
	7.2 Gleysol	7.21	Orthic Gleysol
		7.22	Rego Gleysol
		7.23	Fera Gleysol
		7.2-/5	Saline Gleysol
		7.2-/6	Carbonated Gleysol
		7.2-/7	Cryic Gleysol
		7.2-/9	Lithic Gleysol
	7.3 Eluviated Gleysol	7.31	Humic Eluviated Gleysol
		7.32	Low Humic Eluviated Gleysol
		7.33	Fera Eluviated Gleysol
		7.3-/9	Lithic Eluviated Gleysol
8. Organic	8.1 Fibrisol	8.11a	Fenno-Fibrisol
		8.11b	Hypno-Fibrisol
		8.11c	Sphagno-Fibrisol
		8.12	Mesic Fibrisol
		8.13	Humic Fibrisol
		8.1-/4	Limno
		8.1-/5	Cumulo
		8.1-/6	Terric
		8.1-/7	Cryic
		8.1-/8	Hydric
		8.1-/9	Lithic
	8.2 Mesisol	8.21	Typic Mesisol
		8.22	Fibric Mesisol
		8.23	Humic Mesisol
		8.2-/4	Limno
		8.2-/5	Cumulo
		8.2-/6	Terric
		8.2-/7	Cryic
		8.2-/8	Hydric
		8.2-/9	Lithic
	8.3 Humisol	8.31	Typic Humisol
		8.32	Fibric Humisol
		8.33	Mesic Humisol
		8.3-/4	Limno
		8.3-/5	Cumulo
		8.3-/6	Terric
		8.3-/7	Cryic
		8.3-/8	Hydric
		8.3-/9	Lithic

REPORT OF THE SUBCOMMITTEE ON SOIL HORIZON DESIGNATIONS

D. W. Hoffman, Chairman

The scope of soil horizons as applied in the Canadian system of soil classification is based on the definition of soil as any unconsolidated mineral or organic layer thicker than 4 inches (10 cm) occurring naturally on the earth's surface.[1] Surface layers that do not meet these requirements are not soil and are designated as rockland, ice, or water.

In this report, a major change from that presented in 1965 is the distinction by definitions of organic horizons developed under wet conditions (Of, Om, Oh) and those formed under imperfect or better drainage conditions (L, F, H). Modifications were also made on the definitions of m and R. Another change recommended was the removal of the suffix "j" from the horizon originally designated as Bfj. The intergrade between Bf and Bm was considered unnecessary.

Conventions Concerning the Use of Designations

The capital letters A and B may not be used singly in profile descriptions, but must be accompanied by the lower-case suffix (for example, Ah, Bf, or Bt) indicating the estimated modification from the parent material. The capital letter C may be used alone except when the material is affected by reducing conditions or has the properties of a fragipan.

Unless otherwise specified, additional lower-case suffixes indicate a secondary or subordinate feature or features in addition to those characteristic of the defined major horizon. The symbol Btg, for example, indicates that in addition to the dominance of illuvial clay in the B horizon there is also evidence of strong gleying. Some combinations are redundant or impractical in the light of present knowledge and definitions, thus their use should be avoided, e.g., Bmj. In some cases, such as Bgf, Bfh, and Bhf, the combination of suffixes has a specific meaning differing from that of the sum of the two suffixes used singly.

All horizons except AB, A and B, AC, and B and A may be vertically subdivided by consecutive arabic numbers after the letter designations. The assigned arabic numeral has no meaning except that of vertical subdivision. For example, a profile may be described as having the following: Ae1, Ae2, Bt1, Bt2, Bt3, Bt4, C1, and C2.

Roman numerals are prefixed to horizon designations to indicate unconsolidated lithologic discontinuities in the profile. Roman numeral I is understood for the uppermost material and therefore is not written. Subsequent contrasting materials are numbered consecutively in the order in which they are encountered downward, that is, II, III, and others.

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[1] A minimum thickness limit of 4 inches of organic or unconsolidated mineral material on the immediate surface of the earth is applied to the definition of soil as presented in the glossary of soil terms in the 1967 Proceedings, Canadian Society of Soil Science.

Organic Layers

Organic layers may be found at the surface of the mineral soils or at any depth beneath the surface in buried soils or overlying geologic deposits. They contain more than 30% organic matter. Two groups of these layers are recognized:

O - This is an organic layer or layers developed under poorly drained conditions, or under conditions of being saturated most of the year, or on wet soils that have been artificially drained.

Of - This is the least decomposed layer. It has large amounts of well-preserved fiber that is readily identifiable as to its botanical origin. This layer, called fibric, has a rubbed fiber content of more than 4/10 of the organic volume and an unrubbed fiber content of more than 2/3 of the organic volume.

Om - This is the intermediately decomposed layer. It has intermediate amounts of physically and biochemically altered fiber. This layer, called mesic, has (i) a rubbed fiber content between 1/10 and 4/10 of the organic volume, and (ii) an unrubbed fiber content of more than 1/3 of the organic volume.

Oh - This is the most highly decomposed layer. It has the least amount of plant fiber, the highest bulk density, and the lowest water-holding capacity. This layer, called humic, has (i) a rubbed fiber content of less than 1/10 of the organic volume, and (ii) it usually yields a pyrophosphate extract that is lower in value and higher in chroma than 10YR 7/3.

L-F-H - These are organic layers developed under imperfectly to well-drained conditions.

L - This is an organic layer characterized by an accumulation of organic matter in which the original structures are easily discernible.

F - This is an organic layer characterized by an accumulation of partly decomposed organic matter. The original structures in part are difficult to recognize. The layer may be partly comminuted by soil fauna as in moder[2] or it may be a partly decomposed mat permeated by fungal hyphae as in mor[2].

H - This is an organic layer characterized by an accumulation of decomposed organic matter in which the original structures are indiscernible. This material differs

[2] B. Bernier. 1968. Soils under forest. Proceedings of the Seventh Meeting of the National Soil Survey Committee of Canada.

from the F layer by its greater humification chiefly through the action of organisms. This layer, recognized as moder[2], is a zoogenous humus form consisting mainly of spherical or cylindrical droppings of microarthropods and which, at the junction with the mineral soil but frequently throughout the layer, is intermixed with loose mineral grains.

Master Mineral Horizons and Layers

Mineral horizons are those that contain less organic matter than that specified for organic horizons.

A - This is a mineral horizon or horizons formed at or near the surface in the zone of removal of materials in solution and suspension or maximum in situ accumulation of organic matter, or both. Included are:

1) horizons in which organic matter has accumulated as a result of biological activity (Ah);

2) horizons that have been eluviated of clay, iron, aluminum, or organic matter, or all of these (Ae);

3) horizons having characteristics of 1) and 2) above but transitional to underlying B or C (AB or A and B);

4) horizons markedly disturbed by cultivation or pasture (Ap).

B - This is a mineral horizon or horizons characterized by one or more of the following:

1) an enrichment in silicate clay, iron, aluminum, or humus, alone or in combination (Bt, Bf, Bfh, Bhf, and Bh);

2) a prismatic or columnar structure that exhibits pronounced coatings or stainings and significant amounts of exchangeable Na (Bn);

3) an alteration by hydrolysis, reduction, or oxidation to give a change in color or structure from horizons above or below, or both, and does not meet the requirements of 1) and 2) above (Bm, Bg).

C - This is a mineral horizon or horizons comparatively unaffected by the pedogenic processes operative in A and B, excepting (i) the process of gleying, and (ii) the accumulation of calcium and magnesium carbonates and more soluble salts (Cca, Csa, Cg, and C).

R - This is consolidated bedrock that is too hard to break with the hands or to dig with a spade when moist and that does not meet the requirement of a C horizon. The boundary between the R layer and overlying unconsolidated material is called a lithic contact.

Lower-case Suffixes

b - Buried soil horizon.

c - A cemented (irreversible) pedogenic horizon. The ortstein of a Podzol, a layer cemented by Ca, and a duripan are examples.

ca - A horizon with secondary carbonate enrichment where the concentration of lime exceeds that present in the unenriched parent material. It is more than 4 inches (10 cm) thick, and if it has a $CaCO_3$ equivalent of less than 15% it should have at least 5% more $CaCO_3$ equivalent than the parent material (IC). If it has more than 15% $CaCO_3$ equivalent it should have 1/3 more $CaCO_3$ equivalent than IC. If no IC is present, this horizon is more than 10 cm thick and contains more than 5% by volume of secondary carbonates in concretions or soft, powdery forms.

cc - Cemented (irreversible) pedogenic concretions.

e - A horizon characterized by the removal of clay, iron, aluminum, or organic matter alone or in combination. It is higher in color value by 1 or more units when dry than an underlying B horizon. It is used with A (Ae).

f - A horizon enriched with hydrated iron. It usually has a chroma of 3 or more. It is used with B alone (Bf), with B and h (Bfh and Bhf), with B and g (Bfg), and others.

The criteria for an f horizon (excepting Bgf) are that the oxalate-extractable Fe + Al exceeds that of the IC horizon by 0.8% or more (ΔFe + ΔAl $>$ 0.8%) and the ratio of organic matter to oxalate-extractable Fe is less than 20.

These horizons are differentiated on the basis of organic matter content into:

Bf, less than 5% organic matter
Bfh, 5 to 10% organic matter
Bhf, more than 10% organic matter

g - A horizon characterized by gray colors or prominent mottling, or both, indicative of permanent or periodic intense reduction. Chromas of the matrix are generally 1 or less. It is used with A and e (Aeg); with B alone (Bg); with B and f (Bfg); with B, h, and f (Bfhg and Bhfg); with B and t (Btg); with C alone (Cg); with C and k (Ckg); and several others.

In some reddish parent materials, matrix colors of reddish hues and high chromas may persist, in spite of long periods of reduction. In these soils, horizons are designated as g if there is gray mottling or if there is marked bleaching on ped faces or along cracks.

Aeg - This horizon must meet the definitions of A and e as well as those of g.

Bg - This horizon cannot be defined precisely at present. It includes those horizons occurring between A and C horizons in which the main features are (i) colors of low chroma and a change in structure from that of the C, or (ii) matrix colors of low chroma accompanied by mottles more prominent or abundant, or both, than those in the C, but not satisfying the requirements of Bgf horizons.

Bg horizons occur in some Orthic Humic Gleysols and in some Orthic Gleysols. These horizons are comparable, to some extent, with the Bm horizons of soils that are not strongly gleyed.

Bfg, Bfhg, Bhfg, Btg, and others - When used in any of these combinations the horizons must be within the limits set for f, fh, hf, t, and others.

Bgf - The dithionite-extractable Fe of this horizon exceeds that of the IC by 1% or more and the dithionite-extractable Al does not exceed that of the IC by more than 0.5%.

This horizon occurs in Fera Gleysols and Fera Humic Gleysols, and possibly below the Bfg horizons of gleyed Podzols. It is distinguished from the Bfg horizon of Podzols on the basis of the extractability of the Fe and Al. The Fe in the Bgf horizon is thought to have accumulated as a result of oxidation of ferrous iron. The FeO formed is not associated intimately with organic matter or with Al, and it is sometimes crystalline. Bgf horizons are usually prominently mottled and more than half of the soil material occurs as mottles of high chroma.

Cg, Ckg, Ccag, Csg, Csag - When g is used with C alone or with C and one of the lower-case suffixes k, ca, s, or sa, it must meet the definitions for C and these suffixes.

h - A horizon enriched with organic matter. It is used with A alone (Ah); or with A and e (Ahe); or with B alone (Bh); or with B and f (Bfh, Bhf).

Ah - When used with A alone it refers to the accumulation of organic matter and must contain less than 30% organic matter. It must show one Munsell unit of value darker than the layer just below, or have 1% more organic matter than IC.

Ahe - When used with A and e it refers to an Ah horizon that has been degraded as evidenced, under natural conditions, by streaks and splotches and often by platy structure. It may be overlain by a darker-colored Ah and underlain by a lighter-colored Ae.

Bh - This horizon contains more than 2% organic matter and the ratio of organic matter to oxalate-extractable Fe is 20 or more.

In general this horizon has a color with value and chroma of less than 3 when moist. Usually the Δ(Fe + Al) is less than 0.8%, but in some cases ΔAl is great enough to exceed this value.

j - Used as a modifier of suffixes e, g, n, and t to denote an expression of, but failure to meet, the specified limits of the suffix it modifies. It must be placed to the right and adjacent to the suffix it modifies.

Aej - When used with A and e it denotes an eluvial horizon that is thin or discontinuous or slightly discernible.

Btj - When used with B and t it is a horizon with some illuviation of clay, but not enough to meet the limits of Bt.

Btgj, Bmgj - When used with g it refers to horizons that are mottled, but do not show the neutral colors of intense reduction.

Bnjt - j may be used with n when secondary enrichment of Na is present, but does not meet the limits for n.

k - Presence of carbonate as indicated by visible effervescence with dilute HCl. May be used with any master horizon or combination of master horizon and lower-case suffix. Most often is used with B and m (Bmk) or C (Ck).

m[3] - A horizon slightly altered by hydrolysis, oxidation, or solution, or all three, to give a change in color or structure, or both. It has:

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[3] The Bm is similar to the cambic horizon described in the American and World soil classification systems except for the following:

1) It may occur under a Bf or Bt horizon.
2) Its lower boundary must be 2 inches (5 cm) or more from the surface compared with 10 inches (25 cm) in the other systems.

1) Soil structure rather than rock structure in more than half the volume of all subhorizons.
2) Some weatherable minerals.
3) Evidence of alteration in one of the following forms:
   (a) Stronger chromas and redder hues than the underlying horizons.
   (b) Evidence of the removal of carbonates.
4) Illuviation, if evident, is too slight to meet the requirements of a textural B or a podzolic B.
5) No cementation or induration and lacks a brittle consistence when moist.

This suffix can be used as Bm, Bmgj, Bmk, and Bms.

n - A horizon in which the ratio of exchangeable Ca to exchangeable Na is 10 or less. When used with B it must also have the following distinctive morphological characteristics: prismatic or columnar structure, dark coatings on ped surfaces, and hard to very hard consistence when dry.

p - A layer disturbed by man's activities, that is by cultivation or pasturing, or both. It is to be used only with A.

s - A horizon with salts including gypsum, which may be detected as crystals or veins, or as surface crusts of salt crystals, or by distressed crop growth, or by the presence of salt-tolerant plants. It is commonly used with C and k (Csk), but can be used with any master horizon or combination of master horizon and lower-case suffix.

sa - A horizon with secondary enrichment of salts more soluble than calcium and magnesium carbonates where the concentration of salts exceeds that present in the unenriched parent material. The horizon is 4 inches (10 cm) or more thick. The conductivity of the saturation extract must be at least 4 mmhos/cm and must exceed that of the C horizon by at least one-third.

t - A horizon enriched with silicate clay. It is used with B alone (Bt), with B and g (Btg), and others.

Bt - A Bt horizon is one that contains illuvial layer-lattice clays. It forms below an eluvial horizon, but may occur at the surface of a soil that has been partially truncated. It usually has a higher ratio of fine clay to total clay than IC. It has the following properties:

1) If any part of an eluvial horizon remains and there is no lithologic discontinuity between it and the Bt horizon, the Bt horizon contains more total and more fine clay than the eluvial horizon as follows:

(a) If any part of the eluvial horizon has less than 15% total clay in the fine earth fraction, the Bt horizon must contain at least 3% more clay, e.g., Ae 10% clay - Bt minimum 13% clay.

(b) If the eluvial horizon has more than 15% and less than 40% total clay in the fine earth fraction, the ratio of the clay in the Bt horizon to that in the eluvial horizon must be 1.2 or more, e.g., 20% clay increase in the Bt over Ae.

(c) If the eluvial horizon has more than 40% total clay in the fine earth fraction, the Bt horizon must contain at least 8% more clay than the eluvial horizon.

2) A Bt horizon must be at least 2 inches (5 cm) thick. In some sandy soils where clay accumulation occurs in the lamellae, the total thickness of the lamellae should be more than 4 inches (10 cm) in the upper 60 inches (150 cm) of the profile.

3) In massive soils the Bt horizon should have oriented clays in some pores and as bridges between the sand grains.

4) If peds are present a Bt horizon shows clay skins on some of both the vertical and horizontal ped surfaces and in the fine pores or shows oriented clays in 1% or more of cross section.

5) If a soil shows a lithologic discontinuity between the eluvial horizon and the Bt horizon or if only a plow layer overlies the Bt horizon, the Bt horizon need show only clay skins in some part, either in some fine pores or on some vertical and horizontal ped surfaces. Thin sections should show that some part of the horizon has about 1% or more of oriented clay bodies.

Btj and Btg are defined under j and g.

x - A horizon of fragipan character. A fragipan is a loamy subsurface horizon of high bulk density. It is very low in organic matter and when dry it has a hard consistence and is seemingly cemented. When moist it has a moderate to weak brittleness. It has few or many bleached fracture planes. It is overlain by a friable B horizon.

z - A permanently frozen layer.

Notes:

1) Transition horizons need capitals only, and
   (a) if transition is gradual use, e.g., AB or BC.
   (b) if transition is interfingered use, e.g., A and B, or B and C.
   (c) if desired, dominance can be shown by order, e.g., AB and BA.

2) The designations for diagnostic horizons must be given in the same sequence as shown for the definition, e.g., Ahe not Aeh.

3) Although definitions have been given to all diagnostic horizons, all possible combinations of horizon designations have not been covered. It is still necessary to write profile descriptions.

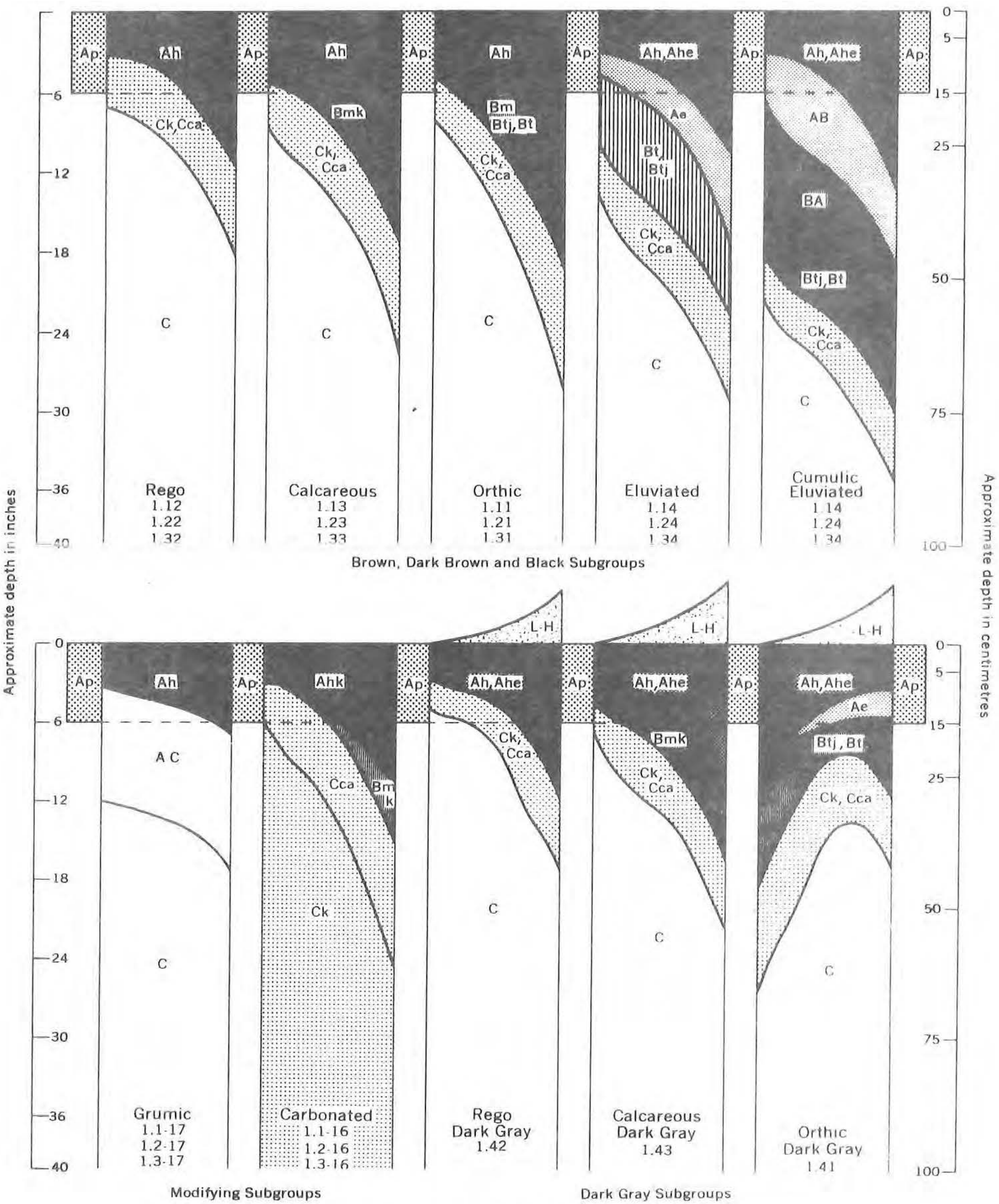

Fig. 4 A diagrammatic horizon pattern of representative Chernozemic profiles.

REPORT OF THE SUBCOMMITTEE
ON THE CLASSIFICATION OF CHERNOZEMIC SOILS

J. S. Clayton, Chairman

1. Chernozemic Order

Great Group	Subgroup	
1.1 Brown (Light Chestnut)	1.11	Orthic Brown
	1.12	Rego Brown
	1.13	Calcareous Brown
	1.14	Eluviated Brown
	1.11-2.11	Solonetzic Brown
	1.14-2.21	Solodic Brown
	1.1-/5	Saline Brown
	1.1-/6	Carbonated Brown
	1.1-/7	Grumic Brown
	1.1-/8	Gleyed Brown
	1.1-/9	Lithic Brown
1.2 Dark Brown (Dark Chestnut)	Subgroups same as for Brown except for great group name 1.21 Orthic Dark Brown	
1.3 Black	Subgroups same as for Brown except for great group name 1.31 Orthic Black	
1.4 Dark Gray	1.41	Orthic Dark Gray
	1.42	Rego Dark Gray
	1.43	Calcareous Dark Gray
	1.41-2.12	Solonetzic Dark Gray
	1.41-2.22	Solodic Dark Gray
	1.4-/5	Saline Dark Gray
	1.4-/6	Carbonated Dark Gray
	1.4-/7	Grumic Dark Gray
	1.4-/8	Gleyed Dark Gray
	1.4-/9	Lithic Dark Gray

A diagrammatic representation of the horizon pattern of the main subgroup profiles in the Chernozemic Order is shown in Figure 1.

1. Chernozemic Order

Definitions and Criteria at the Order Level

Chernozemic soils are well to imperfectly drained mineral soils with dark surface Ah, Ahe, or Ap, Chernozemic A horizons as defined, and with B or C horizons of high base saturation with divalent cations, calcium usually being dominant. These soils are found in areas with cool (mean annual temperature usually less than 42 F, 5.5 C), semiarid to subhumid continental (boreal) climate. The characteristics of the A horizons are developed and maintained from the accumulation and decomposition of a cyclic growth of xero- or meso-phytic grasses and forbs, representative of grassland communities or of transitional grassland-forest communities with associated shrubs and forbs.

At the order level the definitions and criteria established for Chernozemic soils are such that they may be closely correlated with the suborder Borolls in the American System[1] and with Castanozems and Chernozems in the proposed units for the World System[2]. However, a number of other soils with similar dark-colored surface horizons (Mollic Epipedons or Melanic A horizons) are excluded from the Chernozemic Order by definition. These exclusions include:

1. Dark surface soils with distinct solonetzic (Bn) horizons, as defined in the Solonetzic Order, including soils comparable with Natriborolls in the American System and Humic Solonetz in the World System.

2. Dark surface soils developed under hydrophytic vegetation and exhibiting strongly gleyed characteristics as defined within the Gleysolic Order, including soils comparable with Aquolls in the American and Humic Gleysols in the World systems.

3. Dark surface soils developed in areas with cold (cryic) climates and under vegetative communities characteristic of the subarctic, Arctic, subalpine, and Alpine regions, comparable with soils classed as Pergelic Cryoborolls in the American System, M.A.S.T. (mean annual soil temperature) $<$32 F(0 C), and of cryic climates in the World System.

4. Dark surface soils developed under very dry (xeric) temperate climates with M.A.T. (mean annual temperature) $>$ 42 F (5.5 C), comparable with those classified as Ustolls in the American and Ermosols in the World systems.

5. Dark surface soils developed under deciduous or mixed-wood forest vegetation of moist (udic) temperate climates, or under boreal forest vegetation where prominent Ae horizons $>$ 2.5 inches (6 cm) in thickness have developed due to podzolization. These exclusions include Dark Gray Wooded (Dark Gray Luvisol) soils comparable with American Mollic Cryoboralfs, and some Gray Brown Luvisol (Gray Brown Podzolic) and Melanic Brunisol (Brown Forest) soils comparable with Mollic Hapludalfs and Hapludolls in the American System and Brunic Luvisols and Eutric Cambisols in the World System.

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1. Soil Classification, A Comprehensive System, 7th Approximation (1960) and Supplement (March 1967) and Amendments (July 1968). SCS, USDA, Washington, D.C.

2. Definitions of Soil Units for the Soil Map of the World. World Soil Resources Report 33 and Addendum (May 1968). FAO/UNESCO.

Definition--A Chernozemic A horizon should have the following characteristics:

The Ah horizon in virgin soils should be not less than 3.5 inches (9 cm) thick having colors with values darker than 3.5 when moist and 5.5 when dry, and with chroma of less than 3.5 when moist. In soils disturbed by man's activities, by cultivation or pasturing, or both, the Ap horizon should be thick and dark enough to provide 6 inches (15 cm) of surface horizon with the above color criteria. The Ah or Ap, moist or dry, should be at least 1 Munsell unit darker in value than the C horizon and should not be higher in chroma than the B horizon, if present.

The Ah of a virgin soil usually has more than 1.5% organic matter for 6 inches (15 cm) when mixed or disturbed, and a carbon-to-nitrogen ratio of 17 or less. The organic matter content must not exceed 30%.

An Ap horizon 6 inches (15 cm) thick usually meets the requirements of 1.5% organic matter specified for the Ah horizon. However, where the original Ah was thin or where the present Ap horizon is thin or partly eroded, the surface soil may contain as little as 1% organic matter. If the Ah or Ap horizon rests on consolidated bedrock (R), it must be at least 4 inches (10 cm) thick.

Virgin and cultivated A horizons of Chernozemic soils have peds or clods with well-flocculated, moderate to strong structures that do not become amorphous (massive) on wetting or single grained on drying.

1.1 Brown Great Group (Light Chestnut)

These Chernozemic soils have Ah horizons with values darker than 3.5 moist and 5.5 dry and thick enough to produce 6 inches (15 cm) of mixed surface or Ap horizons with color values darker than 3.5 moist and 4.5 to 5.5 dry. Chromas are usually greater than 1.5 dry. In virgin Brown Chernozemic soil the surface layers of the Ah horizons are usually as light as or lighter in value than the lower parts of the Ah or the upper B horizons.

Brown soils are associated with and developed from the decomposition of a cyclic growth of mixed xero- to meso-phytic grasses and forbs. They are closely correlated with the concept of aridic Borolls in the American System and with Castanozems (borustic-aridic phase - Light Chestnut) in the World System.

1.11 Orthic Brown Profile type: <u>Ah</u>, <u>Bm</u>, <u>Btj</u>, or <u>Bt</u>, <u>C</u>, (Cca), (Ck)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by a color or structural Bm, or a weak to moderately textural Btj or Bt. The B horizons are free from primary carbonates, and range in reaction from slightly alkaline to slightly acidic.

The B horizons are normally medium to fine prismatic in macrostructure, breaking to medium and fine blocky or to coarse granular aggregates. Coarse prismatic structure is usually associated with coarse-textured fabric. Decreasing size of macroprismatic structure and an increasing tendency to break into fine, blocky, and granular aggregates is apparently associated with increasing clay content of the solum, and particularly with the occurrence of a textural (Bt) horizon. Thin discontinuous coatings on the surface of peds may occur in textural (Bt) horizons. Although these are not readily visible to the naked eye, they may be observed with a hand lens or in a thin section.

The occurrence of distinctive textural B horizons is not common in orthic Chernozemic soils, but may reflect simple gravitational movement and colloidal flow through pores and cleavages, or trends towards minimal development of solonetzic or luvisolic characteristics. A thin weakly developed Bm horizon or a transitional BC horizon is often present between the Bt and C horizons. A light-colored horizon of carbonate accumulation, Cca, is usually present, but is not an essential criterion.

Orthic Chernozemic soils may be closely correlated with the concept of Haploboroll in the American System or Haplic Castanozem and Chernozems in the World System, except when a significant textural B is present. Then they are more comparable with the concept of Argiborolls and Luvic Castanozems and Chernozems.

Orthic profiles with minimal grumic characteristics occur in soils of high clay content and are characterized by granular to fine subangular blocky peds in the A horizons and massive to angular blocky structure in the B horizons. Dark tongues of the A horizon often extend into the B and C due to sloughing into cracks. The boundaries between A, Bm, and Ck horizons are usually sharper and less diffuse than in rego and calcareous Chernozemic subtypes. This profile type is designated as Grumic Orthic Brown 1.11/7.

1.12 Rego Brown   Profile type: Ah, C, (Cca), (Ck)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by C horizons. In the profiles no major leaching of primary alkaline earth carbonates has occurred below the A horizons. Transition AC horizons may occur. There is no distinctive development of B horizons in Rego Chernozemic soils. They are very closely correlated with the concept of Entic Haploborolls in the American System.

In profiles with well-developed internal drainage, or in those on sites with moderate to excessive surface drainage, the virgin Ah horizons are commonly free from carbonates or salts. When disturbed or under cultivation, the A horizons are usually calcareous.

In profiles with limited internal drainage, or in those occurring on imperfectly drained sites, the A horizons may be infused with secondary carbonates, or salts that have precipitated from solution. Carbonated rego profiles may usually be detected by visual observation of strings or beads of carbonate crystals in the Ah horizon and confirmed by an effervescence test with acid (Ahk). Under cultivation these soils usually have a distinctly grayish surface cast or color.

Grumic rego profiles are mainly confined to fine-textured soils, usually containing 50% clay. The self-mulching properties of these soils, due to the repetition of swelling, shrinking, and the sloughing of surface material into cracks, result in profiles with ill-defined A horizons, which merge into transitional AC horizons. A tendency to form a surface granular mulch is particularly characteristic of grumic phases.

Soils with grumic characteristics are closely comparable with the concept of Vertic Borolls in the American System.

Gleyed rego profiles are characterized by weak development of mottling, and other characteristics of temporary wetness in the A and upper C horizons. Carbonated and saline profiles often show evidences of gleying.

1.13 Calcareous Brown   Profile type: Ah, Bmk, Cca, or Ck

These soils have Ah or Ap horizons as defined in the order and great group, underlain by Bm horizons, from which primary alkaline earth carbonates have not been completely removed (Bmk).

The B horizon is usually medium to fine prismatic in macrostructure, brownish in color, and slightly to moderately alkaline in reaction. Coarse prismatic structure is usually associated with coarse textures. A light-colored Cca horizon of carbonate accumulation is usually present above the C and where this condition occurs the soil may be closely compared with Calciborolls in the American System and Calcic Castanozems or Chernozems in the World System.

In profiles on sites with moderate to excessive surface drainage, the primary carbonates in the B horizons are present because of insufficient leaching.

Salinized, carbonated, grumic, and gleyed modifications of Calcareous Brown profiles occur and may be designated as Saline Calcareous Brown 1.13/5, Carbonated Calcareous Brown 1.13/6, Grumic Calcareous Brown 1.13/7, and Gleyed Calcareous Brown 1.13/8.

In profiles on imperfectly drained sites, the occurrence of carbonates or salts above the C horizon may be primarily due to retardation of leacning (Bmk), or to the upward movement of moisture and precipitation of secondary carbonates. In this latter circumstance both carbonated and gleyed phases may be recognized where significant. It is not practical to recognize a carbonated calcareous profile unless there is a significant accumulation of carbonates in the surface Ah or Ap horizon.

Grumic phases of calcareous profiles with self-mulching characteristics may be found in profiles of fine texture (greater than 50% clay). In these soils a tendency to form a surface granular mulch is common and the separations of A, B, and C horizons tend to be diffuse and transitional. Tongues of an A horizon often extend into the B and C horizons due to sloughing into cracks. Slickensides may often be observed in the C horizons. Gleyed Calcareous Brown profiles may be recognized by mottling in the A or Bmk horizons.

1.14 Eluviated Brown Profile type: Ah, (Ahe), Ae, or AE, Bt, or Btj, C, (Cca), (Ck)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by significant horizons of leaching or eluviation, beyond the concepts of the orthic chernozemic development. This eluviation is manifested by the occurrence of combinations and sequences of eluvial Ahe, Ae, and transitional AB horizons, underlain by weakly to moderately developed illuvial Btj or Bt horizons.

The leached horizons are characterized by the development of slight to moderate acidity and a minor reduction in base saturation.

Two variations of this subgroup may be recognized. They are:

A. A profile type in which eluviation is characterized by light-colored relic macroprismatic structure below the Ah or Ap, which breaks into coarse to medium platy peds that often exhibit vesicular or tubular voids, suggesting the formation of eluviated Ae or AB horizons from a former prismatic B. The Btj or Bt horizon is somewhat finer textured than the Ae with well-developed macroprismatic structure breaking to blocky peds of lower color value and slightly higher chroma than the Ae. The development of coatings on the surface of the peds, if present, is less strongly expressed than in Solonetzic Bn or Bnj horizons and the cationic ratio of Ca to other ions usually remains high. This type is closely correlated with the American concept of an albic Argiboroll and the World concept of Luvic Castanozem or Luvic Chernozem.

B. A "cumulic" eluviated type in which accumulated surface deposits of transported soil material modify the horizon differentiation due to leaching within the profile. Such soils are characterized by thick horizons of partly leached accumulated materials, overlying former A or transitional AB horizons. They are usually found on lower concave slopes where accumulation of excess runoff and sediments may be expected to occur. These profiles are often imperfectly drained and may be weakly gleyed. This profile type may be referred to as Cumulic Eluviated. A suggested criterion for recognizing this type is a depth of surface horizons greater than 16 inches (40 cm) above what is considered as the original B horizon. This type is closely correlated with the American concept of Pachic Argiboroll.

Eluviated Gleyed Brown profiles, 1.14/8, are common. Saline Eluviated Brown 1.14/5 and Carbonated Eluviated Brown 1.14/6 are uncommon, but are known to occur. Grumic Eluviated Brown profiles, 1.14/7, have not been observed and their occurrence is doubtful.

Fine-textured phases are usually characterized by an increase in granular (shotty) and fine subangular rather than medium to coarse blocky structures in the Ahe, Ae, and B horizons.

Solonetzic and Solodic Brown

Solonetzic Brown and Solodic Brown profile types have been listed as subgroups within the Chernozemic Order, but should be considered as intergrades between Solonetzic and Chernozemic soils rather than as typical subgroups within either order. The soils are characterized by a Chernozemic Ah horizon and a Bnjt horizon with pronounced structure and hard consistence, usually overlying a saline subsoil. The Bnjt horizon as defined would not meet the chemical requirements of a Bn, i.e., a ratio of exchangeable Ca to exchangeable Na of 10 or less, but would have a significant amount of Na, or Na + Mg, more than that considered normal for Chernozemic soils.

1.11-2.11 Solonetzic Brown Profile type: Ah, Bnjt, C, (Cca), Csk)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by a prismatic structured Bnjt horizon with hard consistence and with blocky secondary structure characterized by a "varnish-like" coating. A Cca, Csk horizon may underlay the Bnjt. The soils may be considered as intergrades between Orthic Brown and Brown Solonetz profiles.

1.14-2.21 Solodic Brown Profile type: Ah, (Ahe), Ae or AB, Bnjt, C, (Cca), (Csk)

These are soils with Ah or Ap horizons as defined in the order and great group, underlain by a sequence of eluvial Ahe, Ae, or transitional AB horizons, underlain by a prismatic or blocky Bnjt horizon with pronounced coatings. The eluvial Ae or AB horizons are often characterized by macroprismatic structures breaking into coarse to medium platy peds. These soils may be considered as intergrades between Eluviated Brown and Brown Solod profiles.

Saline, carbonated, and gleyed modifications of Solonetzic Brown and Solodic Brown profiles may occur, and can be designated in a similar manner to other modified Brown Subgroup profiles. Grumic modifications of these intergrades have not been observed.

Modifying Subgroups

Saline, carbonated, grumic, and gleyed lithic modifications of all major Brown Subgroup profiles may occur and are identified by the following horizons:

1.1-/5 Saline Brown	Saline A and C or saline B and C horizons (s or sa). Salinity may be detected by visual evidence of salt crystals and confirmed by a simple qualitative field test.
1.1-/6 Carbonated Brown	A or B horizons of secondary enrichment. Ak, (Aca), Bk (Bca), Ck

1.1-/7 Grumic Brown	Clayey soils with A and B transitional self-mulching horizons.
1.1-/8 Gleyed Brown	Weakly gleyed A, B, or C horizons
1.1-/9 Lithic Brown	Any Brown soil with a lithic contact 4 to 20 inches (10 to 50 cm) below the mineral surface.

1. 2 Dark Brown Great Group (Dark Chestnut)

These are soils that have Ah horizons with values darker than 3.5 moist and 4.5 dry, with chroma usually greater than 1.5 dry, and thick enough to produce 6 inches (15 cm) of mixed surface or an Ap horizon with color values darker than 3.5 moist and between 3.5 and 4.5 dry, and with chroma greater than 1.5 dry.

In virgin Dark Brown Chernozemic soils the Ah horizons are usually darkest in value at the surface and become progressively lighter with depth.

Dark Brown soils are usually associated with and developed from the decomposition of a cyclic growth of mesophytic grasses and forbs. They are closely correlated with the concept of Typic Borolls in the American System and the Castanozems (borustic typic phase - Dark Chestnut) in the World System.

1.21 Orthic Dark Brown Profile type: <u>Ah</u>, <u>Bm</u>, <u>Btj</u> or <u>Bt</u>, <u>C</u>, (Cca), (Ck)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by a Bm, or a weak to moderately textural Btj or Bt. The B horizons are free from primary carbonates.

Additional features characteristic of Orthic Dark Brown profiles are similar to those described for Orthic Brown 1.11.

1.22 Rego Dark Brown Profile type: <u>Ah</u>, <u>C</u>, (Cca), (Ck)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by C horizons.

Additional features characteristic of Rego Dark Brown profiles are similar to those described for Rego Brown 1.12.

1.23 Calcareous Dark Brown Profile type: <u>Ah</u>, <u>Bmk</u>, <u>Cca</u>, or <u>Ck</u>

These soils have Ah or Ap horizons as defined in the order and great group, underlain by Bm horizons, from which primary alkaline earth carbonates have not been completely removed (Bmk).

Additional features characteristic of Calcareous Dark Brown profiles are similar to those described for Calcareous Brown 1.13.

1.24 Eluviated Dark Brown Profile type: Ah, (Ahe), Ae, or AB, Bt, or Btj, C, (Cca), (Ck)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by sequences of eluvial Ahe, Ae, and transitional AB horizons overlying weakly to moderately developed illuvial B horizons. The leached horizons are characterized by the development of slight to moderate acidity and a minor reduction in base saturation.

Additional features characteristic of Eluviated Dark Brown profiles are similar to those described for Eluviated Brown 1.14.

1.21-2.11 Solonetzic Dark Brown Profile type: Ah, Bnjt, C, (Cca), (Ck), (Cs)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by a prismatic structured Bnjt horizon with hard consistence and with blocky secondary structure characterized by a "varnish-like" coating. A Cca, Ck, or Cs horizon may underlie the Bnjt. The soils may be considered as intergrades between Orthic Dark Brown and Brown Solonetz profiles.

1.24-2.21 Solodic Dark Brown Profile type: Ah, (Ahe), Ae or AB, Bnjt, C, (Cca), (Csk)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by a sequence of eluvial Ahe, Ae, or transitional AB horizons overlying a prismatic or blocky Bnjt horizon with pronounced coatings. The eluvial Ae or AB horizons are often characterized by macroprismatic structure breaking to coarse or medium platy peds. They may be considered as intergrades between Eluviated Dark Brown and Brown Solod profiles.

Saline, carbonated, and gleyed modifications of Solonetzic Dark Brown and Solodic Dark Brown profiles may occur and can be designated in a similar manner to other modified Dark Brown profiles. Grumic modifications of these intergrades have not been observed.

Modifying Subgroups

Saline, carbonated, grumic, gleyed, and lithic modifications of all major Dark Brown Subgroup profiles may occur and are identified by the following horizons:

1.2-/5	Saline Dark Brown	Saline A and C or saline B and C horizons (s or sa).
1.2-/6	Carbonated Dark Brown	A or B horizons of secondary carbonate enrichment. Ak, (Aca), Bk, (Bca), Ck
1.2-/7	Grumic Dark Brown	Clayey soils with A and B transitional self-mulching horizons.
1.2-/8	Gleyed Dark Brown	Weakly gleyed A, B, or C horizons. Ah or Ahgj, Bgj, Cgj
1.2-/9	Lithic Dark Brown	Any Dark Brown soil with a lithic contact 4 to 20 inches (10 to 50 cm) below the surface of the mineral horizon.

1.3 Black Great Group

These soils have Ah horizons with values darker than 3.5 moist or dry, chromas of 1.5 or less moist, and thick enough to produce 6 inches (15 cm) of mixed surface or Ap horizons of similar value and chroma.

Although Thin Black soils with Ah horizons less than 6 inches in depth are quite common, many Black soils have Ah horizons that extend well below the normal depths of a cultivated Ap layer.

Black soils are usually, but not exclusively, associated with and developed from the decomposition of a cyclic growth of mesophytic grasses and forbs, but may also be associated with thin or discontinuous tree and shrub cover. Where this latter condition prevails the dominant ground cover is one of forbs and grasses. Black soils are closely correlated with the concept of Udic Borolls in the American System and with Chernozems in the World System.

1.31 Orthic Black Profile type: Ah, Bm or Btj, C, (Cca), (Ck)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by a color Bm, or a weak to moderately textural Btj or Bt. The B horizon is free from primary carbonates.

Additional features characteristic or Orthic Black profiles are similar to those described for Orthic Brown 1.11.

1.32 Rego Black Profile type: Ah, C, (Cca), (Ck)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by C horizons.

Additional features characteristic of Rego Black profiles are similar to those described for Rego Brown 1.12.

1.33 Calcareous Black Profile type: Ah, Bmk, Cca, or Ck

These soils have Ah or Ap horizons as defined in the order and great group, underlain by Bm horizons, from which primary alkaline earth carbonates are not completely removed (Bmk).

Additional features characteristic of Calcareous Black profiles are similar to those described for Calcareous Brown 1.13.

1.34 Eluviated Black Profile type: Ah, (Ahe), Ae or AB, Bt or Btj, C, (Cca), (Ck)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by a sequence of eluvial Ahe, Ae, and transitional AB horizons overlying weakly to moderately developed illuvial B horizons. The leached horizons are characterized by the development of slight to moderate acidity and a minor reduction in base saturation.

Additional features characteristic of Eluviated Black soils are similar to those described for Eluviated Brown 1.14.

Solonetzic and Solodic Black

1.31-2.12 Solonetzic Black Profile type: Ah, Bnjt, C, (Cca), (Ck), (Cs)

These are soils with Ah or Ap horizons as defined in the order and great group, underlain by a prismatic structured Bnjt horizon with hard consistence and with blocky secondary structure, characterized by dark "varnish-like" coatings. A Cca, Ck, or Cs horizon may underlie the Bnjt. These soils may be considered as intergrades between Orthic Black and Black Solonetz profiles.

1.34-2.22 Solodic Black Profile type: Ah, (Ahe), Ae or AB, Bnjt, C, (Cca), (Csk)

These soils have Ah or Ap horizons as defined in the order and great group, underlain by a sequence of eluvial Ahe, Ae, or transitional AB horizons, overlying a prismatic or blocky structured Bnjt horizon with pronounced coatings. The eluvial Ae or AB horizons are often characterized by macroprismatic structure breaking to coarse or medium platy peds. They may be considered as intergrades between Eluviated Black and Black Solod profiles.

Saline, carbonated, and gleyed modifications of Solonetzic Black and Solodic Black profiles may occur and can be designated in a similar manner to other modified Dark Brown Subgroup profiles. Grumic modifications of the intergrades have not been observed.

Modifying Subgroups

Saline, carbonated, grumic, gleyed, and lithic modifications of all major Black Subgroup profiles may occur and are identified with the following horizons:

1.3-/5 Saline Black	Saline A and C or saline B and C horizons, including sa horizons of saline enrichment (s or sa).
1.3-/6 Carbonated Black	A or B horizons of secondary carbonate enrichment. Ak, (Aca), Bk, (Bca), Ck
1.3-/7 Grumic Black	Clayey soils with A and B transitional self-mulching horizons.
1.3-/8 Gleyed Black	Weakly gleyed A, B, or C horizons.
1.3-/9 Lithic Black	Any Black soil with a lithic contact 4 to 20 inches (10 to 50 cm) below the surface of the mineral horizon.

1.4 Dark Gray Great Group (Formerly termed Degraded Black)

These soils have Chernozemic A horizons, but have significant characteristics indicative of degradation or other modification resulting from the accumulation and decomposition of forest vegetation, including leaf mats (L-H horizons). These soils when undisturbed support a mixed vegetation of trees, shrubs, forbs, and grasses, characteristic of transitional areas between grassland and forest, but if protected from fire tend to be dominated by tree and shrub cover.

Virgin Dark Gray soils usually have leaf mats (L-H horizons), overlying Ah and Ahe horizons. The peds of the A horizons may have rather dark colored surfaces, but these will usually crush or rub out to gray or brown colors of higher value or chroma. A "salt and pepper effect", i.e., light gray spots or bands, may be observable in Ahe horizons and these exhibit a tendency to platy structures, which crush easily to a fine granular condition. In Rego and Calcareous Dark Gray subgroups these evidences of degradation are often weakly expressed and the horizon may be designated as an Ahej.

A Dark Gray Chernozemic A horizon has the following criteria. An Ah horizon, if present, in virgin Dark Gray soils has a value darker than 3.5 moist and 4.5 dry and chroma usually less than 1.5. The Ahe horizon has peds that crush to lighter colors than the Ah, if present, with values between 3.5 and 5.5 dry. The Ah, Ahe, or (Ah Ahe) combination should have a minimum thickness of 3.5 inches (9 cm) or be thick and dark enough to produce 6 inches (15 cm) of a mixed surface or Ap horizon of value darker than 3.5 moist and 5.0 dry and with chroma of less than 2 dry. A minimal development of a lighter colored Ae horizon less than 2.5 inches (6 cm) is allowable provided that the Ap or mixed surface horizon meets the above requirements for Dark Gray soils. Where a distinct Ae horizon greater than 2.5 inches (6 cm) thick and a Bt occur beneath a Dark Gray Chernozemic surface (Ah, Ahe, or Ap), the soil is considered to have undergone sufficient podzolization to be classified with the Dark Gray Wooded (Dark Gray Luvisol Subgroup in the Luvisolic Order).

Dark Gray Chernozemic soils are closely comparable, but not identical with the concept of Boralfic Borolls in the American system. They are at present included in the concept of Chernozems in the World System.

Other soils with dark-colored Ah or Ahe horizons developed under a forest leaf mat with moist values of 3.5 or less, but not thick enough to produce 6 inches (15 cm) of mixed surface or Ap with values darker than 3.5 moist or 4.5 dry are considered to be nonchernozemic. Such soils on the basis of their other horizon characteristics should be classified with the Luvisolic, Brunisolic, or Regosolic orders.

1.41 Orthic Dark Gray Profile type: (L-H), (Ah), Ahe, (Ae), Bm or Bt, C, (Cca), (Ck)

These soils have L-H, Ah-Ahe, L-H, Ahe, or Ap horizons as defined in the order and great group, underlain by a color Bm or textural Bt horizon free from primary carbonates.

There may be a minimal development of Ae horizon of less than 2.5 inches (6 cm) within the 6 inches (15 cm) of surface horizons of orthic profiles, if the mixed combination meets the criteria for a Chernozemic A horizon, and if no undisturbed or continuous Ae horizon is present below this depth.

A Bt horizon is more commonly associated with Orthic Dark Gray soil than a Bm horizon, and becomes more pronounced with increasing degradation of the A horizons. These textural horizons are often subangular blocky to coarse granular in structure and may show a weakly expressed enrichment of hydrated iron. The reaction of the orthic Bt is usually slightly acidic, but the lower B horizon above the Cca may be slightly calcareous.

Salinized (1.41/5) and Carbonated (1.41/6) modifications of Orthic Dark Gray profiles are uncommon. Grumic modifications (1.41/7) are also uncommon, but clayey profiles tend to form a granular (shotty) and fine subangular blocky structure in the Ahe and B horizons. Gleyed modifications (1.41/8) are common.

1.42 Rego Dark Gray Profile type: (L-H), (Ah), Ahe, C, (Cca), (Ck)

These soils have L-H, Ah-Ahe, L-H, Ahe, or Ap horizons as defined in the order and great group, underlain by C horizons, usually moderately to strongly calcareous. In Rego Dark Gray soils the evidences of degradation in the Ahe are often weakly expressed and the horizon may be designated as Ahej. Under continued cultivation such soils are not easily distinguished from Rego Black soils. Rego Dark Gray profiles are most often found in sites of limited internal drainage or in imperfectly drained positions, and gleyed (1.42/8) profiles are common. Rego Dark Gray soils are less commonly associated with sites of moderate to excessive surface drainage.

Salinized modifications (1.42/5) of Rego Dark Gray profiles seldom occur, carbonated modifications (1.42/6) of Rego Dark Gray profiles with some carbonates in the Ah, Ahe below the leaf mat are common, but C horizons of carbonate accumulations are infrequent. Grumic modifications of Rego Dark Gray soils (1.42/7) have not been observed in virgin soils, but have been noted in cultivated clay soils where the L-H layers were destroyed.

Additional features characteristic of Rego Dark Gray soils are similar to those described for Rego Brown 1.12.

1.43 Calcareous Dark Gray Profile type: (L-H), (Ah), Ahe, Bmk, Cca, or Ck

These soils have L-H, Ah-Ahe, L-H, Ahe, or Ap horizons as defined in the order and great group, underlain by color Bm horizons from which primary alkaline earth carbonates are not completely removed (Bmk). In Calcareous Dark Gray soils, the evidences of degradation in the Ahe are often weakly expressed and the horizon may be designated as Ahej. Under continued cultivation with accompanying decomposition of leaf mat material, evidence of degradation is not easily distinguished.

Salinized modifications of Calcareous Dark Gray soils (1.43/5) seldom occur. Carbonated modifications (1.43/6) are uncommon in virgin soils, but are evident under cultivation. Grumic modifications (1.43/7) have not been observed. Gleyed modifications (1.43/8) are common.

Additional features characteristic of Calcareous Dark Gray soils are similar to those described for Calcareous Brown 1.13.

Eluviated Dark Gray - Dark Gray Wooded

This is a "degraded" type, in which pronounced leaching and eluviation have resulted from the genetic influence of accumulation and decomposition of wooded vegetation, including leaf mats. It was formerly classified as the Eluviated Dark Gray (degraded) Subgroup, and was recognized as intergrading towards the Luvisolic Order.

The separation of these soils (which were also formerly designated as moderately degraded black) from Luvisolic soils has presented some difficulties and it has been decided that they will now be classified and described with the Dark Gray Wooded Subgroup in the Luvisolic Order. It should be noted that Dark Gray profiles with an Ae horizon of less than 2.5 inches (6 cm) are included with the Orthic Dark Gray Subgroup. Virgin soils with less than 3.5 inches (9 cm) of an Ah, Ahe beneath a leaf mat, and with an Ae horizon extending below 6 inches (15 cm) in depth will not meet the requirements for Dark Gray Chernozemic soils and will be classified in the Dark Gray Wooded Subgroup of the Luvisolic Order.

Solonetzic and Solodic Dark Gray

1.41-2.12 Solonetzic Dark Gray Profile type: (L-H), (Ah), Ahe, (Ae), Bnjt, C, (Cca), (Csk)

These soils have L-H, Ah-Ahe, L-H, Ahe, or Ap horizons as defined in the order and great group, underlain by a prismatic structured Bnjt horizon with hard consistence and subangular blocky secondary structure characterized by distinct dark coatings on the peds. A Cca, Ck, or Cs horizon may underlie the Bnjt. An Ae horizon less than 2.5 inches (6 cm) thick is often found in this intergrade type within the upper 6 inches of the surface horizon below the leaf mat. If, however, the Ae horizon is thicker than 2.5 inches or extends to more than 6 inches (15 cm) below the leaf mat, the soil must be classified as a Solodic Gray Wooded (3.21-2.23).

1.41-2.22 Solodic Dark Gray Profile type: (L-H), (Ah), Ahe, (Ae), AB Bnjt, C, (Cca), (Csk)

These soils have L-H, Ah-Ahe, L-H, (Ahe), or Ap horizons as defined in the order and great group, with a color of the mixed A horizons of value less than 3.5 moist and less than 4.5 dry, underlain by a transitional AB horizon, or an Ae, AB sequence, overlying a prismatic or blocky structured Bnjt horizon with pronounced coatings. Such soils can be considered as intergrades between an Orthic Dark Gray and a Gray Solod, or as intergrades between a Dark Gray Wooded (Luvisol) and Gray Solod. An Ae horizon, if present, should be less than 2.5 inches (6 cm) thick.

Salinized modifications of all Dark Gray Chernozemic soils (1.4-/5) do not occur frequently. Carbonated modifications (1.4-/6) are commonly associated with Calcareous and Rego Dark Gray profiles but not with Orthic Dark Gray. Grumic modifications (1.4-/7) are of doubtful occurrence; gleyed modifications (1.4-/8) are common.

1.4-/9 Lithic Dark Gray

Any Dark Gray soil with a lithic contact 4 to 20 inches (10 to 50 cm) below the surface of the mineral horizon belongs to this subgroup.

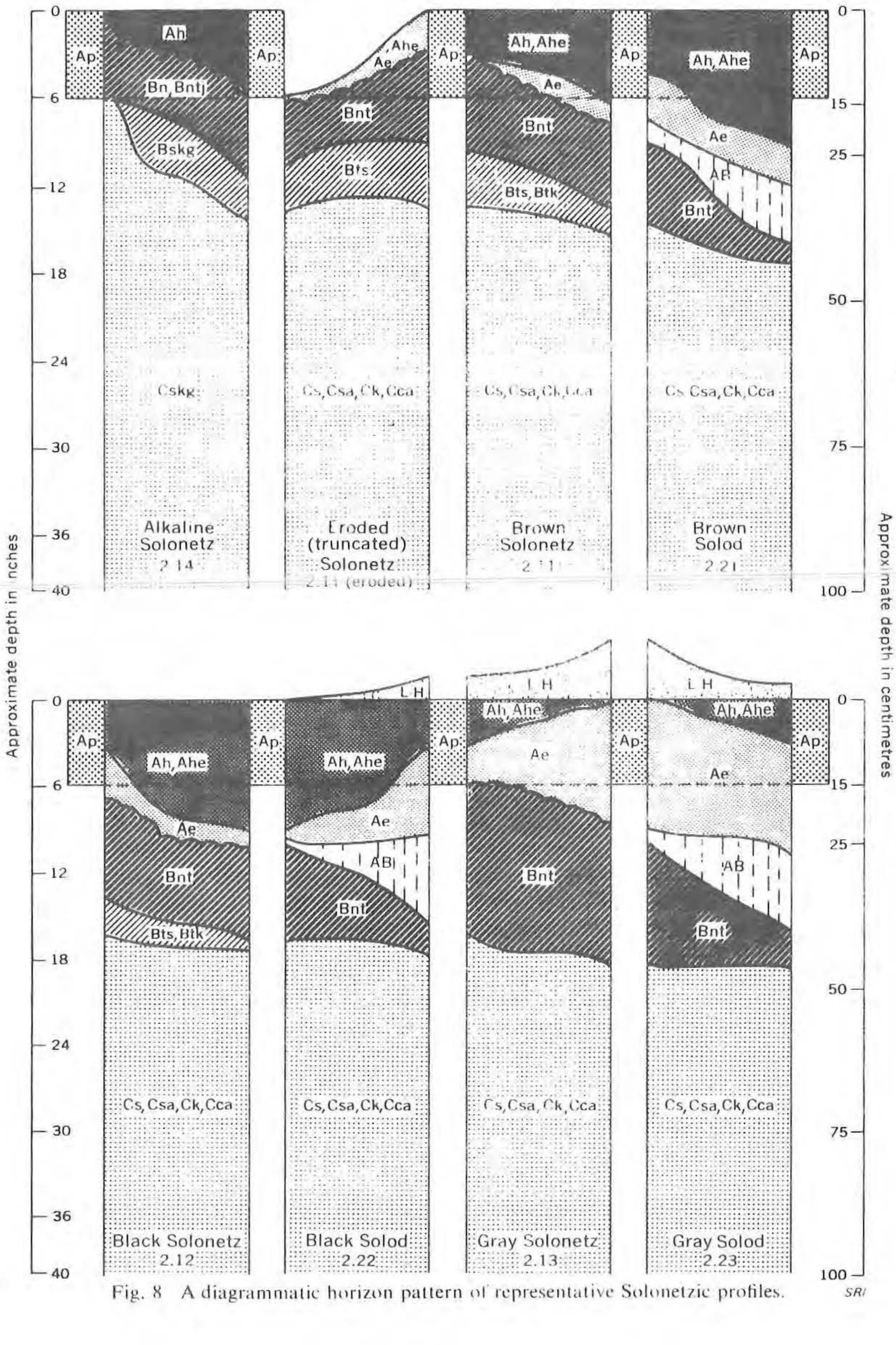

Fig. 8 A diagrammatic horizon pattern of representative Solonetzic profiles.

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REPORT OF THE SUBCOMMITTEE ON THE CLASSIFICATION OF SOLONETZIC SOILS

W. Earl Bowser, Chairman

2. Solonetzic Order

Great Group	Subgroup	
2.1 Solonetz	2.11	Brown Solonetz
	2.12	Black Solonetz
	2.13	Gray Solonetz
	2.14	Alkaline Solonetz
	2.1-/8	Gleyed Solonetz
	2.1-/9	Lithic Solonetz
2.2 Solod	2.21	Brown Solod
	2.22	Black Solod
	2.23	Gray Solod
	2.2-/8	Gleyed Solod
	2.2-/9	Lithic Solod

The occurrence of Solonetzic soils in Western Canada was recognized by the first soil surveyors. In the 1926 Alberta Soil Survey Report No. 2 a soil area is described as loam, blowout phase. The patchy microrelief and the fact that "the surface horizon was more acid than the surface of the adjacent normal soils" were noted. Saskatchewan Soil Survey Report No. 3 (1925) referred to "burn-out" soils and in a 1931 report the Echo soil series was described as having profiles "dominantly solonetz and degraded solonetz (Soloti)."

In 1938 a monograph on the Soils of Manitoba described alkalinized and degraded alkalinized soils and in a footnote called them solonetz and solod.

Following these initial classification attempts the soil survey reports of the 1930's and 1940's began to contain the terms solonetz-like, solonetz, alkali solonetz, solod, soloti, and solodic. In 1955 the National Soil Survey Committee set up a preliminary system of soil classification. This system included at the highest category, a group called Halomorphic soils that contained the Solonetz, Solodized Solonetz, and Solod great groups. In 1960 a Canadian soil classification system was adopted. It included the Solonetzic Order containing the great groups Alkali Solonetz, Solonetz, Solodized Solonetz, and Solod; and in 1965 these four great groups were combined into two, namely Solonetz and Solod.

With rare exceptions all the soils of the Solonetzic Order in Canada are, to some degree, solodized and a significant point in the solodization process is where the Bnt[1] shows visible evidence of breakdown. Practically all the soils

[1] Bnt - Solonetzic B (seen in horizon designations)

"above" this point have an A horizon that is neutral to slightly acidic, showing varying degrees of leaching, and is abruptly separated from the Bnt horizon. All the soils "below" this point have an acidic A horizon with a well-developed Ae subhorizon and usually a well-defined AB horizon.

Because there are varying degrees of leaching in the A horizon, the color of this horizon is much less amenable to precise definition than that of the same horizon of the geographically associated orthic soils. Generally the Ap of the Solonetzic soils is of higher value (lighter in color) than adjacent orthic soils of other orders. Also, because the characteristics of the Bnt horizon are dominant in these soils, the color, and therefore the organic matter content of the A horizon is subdominant. Three color (zonal) separations are all that can be satisfactorily defined at the subgroup level.

2. Solonetzic Order

These soils have solonetzic B and saline C horizons. Morphologically a solonetzic B horizon is characterized by a columnar or prismatic macrostructure that can be broken into a blocky mesostructure. The blocks are hard to very hard in consistence when dry and have dark surface stains. Chemically the solonetzic B horizon has a ratio of exchangeable Ca to exchangeable Na of 10 or less. They are well to imperfectly drained soils.

It is generally assumed that Solonetzic soils originated from a parent material that was more or less uniformly salinized. This material was, and still is, subjected to leaching by rainwater. This leaching caused desalinization and an increase of alkali peptized and deflocculated colloids that concentrated in a B horizon. The next process is assumed to be the removal of the alkali bases and the forming of an acidic A horizon with a platy structure. In the final stages of solodization there is a structural breakdown of the solonetzic B horizon. The occurrence of "pillared black alkali" soils with a strongly alkaline A (the first stage in Solonetz formation) is not frequent in Canada. Practically all the Solonetzic soils of Canada have a neutral to acidic A horizon indicating that solodization has become operative. Also, it is generally true that as solodization proceeds the salt accumulation horizon moves lower in the profile, from the lower B to well down in the C, and the lime accumulation horizon moves downward. In most Solonetzic soils the C horizon has a conductivity (saturation extract) of more than 4 mmhos. There is evidence that solodization is arrested where saline groundwater is within capillary reach of the solum and in some places a recycle of salinization occurs. It is also assumed that most Solonetzic soils developed under a vegetative cover of grasses and forbs. Although some members of this order may occur under a tree cover, it is believed that the trees did not become established until solodization was well under way.

Soils that are intergrades between the Solonetzic Order and the Chernozemic and Podzolic orders are classified in the latter orders. In general, these intergrades fall into two categories: (i) soils with weak solonetzic characteristics that will usually intergrade towards the Chernozemic Order, and (ii) soils with relic solodic characteristics that will intergrade towards either the Chernozemic or Luvisolic orders.

2.1 Solonetz Great Group

These soils have A horizons as defined in the subgroups. There is an abrupt break (less than 1 inch) between the A and B horizons. The Bnt horizon is very hard columnar (the flat or round tops may have a thin capping of white siliceous material). There are dark stains on the cleavage faces. The upper part of the Bnt columns is massive (intact) when removed from the profile. See the note under 2.14.

In soils of the Solonetz Great Group the A horizon is usually thin in relation to the B horizon. There are varying degrees of solodization discernible in the A horizon, indicated by the relative prominence of an eluvial horizon. The B horizon usually has a very low hydraulic conductivity. As a result, during periods of excess moisture, water may be temporarily held above the Bnt; this is often indicated by weak mottling in the lower part of the A horizon. Clay flows can usually be readily discerned on the cleavage faces of the Bnt. Roots tend to concentrate along the cleavage faces rather than penetrate into the peds, and the roots are usually flattened.

2.11 Brown Solonetz   Profile type: Ah or Ahe or both, (Ae), an intact Bnt, (Bts), (Btk), Csa or Cs, (Cca), (Ck)

These soils are associated with grass and forb vegetation and semiarid climate. The mixed A subhorizons have color values of more than 3.5, usually more than 4.5, (dry) and chromas of more than 1.5.

Areas of this subgroup are often characterized by a patchy microrelief due to the differential erosion of the A horizon. The eroded pits usually have steep sides and support very sparse vegetative growth.

2.12 Black Solonetz   Profile type: Ah or Ahe or both, (Ae), an intact Bnt, (Bts), (Btk), Csa or Cs, (Cca), (Ck)

These are soils associated with mesophytic grass and forb, shrub, or discontinuous tree vegetation and subhumid climate. The mixed A subhorizons have color values of less than 4.5 (dry) and chromas of less than 2.5.

There may occasionally be a thin L-H horizon in the profiles that are intergrading to the Gray Subgroup. The differential erosion of the A horizon, common in the areas of the Brown Subgroup, seldom occurs in the Black Subgroup. Where such areas exist they are generally fairly well covered with grass.

2.13 Gray Solonetz   Profile type: (L-H), (Ah), Ahe or Ae or both, an intact Bnt, Csa or Cs, (Ck), (Cca)

These soils are associated with scattered or stunted forest vegetation and subhumid climate. The mixed A subhorizons have color values of more than 4.5 (dry) and chromas of less than 2.5.

2.14 Alkaline Solonetz   Profile type: (Ah), Bn or Bntj, (Bskg), Cskg

These soils are associated with grass and forb vegetation that contains a significant percentage of alkali-tolerant varieties. Areas of this soil have varying degrees of restricted drainage.

Note:

This subgroup occurs rarely in Western Canada. It differs from the other subgroups of the Solonetz Great Group in that the Ah is strongly alkaline and the break between the A and B is usually indistinct. The prisms of the B horizon often have pointed tops that protrude into the A. The Ah usually has a color value (dry) of less than 4.5. These soils show little or no evidence of solodization.

2.1-/8 Gleyed Solonetz

These soils have the same differentiating characteristics as the above subgroups, but have in addition some mottling and duller colors in the A, B, or C or in all three horizons.

Mottling in the A horizon (usually in the lower part) is generally the result of a temporary water table above the Bnt. Mottling is usually quite pronounced in the lower portion of the B horizon and the chroma of the B is usually lower than in the nongleyed subgroups.

2.1-/9 Lithic Solonetz

These are Solonetz soils with a lithic contact between 4 and 20 inches (10 and 50 cm) of the mineral surface.

2.2 Solod Great Group

These soils have A horizons with a color as defined in the subgroups. There is either a distinct (more than 1 inch) AB transition horizon or a prominent (more than 2 inches) Bntl horizon that breaks readily into blocky aggregates; usually both these horizons are present. The contact between the AB and Bnt is not well defined. The Bnt is hard to very hard, but can be broken into darkly stained blocky aggregates. The C horizon is saline and usually calcareous.

In soils of this great group the A horizon is generally thicker in relation to the B horizon than in the geographically associated Solonetz soils. The Ae is pronounced and usually platy. It may retain vertical cleavage lines that are relics of a former columnar B horizon. The blocky aggregates of the AB horizon are usually silica coated and often only the center of the blocks retains the dark color of the former B horizon. The Bnt horizon is usually similar to the lower Bnt of the associated Solonetz soils. It may therefore not have well-developed columnar structure. The Cs horizon is often below the Ck horizon.

2.21 Brown Solod Profile type: Ah or Ahe or both, Ae, AB, Bnt, (Cca), (Ck), Csa or Cs

These soils are associated with xero- to meso-phytic grass and forb vegetation and semiarid climate. The mixed Ah and Ahe has a color value of more than 3.5 (dry) (usually more than 4.5) and a chroma of more than 1.5.

In areas of this soil there is often some incidence of previously eroded pits. They are, however, grassed over and usually quite shallow.

2.22 Black Solod Profile type: (L-H), Ah or Ahe or both, Ae, AB, Bnt, (Cca), (Ck), Csa or Cs

These soils are associated with mesophytic grass and forb, shrub, or discontinuous tree vegetation and subhumid climate. The mixed Ah and Ahe has a color value of less than 4.5 (dry) and a chroma of less than 2.5.

In these soils the Cs or Csa is often considerably below the Ck or Cca horizons.

2.23 Gray Solod Profile type: (L-H), (Ah), (Ahe), Ae, AB, Bnt, (Ck), (Cca), Cs or Csa

These soils are associated with forest vegetation and subhumid climate. The mixed A subhorizons have color values of more than 4.5 (dry) and chromas of less than 2.5.

2.2-/8 Gleyed Solod

These are soils with the same differentiating characteristics as any of the above subgroups, but in addition have some mottling and dull colors in the AB or C horizons or both.

Although some evidence of gleying may occur in any of the three master mineral horizons it is most common in the lower B and C horizons.

2.2-/9 Lithic Solod

Any Solod soil with a lithic contact between 4 and 20 inches (10 and 50 cm) of the mineral surface belongs to this subgroup.

Note 1.

The subgroup separations are based primarily on the color of the A horizon, which in turn is related to the vegetative cover and the regional climate. The color of the Ah horizon, when present, usually approximates the chroma and the value of the geographically associated Chernozemic or Luvisolic soils, specifically it is usually of slightly higher value. Because the nature of the B horizon is the dominating characteristic of Solonetzic soils, the color of the A horizon is relatively less important than in the geographically associated Chernozemic and Luvisolic soils. For this reason, it is suggested that three subgroups, based on the color of the A horizon, are all that can be validly defined at this level of categorization. There is, going from Brown to Black to Gray or from semiarid to subhumid, generally an increase in the depth of the A horizon and in the depth of soil development. Finer subdivisions on the basis of the color of the A horizon can be recognized at the series level, if deemed significant. When there are significant color differences within the subgroup, there are usually other differentiating profile characteristics.

Note 2.

In areas where the A horizon has been eroded away the soil should be classified as an eroded phase and given the subgroup color indicated by geographically associated Solonetzic soils.

Note 3.

The classification of cultivated Solonetzic soils must be based on the diagnostic horizons that remain. For example, if the Bnt horizon lies directly under the Ap, then the subgroup color separation is determined by the Ap and the great group is determined by the characteristics of the Bnt.

Note 4.

Some Solonetzic soils occur that have bisequa features. They have been formed in areas where there is a fairly deep coarse- to medium-textured surface layer over a saline fine-textured substratum. The profiles have the following horizon sequence: Ah, (Ahe), Bm, Ae, IIBnt, IICs, and K. There are insufficient data available as yet to define a specific subgroup.

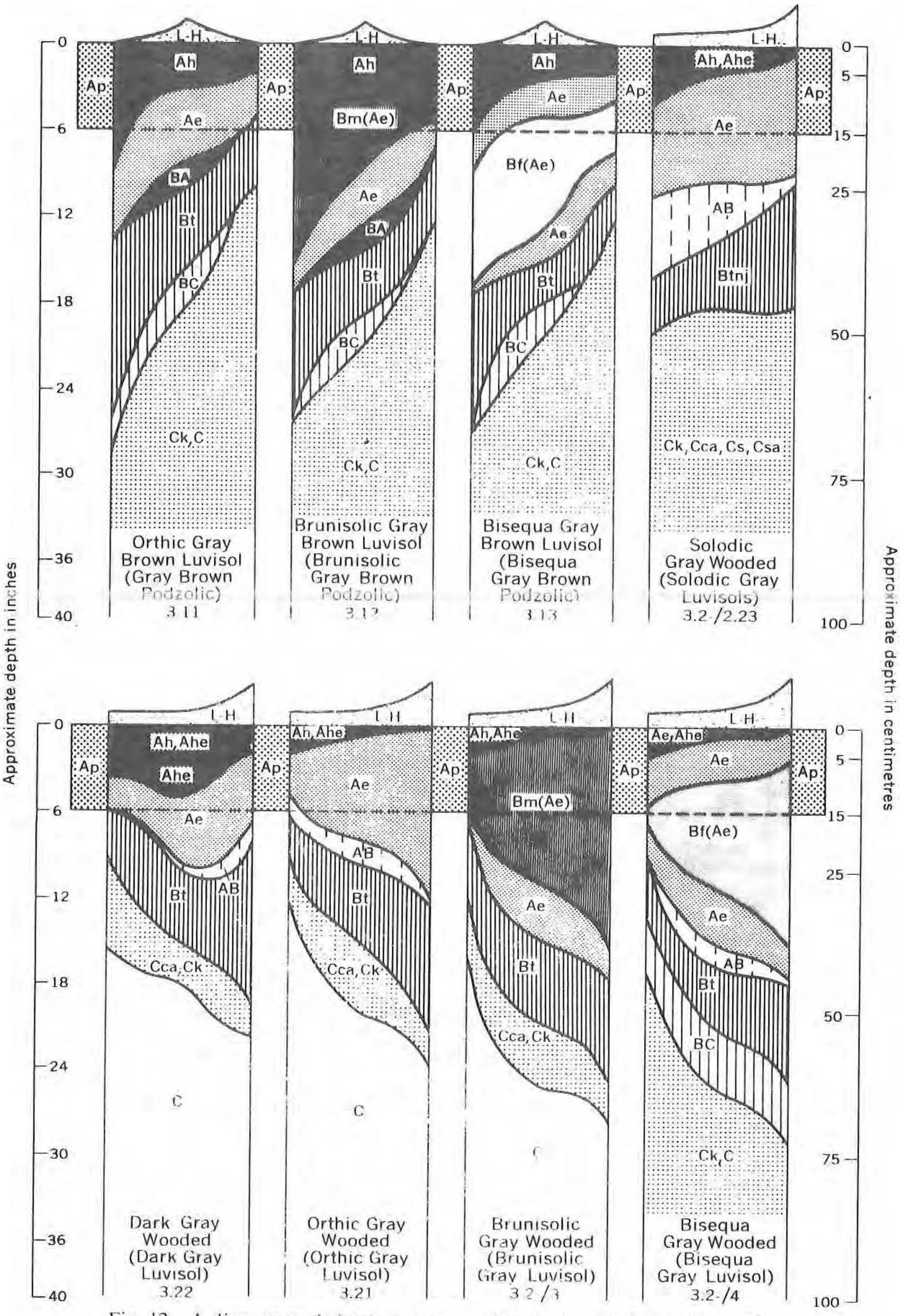

Fig. 12 A diagrammatic horizon pattern of representative Luvisolic profiles.

REPORT OF THE SUBCOMMITTEE ON THE CLASSIFICATION OF LUVISOLIC SOILS

P. C. Stobbe, Chairman

3. Luvisolic Order

Great Group	Subgroup	
3.1 Gray Brown Luvisol	3.11	Orthic Gray Brown Luvisol
	3.12	Brunisolic Gray Brown Luvisol
	3.13	Bisequa Gray Brown Luvisol
	3.1-/8	Gleyed Gray Brown Luvisol
	3.1-/9	Lithic Gray Brown Luvisol
3.2 Gray Wooded (Gray Luvisol)	3.21	Orthic Gray Wooded (Orthic Gray Luvisol)
	3.22	Dark Gray Wooded (Dark Gray Luvisol)
	3.2-/3	Brunisolic Gray Wooded (Brunisolic Gray Luvisol)
	3.2-/4	Bisequa Gray Wooded (Bisequa Gray Luvisol)
	3.21-2.23 3.22-2.23	Solodic Gray Wooded (Solodic Gray Luvisol)
	3.2-/8	Gleyed Gray Wooded (Gleyed Gray Luvisol)
	3.2-/9	Lithic Gray Wooded (Lithic Gray Luvisol)

3. Luvisolic Order

The Luvisolic Order consists of well and imperfectly drained soils that have developed under deciduous, mixed deciduous-coniferous or boreal forests, or under mixed forest in the forest-grassland transition zones in moderate and cool climates. The parent materials are generally neutral to alkaline in reaction.

These soils have eluvial (Ae) horizons and illuvial textural B horizons in which silicate clay is the main accumulation product and which meet the requirements of a Bt horizon as defined. Slight accumulations of $CaCO_3$ may occur under the B horizon, but these seldom meet the requirements of a Cca horizon.

Under virgin conditions the soils have L-H or Ah horizons overlying prominent Ae horizons. Ah horizons, where present, are generally neutral, whereas the Ae and Bt horizons may vary from slightly to moderately acid in reaction.

Under cultivated conditions, the Ap horizon, 6 inches (15 cm) thick, may vary considerably in organic matter and color (dry values 3 or higher) depending on whether the Ap consists of Ah, Ae, or a mixture of these with the Bt horizon. In general, the Ap does not meet the requirements of a Chernozemic Ap horizon. Where it does meet these requirements, it is underlain by a light-colored Ae horizon. In some cases, where the Ah and Ae are thin, the Ap is underlain by the Bt horizon.

3.1 Gray Brown Luvisol

These soils have dark-colored forest-mull type of surface horizons (Ah) more than 2 inches (5 cm) thick, lighter-colored eluvial horizons (Ae), and illuvial horizons in which clay is the main product of accumulation (Bt). The soils have developed on basic or calcareous parent materials and the solum has a high degree of base saturation (by neutral salt extraction).

Under undisturbed conditions, the soils may have thin L, F, and H horizons, but due to high biological activity and the abundance of earthworms the leaf litter is usually quickly incorporated into the soil and humified. A transitional AB or BA horizon having gray coatings on structural aggregates is generally present, particularly in medium- and fine-textured soils. Although the Bt horizons is generally immediately underlain by calcareous materials, a transitional BC horizon, free of lime, may be present. These transitional horizons are not diagnostic for the group. An increase of dithionite-extractable Fe and small increases of organic matter are usually associated with the accumulation of clay, but there are no significant increases in oxalate-extractable Fe and Al.

Under cultivated conditions, the Ah and often part of the Ae are mixed to form an Ap, but the Bt and some of the Ae usually remain intact under the Ap, unless cultivation greatly exceeds 6 inches (15 cm) in depth.

The Gray Brown Luvisols have developed under deciduous or mixed-forest vegetation and in a moderate climate, generally having a mean annual temperature of more than 43 F (5.5 C).

The soils of this group differ from the Degraded Melanic Brunisols in which Ae and B development is weak and the B horizon does not meet the requirements of Bt. They differ from the Dark Gray Luvisols, which have developed in a cool climate, mainly in the nature of the Ah horizons. Whereas the Gray Brown Luvisols have a forest-mull type of Ah, with well-developed granular structure (texture permitting), the Dark Gray Luvisols have a degraded chernozemic-like Ah, as evidenced by gray streaks and splotches, which lacks strongly developed granular structure and may be platy.

The subgroups of the Gray Brown Luvisolic Great Group are established on the basis of the profile development above the Bt horizon and on the evidence of gleying in the solum.

3.11 Orthic Gray Brown Luvisol Profile type: (L-H), <u>Ah</u>, <u>Ae</u>, (AB), (BA), <u>Bt</u>, (BC), (Ck), (C)

These soils have the general characteristics of the great group and have well-developed Ah, Ae, and Bt horizons. The Ae is light-colored, with values of 4.5 or higher and with chromas of 3.0 or less; the difference in chroma between the upper and lower Ae is less than 1. The Ae is underlain directly by a blocky Bt with clay skins or by a BA horizon in which the blocky aggregates have gray coatings and tend to disintegrate. Faint mottling may occur just above the Bt or in the lower part of the B horizon.

The cultivated soil usually has a color value between 3.5 and 5.5 dry and a chroma of 3.0 or less. The color value may vary considerably with the thickness of the original Ah, and with management practices.

3.12 Brunisolic Gray Brown Luvisol Profile type: (L-H), <u>Ah</u>, <u>Ae1</u> or <u>Bm</u>, or (Bf, Bm), (Ae2), (AB), Bt, (BC), (Ck), (C)

These soils have the general characteristics of the great group and have well-developed Ah, Ae, and Bt horizons. The upper Ae (Ae1) is brown, with chromas of 3.0 or more, and grades to a light-colored lower Ae (Ae2). The difference in chroma between the upper and lower Ae is 1 or more.

Two kinds of profiles may develop in the A horizon: (i) a thin Melanic Brunisol having Ah, Bm, "C" (or Ae2), or Ah, Bm horizons in which the Bm can be recognized under an Ap, and (ii) a mini Humo-Ferric Podzol having Ah, (Ae), Bf (or Bfh), "C" (or Ae2) horizons, but in which the Bf (or Bfh) horizons do not extend below the Ap.

The Ae1 (Bm) or (Bf if present) is generally friable and granular, whereas the Ae2 or "C" is often platy and friable when moist, but it may be hard and often vesicular when dry. The lower Ae often has a diffuse and irregular lower boundary with an AB or BA horizon. Faint mottling may occur in the lower Ae or just above the Bt.

This subgroup represents the early stages of podzolic development in the Ae horizon of the Gray Brown Luvisols. The degree of base saturation of the upper solum is more typical of the Gray Brown Luvisols than of the Podzols.

The cultivated surface usually has color values similar to those of the Orthic subgroup, but the chroma may be slightly higher on similar parent materials.

3.13 Bisequa Gray Brown Luvisol Profile type: (L-H), Ah, (Ae), Bfh or Bf, (Ae2 or "C"), Bt, (BC), (Ck), (C)

These are soils with the same general characteristics as the Orthic subgroup (Ah, Ae, Bt), but in which a podzolic sequence of horizons, Ae, Bfh or Bf, "C" (or Ae2), has developed in the Ae of the Gray Brown Luvisol and is underlain by a continuous Bt horizon at a depth of 18 inches (45 cm) or less. The Bfh or Bf as defined must extend below the plow layer or 6 inches (15 cm). Where the upper podzolic sequence does not meet these requirements, the soil should be classified as a Brunisolic Gray Brown Luvisol.

These soils differ from the Bisequa Gray Wooded (Gray Luvisols) in that the latter lack a mull Ah or if present it is less than 2 inches (5 cm) thick.

Under cultivated conditions the Ap is underlain by Bfh or Bf horizons. The Ap usually has color values similar to those of the Orthic subgroup, but the chroma may be slightly higher on similar parent materials.

3.1-/8 Gleyed Gray Brown Luvisol Profile type: Ah, Aegj, Btgj, (Ck), (C); (L-H), Ah, Bmgj or Bfgj, (ABgj), Btgj, (Ck), (C)

These soils have the general characteristics of the above subgroups. Due to periodic wetness in the Ae or Bt horizons, or both, the soils are also mottled and commonly have duller colors than the associated well-drained soils. However, they lack the low chromas and prominent mottling associated with the Gleysolic soils.

The Gleyed Gray Brown Luvisols generally have thicker and darker Ah horizons than the well-drained subgroups on similar parent materials. The color and textural differences between the Ae and Bt are generally less marked in the gleyed than in the well-drained subgroups.

Peaty or mucky phases, having less than 16 inches (40 cm) of mixed peat (bulk density > 0.1) or up to 24 inches (60 cm) of fibric moss peat (bulk density < 0.1) over the Ah horizon, may occur in the gleyed subgroups.

Under cultivated conditions the Ap of the gleyed subgroups is generally darker than that of the orthic subgroups (dry color values may be as low as 2.0). The Ap is generally underlain by gleyed Ae or Bt horizons or both.

3.1-/9 Lithic Gray Brown Luvisol

These soils have the general characteristics of the above subgroups and a lithic contact within 20 inches (50 cm) of the surface.

3.2 Gray Wooded (Gray Luvisol)

These are soils with organic surface horizons (L-H), light-colored illuvial horizons (Ae), and illuvial horizons in which clay is the main accumulation product (Bt). A soil may have a degraded chernozem-like Ah or an Ahe horizon as evidenced by gray streaks and splotches and often by a platy structure. An AB or BA horizon having gray coatings on the structural aggregates is often present. An increase in dithionite-extractable Fe and small increases in organic matter are often associated with the accumulation of clay, but there are no significant increases in oxalate-extractable Fe and Al. The solum generally is slightly to moderately acid, but the degree of base saturation, based on neutral salt extraction, is generally high. The parent materials are usually neutral to slightly alkaline, and they are commonly calcareous. Some of the soils in this great group were formerly classified as Textural Podzols.

Under cultivated conditions, the Ap may consist largely of Ah material, Ae material, or mixed Ah and Ae material. Occasionally it may also contain Bt material. The organic matter content and color of the Ap may therefore vary considerably. The color value of an Ap 6 inches (15 cm) thick when dry may range from 3.5 to 5.5 or more. The Ap is underlain by remnants of Ae or by Bt.

The Gray Wooded (Gray Luvisol) soils have developed in moderately cool climates and under boreal forest or mixed forest in the grassland-forest transition zone, generally on basic materials.

3.21 Orthic Gray Wooded (Orthic Gray Luvisol) Profile type: <u>L-H</u>, (Ah or Ahe), <u>Ae</u>, (AB), <u>Bt</u>, (Cca), (Ck), (C)

These soils have the general characteristics of the great group, and have organic surface horizons (L-H), light-colored Ae, and Bt horizons. An Ah, if present, is less than 2 inches (5 cm) thick. The lower part of the Ae may be slightly mottled and often overlies an AB or BA horizon. The Ae has a dry color value of 5.5 or higher and usually a chroma of less than 3.0 although some higher chromas may be associated with some parent materials.

The cultivated surface soils, Ap 6 inches (15 cm) thick, have a dry color value of 5.0 or higher and are underlain by remnants of Ae or by Bt. Where the total thickness of Ah and Ae is less than 6 inches (15 cm) and substantial amounts of the Bt have been incorporated into the Ap, the Ap may be slightly darker in value than 5.0 dry, due to the darker color of the Bt. In such cases, fragments of the Bt should be clearly identifiable in the Ap.

3.22 Dark Gray Wooded (Dark Gray Luvisol) Profile type: (L-H), Ah or Ahe, Ae, Bt (Cca), Ck, (C)

These soils have the general characteristics of the great group, and have organic surface horizons (L-H), Ah or Ahe horizons or both more than 2 inches (5 cm) thick, prominent Ae horizons more than 2.5 inches (6 cm) thick, and Bt horizons as defined. The total thickness of the Ah and Ae is greater than 6 inches (15 cm).

The Ah or Ahe horizons, or both, show definite signs of degradation as evidenced by gray streaks or splotches when the soil is dry. They may have a platy or weak, fine granular structure and represent a degraded chernozemic Ah horizon. They differ from the forest-mull type of Ah, which generally has a well-developed granular structure with more intimate association of organic and mineral constituents brought about by more active biological activity.

Under cultivated conditions, the Ap is 6 inches (15 cm) thick, and has a dry color value lighter than 3.5 and darker than 5.0, but may be darker than 3.5 when moist. The range in color value of the Ap is the same as in the Dark Gray Chernozemic and Dark Gray Wooded (Dark Gray Luvisol), but the Ap of the former is not underlain by a distinct Ae. The Ap of the Dark Gray Wooded Great Group (Dark Gray Luvisol) is underlain by an Ae over Bt.

These soils represent an intergrade between the Dark Gray Chernozemic and the Orthic Gray Wooded (Orthic Gray Luvisol) soils and lie in the forest-grassland transition zone.

3.2-/3 Brunisolic Gray Wooded (Brunisolic Gray Luvisol) Profile types: L-H, (Ah), Ael or Bm or (Bf, Bm), (Ae2 or "C"), (AB), Bt, (Ck), (C)

(L-H), Ah or Ahe, Ael or Bm or (Bf, Bm), (Ae2 or "C"), (AB), Bt, (Ck), (C)

These soils have the general characteristics of the great group and have L-H or Ah horizons over Ae and Bt horizons. The upper Ael is brown, with chromas of 3.0 or more, and usually grades to a light-colored lower Ae2. Two kinds of profiles may develop in the A horizon: (i) those having L-H or Ah, Bm, "C" (or Ae2) horizons, and (ii) those having L-H, (Ah), Bfh or Bf, or both, "C" (or Ae2) horizons. The Bm horizon should be thick enough to be recognizable under an Ap, but the Bf horizon should not extend below the plow depth. The Bm or Bf (or Bfh) horizons are underlain by an Ae or a Bt horizon or both.

The upper Ae1 (Bm, or Bf if present) is generally friable and granular with a chroma of 3.0 or more, whereas the lower Ae2 or "C", if present, is often platy and friable when moist, but may be hard and often vesicular when dry. The lower Ae often has an irregular diffuse boundary with an AB or BA horizon, which often has gray coatings on the structural aggregates. Faint mottling may occur in the lower Ae or "C".

This subgroup represents early stanges of podzolic development in the Ae horizons of the Luvisols. The degree of base saturation in the upper solum is more typical of the Luvisols than of the Podzols.

The cultivated surface soil usually has color values similar to those of the 3.21 and 3.22 subgroups, but the chroma may be slightly higher on similar materials. The Ap is underlain by Bm, which in turn may be underlain by "C" (Ae2) and by the Bt horizon.

The Brunisolic subgroup may be intergraded with the Orthic Gray Wooded (Gray Luvisol) 3.21/3 or with the Dark Gray Wooded (Dark Gray Luvisols) 3:22/3.

3.2-/4 Bisequa Gray Wooded (Bisequa Gray Luvisol) Profile type: <u>L-H</u>, (Ah), (Ae), <u>Bfh</u> or <u>Bf</u>, (Ae2 or "C"), (AB), (ABt), <u>Bt</u>, (Ck), (C)

These are soils with the same general characteristics as 3.21 or 3.22 (L-H or Ah, or both, Ae, Bt), but in which a podzolic sequence of horizons (Ae, Bfh, or Bf or both) has developed in the Ae of the Gray Wooded (Gray Luvisols) and is underlain at a depth of 18 inches (45 cm) or less by a continuous Bt horizon. A further limitation is that the Bfh or Bf horizon, as defined, must extend below the plow layer or below 6 inches (15 cm). When the upper podzolic sequence does not meet the above limitations, the soil should be classified as a Brunisolic Gray Wooded (Brunisolic Gray Luvisol).

The Bisequa profiles are most commonly intergraded with the Orthic Gray Wooded Subgroup 3.21/4. This subgroup has essentially the same profile characteristics as 3.13. The climatic differences and geographic distribution may help to separate these soils. This subgroup is seldom intergraded with the Dark Gray Wooded (Dark Gray Luvisols) 3.22/4.

Under cultivated conditions, the Ap is underlain by a Bfh or Bf horizon. The Ap usually has color values similar to those of the Orthic Gray Wooded or Dark Gray Wooded subgroups, but the chroma may be slightly higher on similar materials.

3.21 - 2.23 Solodic Gray Wooded (Solodic Gray Luvisol) Profile types: <u>L-H</u>,
3.22 - 2.23 <u>Ah</u> or <u>Ahe</u>, <u>Ae</u>, (AB), <u>Btnj</u>, (Cca), (Csk), (C)

<u>L-H</u>, (Ah) or (Ahe), <u>Ae</u>, (AB), <u>Btnj</u>, (Cca), (Csk), (C)

These soils have the general characteristics of the great group, but have hard, prismatic, or blocky structural Btnj horizons with pronounced dark coatings instead of the Bt horizons characteristic of the great group.

These soils resemble the Solod structurally, but they contain somewhat less exchangeable Na than is required for Bn horizons of Solonetz soils. They may be considered as intergrades between the Dark Gray Wooded and Orthic Gray Wooded soils and the Solod.

3.2-/8 Gleyed Gray Wooded (Gleyed Gray Luvisol) Profile types: L-H, (Ah), Aegj, (ABgj), Btgj, (Btg)(BCg)(Cg), (Ck), (C)
(L-H), Ah or Ahe, Ael or Bmgj, (Ae2gj), (ABgj), Btgj, (Ck), (C)

These are soils with the same type of profile as any of the above subgroups, but due to periodic wetness and reducing conditions in the Ae and Bt horizons are mottled and commonly have duller colors than the associated well-drained soils.

The Gleyed Gray Luvisols generally have thicker L-H horizons than the well-drained subgroups. Peaty or mucky phases, with less than 16 inches (40 cm) of mixed peat (bulk density > 0.1) or up to 24 inches (60 cm) of fibric moss peat (bulk density < 0.1) on the surface of the mineral soil, may occur. They often have thicker Ae and stronger-developed Bt horizons in depressions, on reasonably permeable materials, than the associated well-drained soils in the forest-grassland transition zone. In more humid regions, on level land, particularly on less permeable materials, the gleyed members may have weaker-developed Ae and Bt horizons than the associated well-drained soils. They differ from the Low Humic Eluviated Gleysols in that the latter have developed under greater extremes of wetness and usually have matrix colors of lower chroma, or more prominent mottling in the upper 20 inches (50 cm) or both.

Specific profiles may be designated as 3.21/8, 3.23/8, etc.

3.2-/9 Lithic Gray Wooded (Lithic Gray Luvisol)

These soils have the general characteristics of the above subgroups but also a lithic contact within 20 inches (50 cm) of the surface.

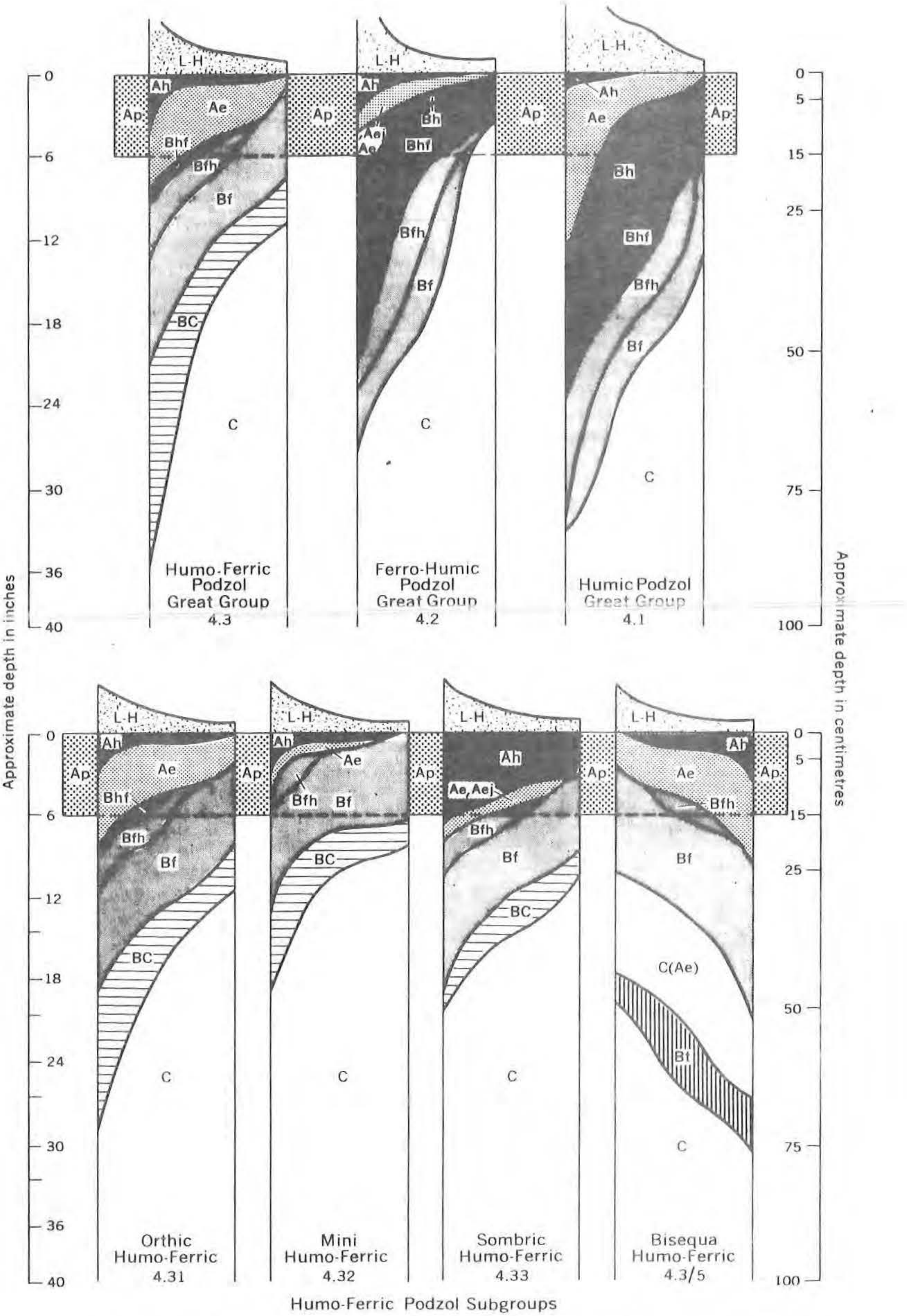

Fig. 16 A diagrammatic horizon pattern of representative Podzolic profiles. SRI

REPORT OF THE SUBCOMMITTEE ON THE CLASSIFICATION OF PODZOLIC SOILS

P. C. Stobbe, Chairman

4. Podzolic Order

Great Group		Subgroup
4.1 Humic Podzol	4.11	Orthic Humic Podzol
	4.14	Placic Humic Podzol
	4.1-/8	Gleyed Humic Podzol
	4.1-/9	Lithic Humic Podzol
4.2 Ferro-Humic Podzol	4.21	Orthic Ferro-Humic Podzol
	4.22	Mini Ferro-Humic Podzol
	4.23	Sombric Ferro-Humic Podzol
	4.2-/4	Placic Ferro-Humic Podzol
	4.2-/8	Gleyed Ferro-Humic Podzol
	4.2-/9	Lithic Ferro-Humic Podzol
4.3 Humo-Ferric Podzol	4.31	Orthic Humo-Ferric Podzol
	4.32	Mini Humo-Ferric Podzol
	4.33	Sombric Humo-Ferric Podzol
	4.3-/4	Placic Humo-Ferric Podzol
	4.3-/5	Bisequa Humo-Ferric Podzol
	4.3-/7	Cryic Humo-Ferric Podzol
	4.3-/8	Gleyed Humo-Ferric Podzol
	4.3-/9	Lithic Humo-Ferric Podzol

4. Podzolic Order

Podzolic soils are well and imperfectly drained soils that have developed under coniferous and mixed-forest vegetation and heath, mostly in cold and temperate climates and on acid parent materials.

These soils have podzolic B horizons,[1] in which the characteristic accumulation products are organic matter (dominantly fulvic acid) combined in varying degrees with Fe and Al. These amorphous materials form coatings on sand, silt-sized particles, or fine pellets. The lowest values, reddest hues, or highest chromas occur in the upper part of the B horizon. The soils are acid (usually pH < 5.5) and have a high pH-dependent cation exchange capacity (usually > 8 meq/100 g) in the B horizon.

Under virgin conditions, the soils have organic surface horizons (L-H), dominantly of a mor or moder type. They may or may not have an Ah horizon below the organic surface layer. Generally, they have eluviated, light-colored horizons (Ae), but these may be indistinct or absent.

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[1] A podzolic B horizon consists of one or more Bh, Bhf, Bfh, or Bf horizons. By definition this horizon is similar to the spodic B horizon in the American System.

Under cultivated conditions, the Ap horizon is usually underlain by remnants of the Ae and a podzolic B horizon. If the Ae and podzolic B horizons are incorporated in the Ap, the Ap must have (a) more than 3% organic matter (1.7% C), (b) Δ (Fe + Al) greater than 0.8%, and (c) hues redder than 10YR and moist color values less than 3.0, or chromas of 3.0 or more in hues of 10YR or redder.

The Podzolic Order is divided into the Humic, Ferro-Humic, and Humo-Ferric great groups based on the dominance of the Bh, Bhf, or Bfh (or Bf) horizons as defined.

4.1 Humic Podzol

These soils have dark-colored (values and chromas usually < 3.0 moist) illuvial Bh horizons at least 4 inches (10 cm) thick in which organic matter is the main accumulation product. The upper B horizon (Bh) contains more than 2% organic matter but very little or no free Fe; it usually contains extractable Al; it does not turn redder on ignition; and the ratio of organic matter to free Fe is 20 or more. The Bh horizon may be underlain by Bhf, Bfh, or Bf horizons. A thin, or a series of very thin (total thickness <1 inch) involute, impervious, hard, and dark reddish-brown hardpans (placic horizons) may occur in the solum.

Under virgin conditions, the soil has thick, mor-type surface horizons (L, F, H) that are underlain by light-colored eluviated horizons (Ae), or by eluviated horizons that are stained with infiltrated humic materials, or by Bh horizons. The Bh horizons may be underlain by Bhf, Bfh, or Bf horizons that contain appreciable amounts of free Fe and Al as well as organic mattter. They may vary from soft and friable to firm or very hard in consistence and may be strongly mottled.

The Humic Podzols have developed under heath, under forest with heath and sphagnum undercover, or under western coastal forest. Consequently, the L-H horizons are generally thick and peaty. These soils occur in moist coastal regions, in cool moist locations at high altitudes inland, and locally in some peaty depressions in warmer or less moist regions. These soils have formed on materials originally low in Fe or on materials that have been strongly leached and have most of the free Fe removed (Bh horizons developed in deeply leached Ae horizons).

4.11 Orthic Humic Podzol Profile type: <u>L</u>, <u>F</u>, <u>H</u>, <u>Ae</u>, <u>Bh</u>, (Bhf), (Bfh), (Bf), (C)

These soils have the general characteristics of the great group including L-H, Ae, and Bh horizons, but lack a placic horizon. The Bh horizon generally contains more than 2% organic matter and less than 0.35% of oxalate-extractable Fe and does not turn redder on ignition. It generally contains free Al. The Bh may or may not be underlain by a Bhf, Bfh, or Bf horizon.

4.14 Placic Humic Podzol Profile type: <u>L</u>, <u>F</u>, <u>H</u>, <u>Ae</u>, <u>Bh</u>, (Bhf), <u>Bhfc</u> or <u>Bfc</u>, (Bf), (C)

These soils have the general characteristics of the great group, but have a thin placic horizon usually less than 1 inch (2.5 cm) thick. The placic horizon consists of a single band, or a series of very thin (generally $<1/8$ inch) bands that are irregular or involute, hard, impervious, often vitreous, and dark reddish-brown in color. These horizons (pans) are apparently cemented by organic matter (mainly fulvic acid) and free Fe; free Fe; or free Fe and Mn. In the soils studied so far the carbon content is 1-12%, Fe 5-20%, and Mn 0-15%. The pan may occur in any part of the B horizon, except the Bh, and often extends into the C horizon.

Owing to the impermeability of the pan, some gleying generally occurs just above it, particularly in the troughs of the involute pans, but the soil may be well drained below the pan. The wavy nature of the pan causes a substantial variation in the moisture regime of the overlying profiles. Orthic Humic Podzols, and Gleyed Humic Podzols occur on the lower slopes and troughs. In extreme cases Gleysols with a peaty surface may occur over the deeper troughs of the pan.

4.1-/8 Gleyed Humic Podzol Profile type: L, F, H, Aegj, Bhgj, (Bhfgj), (Bfhgj), (Bfgj), (Bhfc), (C)

These soils have the general characteristics of the above subgroups and indications of wetness in the upper part of the solum. Iron mottling, indicative of reducing conditions, is not noticeable in the Ae and Bh horizons, but occurs in the underlying Bhf, Bfh, or Bf horizons. The Bh horizons are often splotched black and gray; they may have diffuse upper and lower boundaries depending on the alternating water table.

4.1-/9 Lithic Humic Podzol

These soils have the general characteristics of the above subgroups, but have also a lithic contact within 20 inches (50 cm) of the surface.

4.2 Ferro-Humic Podzol

These are soils with podzolic B horizons in which organic matter, Fe, and Al are the main accumulation products. Under undisturbed conditions, they have mineral-organic surface horizons (L-H or Ah) usually underlain by eluviated light-colored horizons (Ae). In some cases the Ae may be thin, indistinct, or missing. The upper 4 inches (10 cm) of the B horizon contains more than 10% organic matter and the oxalate-extractable Fe + Al exceeds that of the C horizon by 0.8% or more. The ratio of organic matter to oxalate-extractable Fe in the B horizon is less than 20. A Bh horizon less than 4 inches (10 cm) thick may overlie the Bhf horizon or the Bhf may directly underlie the Ah or Ae horizon. The Bhf may be underlain by Bfh or Bf horizons.

The solum is acid (usually $pH < 5.5$) and has a low degree of base saturation based on permanent charge. The B horizon has a high pH-dependent charge. A thin, or a series of very thin, involute, impervous, hard, dark reddish-brown hardpan (placic horizon) may occur in the B horizon. The B horizon may be underlain by a placic horizon, a textural B horizon, or permafrost.

The Ferro-Humic Podzols have developed mainly under a coniferous or mixed-forest vegetation in cold and temperature climates. The parent materials are usually less leached or richer in Fe than those from which the Humic Podzols develop in a similar climate. There is evidence that some of the Ferro-Humic Podzols developed under oak forests with an understory of grasses and ferns.

4.21 Orthic Ferro-Humic Podzol Profile type: L, F, H, Ae, (Bh), Bhf, (Bfh), (Bf), (C)

These soils have podzolic B horizons that are dark colored (moist value and chromas usually 3.0 or less) in the upper part, are 4 inches (10 cm) or more thick, and contain more than 10% organic matter, and in which Δ(Fe + Al) is greater than 0.8% and the ratio of organic matter to oxalate-extractable Fe is less than 20.

Under undisturbed conditions, these soils have thick organic surface horizons (L, F, H) of the mor type, underlain by light-colored Ae horizons more than 1 inch thick. They may have a Bh horizon less than 4 inches (10 cm) thick that grades into the Bhf that in turn may be underlain by Bfh or Bf horizons or both.

The Bhf horizon may contain more clay than the Ae or C horizons, but the clay is not oriented and does not form clay skins. The most prominent accumulation of clay occurs just below the Ae in the horizon of greatest organic matter and sesquioxide accumulation.

The B horizons may be friable, firm, or cemented, and they may be underlain by a fragipan. There is no thin hardpan (placic horizon).

Although the soils generally are not cultivated, when cultivated the Ap may vary considerably. Where the Ae is rather thin and the Ap consists largely of a mixture of the organic surface layers or contains a considerable admixture with Bhf horizon, the Ap may be dark. Where the Ap consists mainly of Ae material, it may be light colored. Generally clean, white, bleached mineral grains are clearly visible in the Ap.

The Orthic Ferro-Humic Podzols have developed under heath, under forest with heath-type undercover, or under western coastal forest.

4.22 Mini Ferro-Humic Podzol Profile type: L, F, H, (Ae), Bhf, (Bfh), (Bf), (C)

These soils have the general characteristics of 4.21, but have a thin Ae ($<$1 inch) or lack a visible Ae horizon. Thin ($<$3 inches) Ah horizons may be present.

Under cultivation the Ap is dark (moist value and chromas of 3.0 or less). Clean bleached sand grains are rare, but amorphous coatings and pellets may be plentiful.

4.23 Sombric Ferro-Humic Podzol Profile type: (L-H), Ah, (Aej), Bhf, (Bfh), (Bf),(C)

These are soils with L-H, Ah, and podzolic Bhf horizons, but without distinct eluviated Ae horizons. The podzolic B horizon has oxalate-extractable Δ (Fe + Al) greater than 0.8% and the upper 4 inches (10 cm) of the B horizon (Bhf) contains more than 10% organic matter. The pH (0.01 M $CaCl_2$) is less than 5.5 and the pH-dependent charge is high ($>$0.8 meg/100 g). The base saturation (NaCl) is 90-100%. The chroma is 3.0 or higher and the difference in chroma between the B and C is 1 or more.

Under undisturbed conditions, the soils have thin organic surface horizons (L-H) of mor or moder type and a sombric (umbric) Ah horizon more than 3 inches thick with a value less than 3.5 moist and less than 4.5 dry and chromas less than 2.0 moist and dry. The pH ($CaCl_2$) is generally less than 5.5 and the base saturation (acetate) is low. The free Fe content is moderately high.

A distinct Ae horizon is generally lacking and the only evidence of eluviation is the clean mineral grains (salt and pepper) over the Bhf horizon. Usually the Ah-Bhf boundary is gradual. The Bhf horizon generally grades through Bfh or Bf horizons to the acidic C horizon. The soils lack thin (placic) hardpans, but they may be underlain by fragipans.

Under cultivated conditions, the Ap horizon 6 inches (15 cm) thick has a value of less than 3.5 moist and less than 4.5 dry. When the Ap is underlain by remnants of Ah, the chroma is less than 2.0, but if a substantial amount of B material is incorporated into the Ap, the chroma may be 2.0 or 2.5. The Ap is underlain by remnants of Ah or by podzolic B horizons.

There is evidence that these soils have developed under grass and fern vegetation having a canopy of oak trees and that this vegetation has been or is being replaced by coniferous vegetation and shrubs. These soils occur mainly in the coastal areas of British Columbia where the mean annual temperature is above 47 F (8 C) and the annual precipitation varies from 27 to 45 inches, of which only 1.1 to 2.2 inches falls during July and August. These soils are not common in Eastern Canada.

4.2-/4 Placic Ferro-Humic Podzol Profile type: L, F, H, (Ae), (Bh), Bhf, Bhfc or Bfc, (C)

These soils have the general profile characteristics of 4.21 and 4.22 and a placic horizon as described in 4.14. This horizon may occur in any of the B horizons and may extend into the C horizon.

4.2-/8 Gleyed Ferro-Humic Podzol Profile type: L, F, H, or Ah, (Aegj), Bhfgj, (Bfhgj), (Bfgj), (C)

These soils have the general characteristics of the above subgroups, but have indications of wetness and reducing conditions (mottling and dull colors) in the upper part of the solum. The Bhf horizons may be splotched black and gray and the upper and lower boundaries are often diffuse depending on the alternating water table. Iron mottling is generally distinct in the lower B horizons, but may be faint in the Bhf horizons. Peaty or mucky phases having less than 16 inches (40 cm) of mixed peat (bulk density >0.1) or up to 24 inches (60 cm) of fibric moss peat (bulk density <0.1) on the surface may occur in the gleyed subgroups.

4.2-/9 Lithic Ferro-Humic Podzol

These soils have the general characteristics of the above subgroups and a lithic contact within 20 inches (50 cm) of the surface.

4.3 Humo-Ferric Podzol

These soils have podzolic B horizons in which organic matter, Fe, and Al are the main accumulation products. The upper 4 inches (10 cm) of the B horizon contains less than 10% organic matter and the oxalate-extractable Fe + Al exceeds that of the C horizon by 0.8% or more. The ratio of organic matter to oxalate-extractable Fe is less than 20.

Under undisturbed conditions, these soils have an organic surface horizon (L-H), usually of a mor or moder type. The L-H horizon is directly underlain by a mineral-organic Ah horizon, an Ae horizon, or a podzolic B horizon. The soils may or may not have a distinct eluviated bleached horizon (Ae). They may or may not have an Ah horizon.

Under cultivated conditions, the Ap or remnants of the Ae are underlain by a podzolic B horizon.

The Humo-Ferric Podzols have developed under mixed and coniferous-forest cover over a wide range of climatic conditions, but they are dominant on the well-drained sites in moist cool regions on coarse, noncalcareous materials, or on materials from which free lime has been removed.

4.31 Orthic Humo-Ferric Podzol   Profile type: L-H, Ae, (Bhf), Bfh or Bf, (C)

These soils have the general characteristics of the great group and L-H, Ae, and Bfh or Bf horizons.

Under virgin conditions, these soils have organic surface horizons (L, F, H) and eluviated light-colored horizons (Ae) more than 1 inch thick, which overlie Bfh or Bf horizons or both.

The podzolic B horizons generally have a chroma of 4.0 or more. A thin Bhf horizon may be present above the Bfh, but the average organic matter content of the upper 4 inches of a B horizon is less than 10%. In the Bfh and Bf horizons Δ(Fe + Al) is greater than 0.8% except for some soils with textures of loamy sand or coarser. The B may be friable, may contain concretionary structures, or may be cemented into ortstein. The Bfh horizon may contain more clay than the Ae or C horizons, but the clay is not oriented and does not form clay skins. The most prominent accumulation of clay occurs just below the Ae in the horizon containing the greatest organic matter and sesquioxide accumulation. Some mottling may occur in the lower B horizon, particularly if the latter is underlain by a fragipan. The B is not underlain by a thin hardpan, a textural B horizon, or permafrost.

Under cultivated conditions, the organic surface, the Ae, and the upper B horizons may be mixed. The Ap horizon is underlain by remnants of Ae or by Bfh or Bf horizons or both.

4.32 Mini Humo-Ferric Podzol   Profile type: L, F, H, (Ah), (Ae), Bfh or Bf, (C)

These soils have the general characteristics of the great group except that under undisturbed conditions the eluviated horizon (Ae) is thin (generally $<$ 1 inch), discontinuous, indistinct (salt and pepper), or missing. The B horizons have a chroma of 4.0 or more in hues of 10YR or redder and they have Δ(Fe + Al) greater than 0.8%, except in loamy sands or soils with coarser textures. Thin ($<$ 3 inch) Ah horizons may be present.

Under cultivated conditions, the Ap horizon (6 inches [15 cm] thick) generally contains substantial amounts of Bfh or Bh horizons or both. If it is not underlain by a diagnostic podzolic B horizon, the Ap should contain more than 3% organic matter, have Δ(Fe + Al) greater than 0.8%, and have color values less than 3.0 moist in hues redder than 10YR, or chromas of 3.0 or more in hues of 10YR or redder.

4.33 Sombric Humo-Ferric Podzol Profile type: (L-H), Ah, Bfh or Bf (C)

These are soils with L-H, Ah, and podzolic Bfh or Bf horizons or both containing less than 10% organic matter in the upper 4 inches (10 cm) and oxalate-extractable Δ (Fe + Al) greater than 0.8%. The pH (0.01 M $CaCl_2$) is less than 5.5 and the degree of base saturation (NaCl) is 90-100%. The pH-dependent charge is high (> 8 meg/100 g). The chroma is 3.0 or more, moist or dry, and the difference in chroma between the B and the C is 1 or more.

Under undisturbed conditions these soils have thin L, F, and H horizons over dark-colored mineral-organic horizons (Ah) 3 inches or more thick, underlain by Bfh or Bf horizons or both. The Ah horizon has a color value less than 3.5 moist and 4.5 dry and a chroma of less than 2 moist or dry. One of these soils contains at least 1% organic matter, has a base saturation (NaCl) of 80-100%, and has a pH (0.01 M $CaCl_2$) less than 5.5. A continuous Ae horizon is generally lacking or there is evidence of eluviation in the form of clean mineral grains (salt and pepper) over the Bfh or Bf horizon. These soils lack placic horizons, but may be underlain by fragipans.

Under cultivated conditions, the Ap horizon (6 inches [15 cm] thick) has a color value less than 3.5 moist and less than 4.5 dry and a chroma of less than 2.0. If considerable B horizon is incorporated into the Ap, the chroma may be 2.0 or 2.5. The Ap is underlain by remnants of Ah or by podzolic B horizons.

These soils occur in parts of Eastern Canada where the mean annual temperature is often below 42 F (5.5 C) and the precipitation averages about 40 inches annually, well distributed throughout the year. Here they occur mainly under deciduous trees and the development of the Ah horizons is attributed to the incorporation of the L-H horizons by earthworms into the upper part of the mineral sola of the Podzols.

4.3-/4 Placic Humo-Ferric Podzol Profile type: L-H, Ae, Bfh or Bf, Bc, (C)

These soils have the general characteristics of 4.31, but have a placic horizon as defined in 4.14. This horizon may occur in any of the B horizons and extend into the C horizon. This pan occurs less often in the Humo-Ferric Podzols than in the Ferro-Humic Podzols.

4.3-/5 Bisequa Humo-Ferric Podzol Profile type: L-H, (Ae), Bfh or Bf (Ae2 or "C"), Bt, (C)

These are soils with the general characteristics of 4.31 and 4.32, but the podzol sola are underlain by a textural (Bt) horizon at a depth of 18 inches (45 cm) or more. These Podzols have developed in the Ae horizons of Luvisols. The diagnostic Bfh, Bf, and Bt horizons should meet the requirements of the respective horizons as defined. The podzolic B horizon must extend below a depth of 6 inches (15 cm).

Soils in which the Bt horizon occurs at 18 inches (45 cm) or less and in which a podzol sequence that meets the above requirements, should be classified with the Bisequa Luvisols. Where the upper sequence does not meet the minimal requirements of the Podzol, as defined above, the soils should be classified with the Brunisolic Luvisols. Soils in which the textural B horizon shows enough evidence of degradation so that it does not meet the requirements of a Bt horizon as defined, or in which the Bt horizon is at such a depth that it does not influence the moisture regime of the upper 40 inches (1 m) of the soil, are classified in other subgroups of the Humo-Ferric Podzols.

4.3-/7 Cryic Humo-Ferric Podzol   Profile type: L-H, (Ae), Bfhz or Bfz, (Cz)

These soils have the general characteristics of 4.31 and 4.32, but have permafrost within 40 inches (100 cm) of the mineral surface. Most of the Cryic Podzols studied meet the requirements of Mini Humo-Ferric Podzols.

4.3-/8 Gleyed Humo-Ferric Podzol   Profile type: L, F, H, or Ah, (Aegj), Bfhgj or Bfgj, (C)

These are soils with the general characteristics of the above subgroups but with mottling and duller colors due to periodic wetness in the Ae or B horizons or both. The surface organic horizons are generally thicker in the gleyed subgroups than in the catenary well-drained subgroups. Peaty or mucky phases with less than 16 inches (40 cm) of mixed peat (bulk density > 0.1) or up to 24 inches (60 cm) of fibric moss peat (bulk density < 0.1) on the surface may occur in this subgroup.

4.3-/9 Lithic Humo-Ferric Podzol

These soils have the general characteristics of the above subgroups but also a lithic contact within 20 inches (50 cm) of the surface.

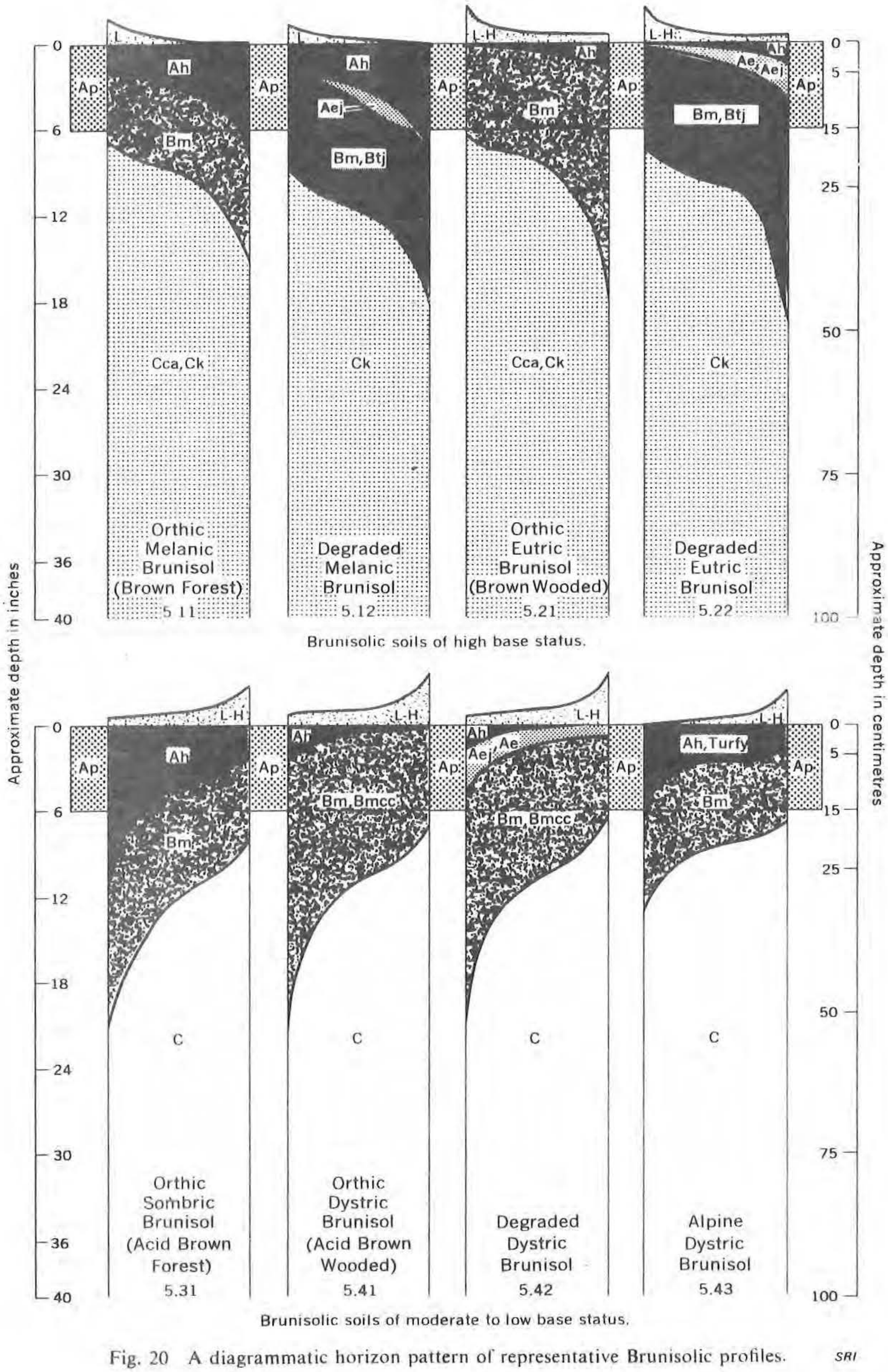

Fig. 20 A diagrammatic horizon pattern of representative Brunisolic profiles. SRI

REPORT OF THE SUBCOMMITTEE ON THE CLASSIFICATION OF BRUNISOLIC SOILS

Paul G. Lajoie, Chairman

5. Brunisolic Order

Great Group		Subgroup
5.1 Melanic Brunisol (Brown Forest)	5.11	Orthic Melanic Brunisol
	5.12	Degraded Melanic Brunisol
	5.1-/8	Gleyed Melanic Brunisol
	5.1-/9	Lithic Melanic Brunisol
5.2 Eutric Brunisol (Brown Wooded, Cutanic Podzo Regosol)	5.21	Orthic Eutric Brunisol
	5.22	Degraded Eutric Brunisol
	5.23	Alpine Eutric Brunisol
	5.2-/7	Cryic Eutric Brunisol
	5.2-/8	Gleyed Eutric Brunisol
	5.2-/9	Lithic Eutric Brunisol
5.3 Sombric Brunisol (Acid Brown Forest)	5.31	Orthic Sombric Brunisol
	5.31/8	Gleyed Sombric Brunisol
	5.31/9	Lithic Sombric Brunisol
5.4 Dystric Brunisol (Acid Brown Wooded, Concretionary Brown, Arenic Podzo Regosol, Alpine Brown)	5.41	Orthic Dystric Brunisol
	5.42	Degraded Dystric Brunisol
	5.43	Alpine Dystric Brunisol
	5.4-/7	Cryic Dystric Brunisol
	5.4-/8	Gleyed Dystric Brunisol
	5.4-/9	Lithic Dystric Brunisol

5. Brunisolic Order

This order consists of soils with brownish-colored sola indicative of good to imperfect drainage or of good to moderate oxidizing conditions, that have developed under forest, mixed forest and grass, grass and fern, or heath and tundra vegetation associations representative of forest, alpine, or tundra communities. Under virgin conditions, they may have organic surface horizons (L-H) and Ah horizons. They may also have weakly (salt and pepper Aej) or strongly (Ae) developed eluvial horizons. All have a brownish Bm, but none have a Bt (textural) or a podzolic B horizon.

5.1 Melanic Brunisol Great Group

These are Brunisolic soils that, under virgin conditions, generally lack F and H horizons, and have mineral-organic (Ah) surface horizons thicker than 2 inches (5 cm) developed primarily from the incorporation of plant residues into the soil through the action of soil fauna, principally earthworms. The Ah horizons have granular (mull) structure promoted by the intimate mixing of humus and clay.

The Melanic Brunisols have Bm horizons in which the base saturation (NaCl) is 100% and the oxalate-extractable Δ(Fe + Al) is less than 0.8%.

These soils may have weakly expressed Aej and Btj horizons, but the extent of illuviation is insufficient to meet the requirements of the Bt as defined.

The Melanic Brunisols occur mainly in the Great Lakes - St. Lawrence Lowlands where the M.A.T. is higher than 42 F (5.5 C). They have developed under climatic and biotic conditions similar to those of the Gray-Brown Luvisols.

5.11 Orthic Melanic Brunisol Profile type: (L), Ah or Ap, Bm, Ck, (Cca)

These are soils that, under virgin conditions, may have a thin L horizon and generally no F or H horizons, over a mull Ah that has fine- and medium-granular structure, and a Bm that commonly has a granular or blocky structure, or both, grading into larger units or weaker grades with depth. The Bm usually has colors in hues 10 YR and 7.5 YR with chromas of 3 or more. Between the B and C, there is usually a chroma difference of 1 or more, or a shift to more yellowish hues in the C with chroma similar to that of the B. The C horizon is calcareous.

Ap horizons 6 inches (15 cm) thick have color values less than 3.5 moist or 4.5 dry. The Ap is usually underlain by a Bm. If there are no remnants of Bm under the Ap, such cultivated soil should be classified with the Regosols.

Faint mottling may occur in the C or lower B horizons. (This subgroup includes the former 4.11 - Orthic Brown Forest.)

5.12 Degraded Melanic Brunisol Profile type: (L), Ah or Ap, (Aej), Bm, Btj, Ck

These are Melanic Brunisols that may have a weakly expressed eluvial horizon (Aej) under the Ah, and that have illuvial accumulations of clay (Btj - too thin or too weak to meet requirements of Bt) in some subhorizon of the Bm. (This subgroup includes the former 4.12 - Degraded Brown Forest.)

5.1-/8 Gleyed Melanic Brunisol

These are Melanic Brunisols with mottling and dull matrix colors in the B horizon. Under virgin conditions, there generally are L-H horizons on the surface. The Ah is usually thicker and darker in color and the Ap darker in color than in the associated well-drained soils. (This subgroup includes the former 4.1-/8 - Gleyed Brown Forest.)

5.1-/9 Lithic Melanic Brunisol

These are Melanic Brunisol soils with a lithic contact between 4 and 20 inches (10 and 50 cm) of the mineral surface.

5.2 Eutric Brunisol Great Group

These are Brunisolic soils that, under virgin conditions, have organic surface horizons (L-H), over Bm horizons in which the base saturation (NaCl) is 100% and the pH ($CaCl_2$) is usually 5.5 or higher.

These soils may have thin Ah horizons (<2 inches [5 cm]) under forest communities, or moderately thick Ah horizons under alpine vegetation and climate. They may have weakly expressed (Aej) or strongly expressed (Ae) eluvial horizons. They may also have horizons of illuviation that fail to meet the requirements of the Bt as defined. The parent material is usually calcareous.

The Orthic and Degraded Eutric Brunisols occur in the dry valleys in the dry valleys in the Cordillera and extend from the United States into the Yukon Territory. They occur also in the northern forested part of the Great Plains Region. In the valleys of the Cordillera, they are normally found in the dry forest areas, but in the forested Great Plains areas they are developing under climatic (M.A.A.T. 42 F [5.5 C]) and biotic conditions similar to those of the Gray Wooded soils (Gray Luvisols). The Alpine Eutric Brunisols occur in the Cordilleran region.

5.21 Orthic Eutric Brunisol Profile type: L-H or Ap, (Ah), Bm, Ck, (Cca)

These are soils that, under virgin conditions, have organic surface horizons (L-H), overlying Bm horizons that usually have a chroma of 3 or more. Between the B and C the chroma difference is greater than 1 or there is a shift to a more yellowish hue in the C. The parent materials are usually calcareous.

Ap horizons 6 inches (15 cm) thick have color values greater than 3.5 moist or 4.5 dry, and chromas are usually 3 or more when dry. The Ap is usually underlain by a Bm horizon. It there are no remnants of Bm under the Ap horizon, these cultivated soils should be classified as Regosols. (This subgroup includes the former 4.21 - Orthic Brown Wooded).

5.22 Degraded Eutric Brunisol Profile type: L-H or Ap, Aej or Ae, Bm or Btj, Ck

These are Eutric Brunisols that have either an Aej or Ae horizon and a Bm horizon. The Bm horizon may in some subhorizon contain illuvial clay (Btj) or some sesquioxides, but not enough to meet the requirements of Bt or Bf horizons. The Ap horizon may have low chroma if it consists mostly of Ae material. (This subgroup includes what was formerly called 4.22 - Degraded Brown Wooded, 5.21 - Arenic Podzo Regosol, and 5.22 - Cutanic Podzo Regosol.)

5.23 Alpine Eutric Brunisol Profile type: (L-H), Ah, Bm, C or Ck

These are Eutric Brunisols that have thin organic surface horizons (L-H) and moder Ah horizons derived mainly from the mechanical incorporation of humus into the mineral soil. The Ah horizons are turfy and fibrous in the upper part and are underlain by Bm horizons that have base saturation (NaCl) of 100% and pH ($CaCl_2$) generally above 5.5.

The soils are thought to exist in the alpine environment under very cool temperatures in the Cordillera. The parent materials are derived from calcareous or basic rocks. (This subgroup includes some of the former 4.6 - Alpine Brown.)

5.2-/7 Cryic Eutric Brunisol

These are Eutric Brunisols having within the control section (40 inches [100 cm]) a permanently frozen layer, or a layer in which the temperature is 0 C or lower two months after the summer solstice (August 21).

5.2-/8 Gleyed Eutric Brunisol

These are Eutric Brunisols with mottling and dull matrix colors in the B horizon. Under virgin conditions, the L-H horizons are thicker, and the Ap layer may be somewhat darker than in the associated well-drained soils.

5.2-/9 Lithic Eutric Brunisol

These are Eutric Brunisol soils with a lithic contact between 4 and 20 inches (10 and 50 cm) of the mineral surface.

5.3 Sombric Brunisol Great Group

These are Brunisolic soils that, under virgin conditions, have thin L-F horizons, and dark-colored Ah horizons more than 2 inches thick. These Ah horizons have developed primarily from the incorporation of plant residues into the soil by soil fauna, principally micro-arthropods and to a lesser extent earthworms. The humus and mineral fractions have been mechanically mixed (moder).

These soils have Bm horizons in which the base saturation (NaCl) is usually 65 to 100% and the pH ($CaCl_2$) usually about 5.5 or lower. The parent material is acidic.

The Sombric Brunisols occur mainly in the coastal area of British Columbia where winters are mild and the summers are cool and dry. Where these soils are found the M.A.T. is above 47 F (8.3 C), the annual precipitation is 27 to 45 inches, and the July and August precipitation is 1.1 to 2.2 inches.

The present native vegetation on these soils ranges from coniferous forest to grass and fern. However, there is clear evidence that these soils have developed under grass and fern vegetation with a canopy of oak trees and that now this vegetation is being replaced by coniferous trees and shrubs.

These soils occasionally occur in Eastern Canada under mixed deciduous and coniferous vegetation. Here the recent and rapid spreading of earthworms has caused the development of Ah horizons under cool (M.A.T. $<$42 F [5.5 C]) conditions.

5.31 Orthic Sombric Brunisol Profile type: (L-H), <u>Ah</u> or <u>Ap</u>, <u>Bm</u>, <u>C</u>

These are Sombric Brunisols with dark grayish brown to black Ah horizons over brown to yellowish-brown Bm horizons. The C horizons are acidic and may be mottled.

The Ap horizons 6 inches (15 cm) thick have color values less than 3.5 moist or 4.5 dry. The Ap horizon is usually underlain by remnants of Ah and by a Bm horizon. If there are no remnants of a Bm under the Ap, these cultivated soils should be classified as Regosols. (This subgroup includes the remainder of the former 4.41 - Orthic Acid Brown Forest.)

5.31/8 Gleyed Sombric Brunisol

These are Sombric Brunisols with mottling and dull matrix colors in the B horizon. Under virgin conditions, the L-H horizons may be thicker than in the orthic soils.

5.31/9 Lithic Sombric Brunisol

These are Sombric Brunisol soils with a lithic contact between 4 and 20 inches (10 and 50 cm) of the mineral surface.

5.4 Dystric Brunisol Great Group

These are Brunisolic soils that, under virgin conditions, have organic surface horizons (L-H), over Bm horizons in which the base saturation (NaCl) is usually 65 to 100% and the pH ($CaCl_2$) usually 5.5 or lower.

These soils may have thin Ah horizons ($<$2 inches [5 cm]) under forest communities, or moderately thick turfy Ah horizons under alpine vegetation and climate. They may also have weakly expressed (Aej) or strongly expressed (Ae) eluvial horizons over weak illuvial concentrations of sesquioxides that fail to meet the requirements of the podzolic B horizon. The parent materials are usually acidic.

5.41 Orthic Dystric Brunisol Profile type: L-H or Ap, Bm or Bmcc, C

These are Dystric Brunisols that, under virgin conditions, have organic surface horizons (L-H), over Bm horizons. The Bm horizons usually have chromas of 3 or more. Between the B and C the chroma difference is greater than 1 or there is a shift to a more yellowish hue in the C. The Bm horizons may contain concretions.

Ap horizons 6 inches (15 cm) thick have color values greater than 3.5 moist or 4.5 dry, and the chromas are usually 3 or more when dry.

The Ap horizon is usually underlain by a Bm horizon. If there are no remnants of a Bm horizon underneath the Ap horizon, these cultivated soils should be classified as Regosols. (This subgroup includes remnants of former 4.31 - Acid Brown Wooded, and 4.51 - Orthic Concretionary Brown.)

5.42 Degraded Dystric Brunisol Profile type: L-H or Ap, Aej or Ae, Bm or Bmcc, C

These are Dystric Brunisols that have either an Aej or Ae horizon and a Bm horizon that contains insufficient illuvial material to meet the requirements of the podzolic B. The Ap horizon may have low chroma if it consists mostly of Ae material. (This subgroup includes remnants of the former 4.32 - Degraded Acid Brown Wooded, and 5.21 - Arenic Podzo Regosol.)

5.43 Alpine Dystric Brunisol Profile type: (L-H), Ah, Bm, C

These are Dystric Brunisols that have thin organic surface layers (L-H) and moderately thick turfy Ah horizons over Bm horizons.

The parent materials of these soils are moderately acidic and of medium to coarse texture. The cation exchange capacity and base saturation are low. There is no visual evidence of translocation of mineral elements in the profile. Frost processes and downslope movement are active.

These soils have developed in the forest-alpine transitional areas of the Cordillera. With increasing grass cover (higher elevations) the Ah horizons become thicker and more turfy, but with decreasing grass cover and increasing forest cover (lower elevations) the Ah horizons become thinner and less turfy. (This subgroup includes the former 4.6 - Alpine Brown on acidic parent material.)

5.4-/7 Cryic Dystric Brunisol

These are Dystric Brunisols having within the control section (40 inches [100 cm]) a permanently frozen layer, or a layer in which the temperature is 0 C or lower two months after the summer solstice (August 21).

5.4-/8 Gleyed Dystric Brunisol

These are Dystric Brunisols with mottling and usually duller matrix colors in the B horizon than in the associated orthic soils. However, gleyed concretionary Bm horizons usually have higher chroma than the Bm and the Ap tends to be somewhat darker than those in the orthic types.

5.4-/9 Lithic Dystric Brunisol

These are Dystric Brunisol soils with a lithic contact between 4 and 20 inches (10 and 50 cm) of the mineral surface.

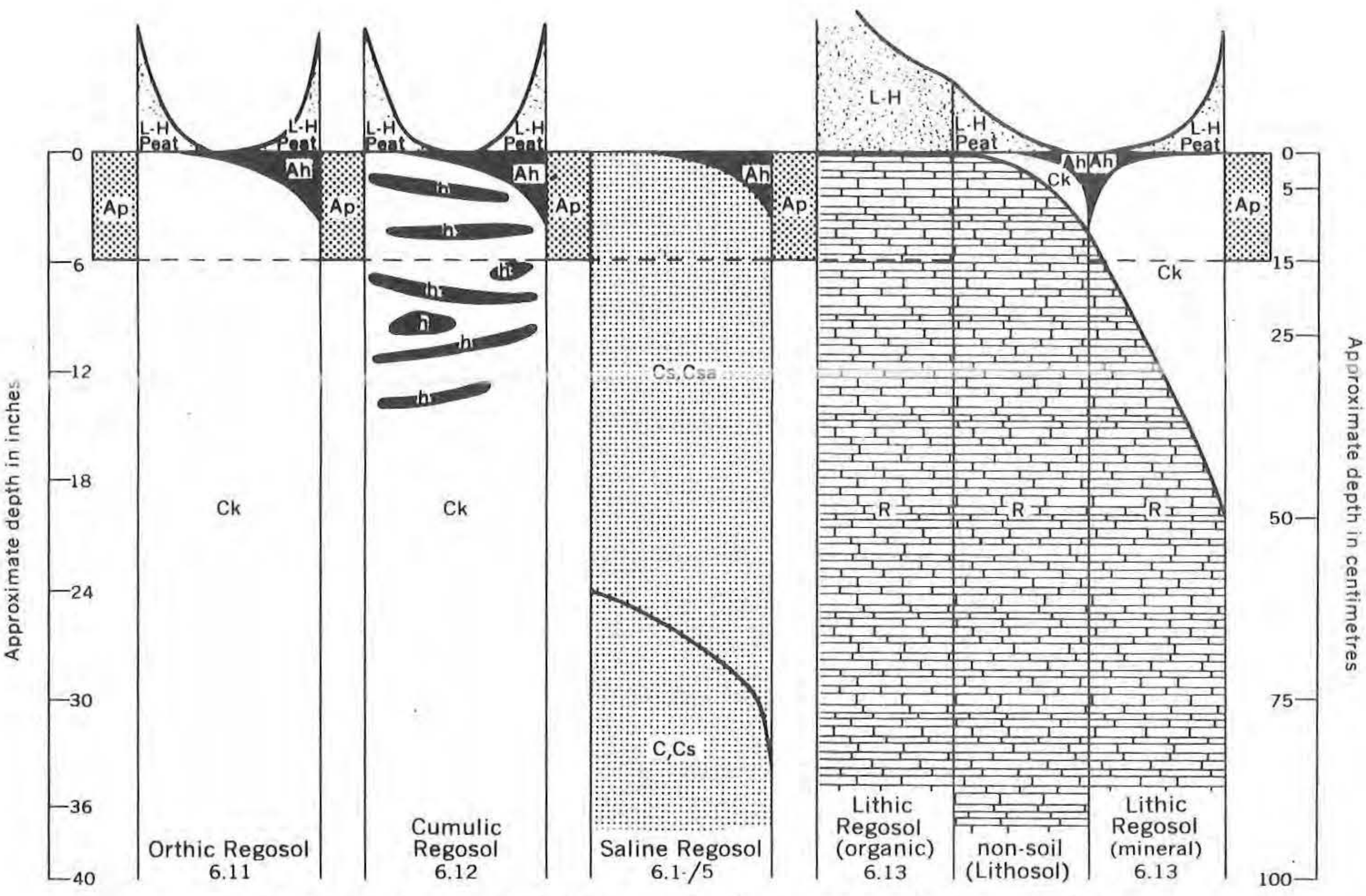

Fig. 23 A diagrammatic horizon pattern of representative Regosolic profiles.

REPORT OF THE SUBCOMMITTEE ON THE CLASSIFICATION OF REGOSOLIC SOILS

L. Farstad, Chairman

6. Regosolic Order

Great Group	Subgroup	
6.1 Regosol	6.11	Orthic Regosol
	6.12	Cumulic Regosol
	6.1-/5	Saline Regosol
	6.1-/7	Cryic Regosol
	6.1-/8	Gleyed Regosol
	6.1-/9	Lithic Regosol

6. Regosolic Order

These are well and imperfectly drained mineral soils with good to moderate oxidizing conditions having horizon development too weak to meet the requirements of soils in any other order. Soils with nonchernozemic[1] Ah horizons may be included.

6.1 Regosol Great Group

Only one great group has been established, therefore its definition is the same as the one for the order.

6.11 Orthic Regosol Profile type: (L-H), (Ah), Ck or C

These soils have from the surface, or below a nonchernozemic Ah horizon, color values that are uniform with depth, or color values that increase gradually to the depth of the control section (40 inches [100 cm]). The organic matter content usually decreases regularly with depth. The soils lack soluble salts, gleying, permafrost, and a lithic contact within the control section.

6.12 Cumulic Regosol Profile type: C, Ahb, C or Ck; Ah, C, Ahb, C or Ck

These soils have from the surface, or below any nonchernozemic Ah horizon, color values that vary by one or more units with depth in the control section. The organic matter content usually decreases irregularly with depth. The soils lack soluble salts, gleying, permafrost, and a lithic contact within the control section.

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[1] See definition of Chernozemic A horizon, page 19.

6.1-/5 Saline Regosol

These are Regosolic soils that have salinity exceeding 4 mmhos/cm in a layer(s) within 24 inches (60 cm) of the surface, or salinity exceeding 6 mmhos/cm between 24 and 40 inches (60 and 100 cm) from the surface if the soil above is nonsaline (<4 mmhos/cm).

6.1-/7 Cryic Regosol

These are Regosolic soils with a permanently frozen layer(s) in which the temperature within the control section is 0 C or lower two months after the summer solstice (August 21).

6.1-/8 Gleyed Regosol

These are Regosolic soils with mottling and dull colors within 20 inches (50 cm) of the surface.

6.1-/9 Lithic Regosol

These are Regosolic soils that have a lithic contact at a depth greater than 4 inches (10 cm) but at less than 20 inches (50 cm) below the mineral soil surface, or soils that have well-drained organic layers (L-H) thicker than 4 inches (10 cm) and may have mineral material up to 4 inches (10 cm) thick on rock.

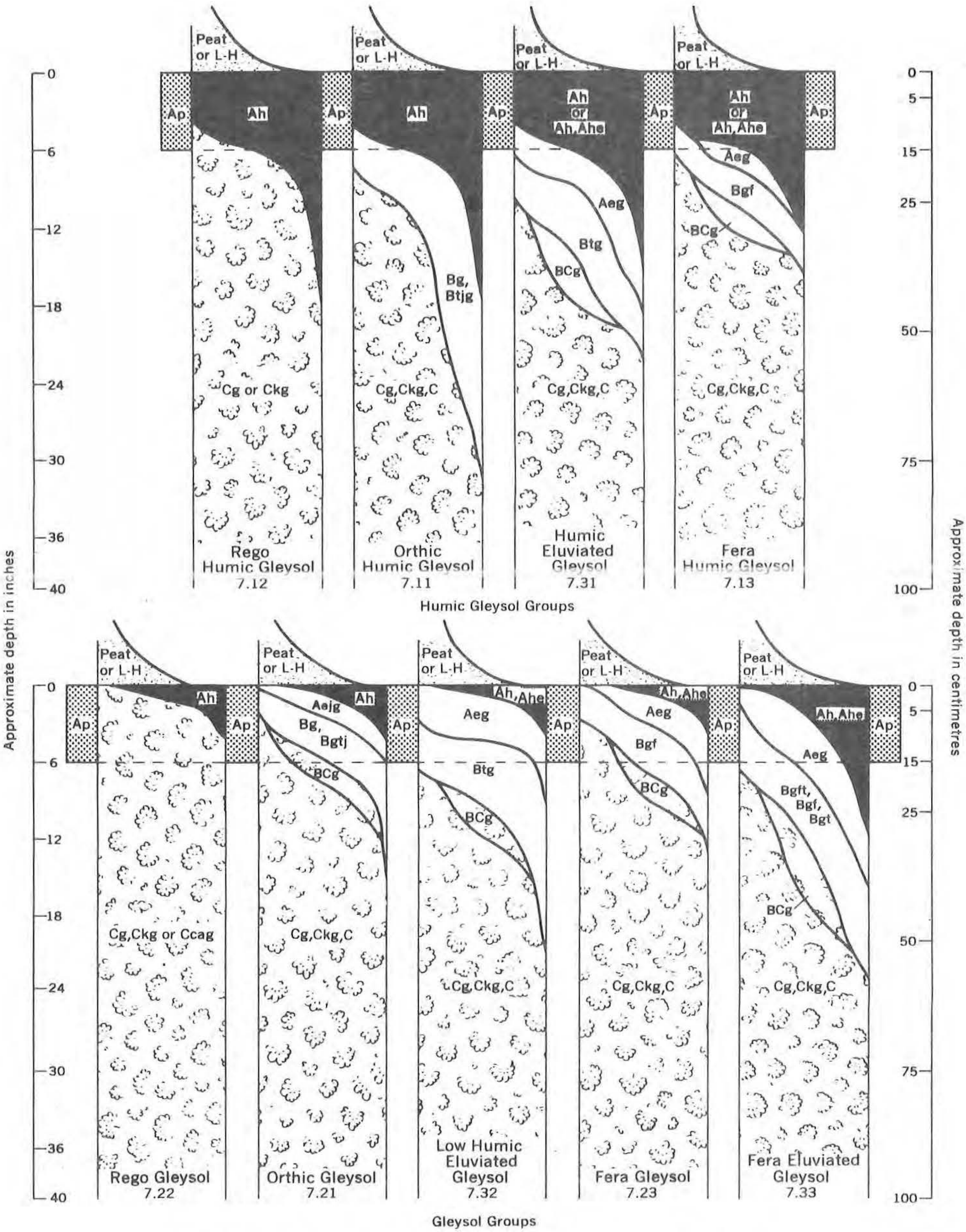

Fig. 25 A diagrammatic horizon pattern of representative Gleysolic profiles.

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REPORT OF THE SUBCOMMITTEE ON THE CLASSIFICATION OF GLEYSOLIC SOILS

J. A. McKeague, Chairman

7. Gleysolic Order

Great Group		Subgroup
7.1 Humic Gleysol	7.11	Orthic Humic Gleysol
	7.12	Rego Humic Gleysol
	7.13	Fera Humic Gleysol
	7.1-/5	Saline Humic Gleysol
	7.1-/6	Carbonated Humic Gleysol
	7.1-/7	Cryic Humic Gleysol
	7.1-/9	Lithic Humic Gleysol
7.2 Gleysol	7.21	Orthic Gleysol
	7.22	Rego Gleysol
	7.23	Fera Gleysol
	7.2-/5	Saline Gleysol
	7.2-/6	Carbonated Gleysol
	7.2-/7	Cryic Gleysol
	7.2-/9	Lithic Gleysol
7.3 Eluviated Gleysol	7.31	Humic Eluviated Gleysol
	7.32	Low Humic Eluviated Gleysol
	7.33	Fera Eluviated Gleysol
	7.3-/9	Lithic Eluviated Gleysol

7. Gleysolic Order

The soils are saturated with water and under reducing conditions continuously or at some period of the year unless they are artificially drained. They have, within 20 inches (50 cm) of the mineral surface, matrix colors of low chroma as a result of reducing conditions and they may have distinct or prominent mottles of high chroma, presumably as a result of localized oxidation of ferrous iron and the deposition of hydrated ferric oxides. They have, within 20 inches (50 cm) of the surface, a horizon or horizons at least 4 inches (10 cm) thick with dominant moist colors as follows:

a) Chromas of 1 or less on ped surfaces or in the matrix if peds are lacking, without mottles; or

b) Chromas of 2 or less in hues of 10YR or redder on ped surfaces or in the matrix if peds are lacking, accompanied by prominent mottles; or

c) Chromas of 3 or less in hues yellower than 10YR on ped surfaces or in the matrix if peds are lacking, accompanied by prominent mottles; or

d) Hues bluer than 10Y, with or without mottles, on ped surfaces or in the matrix if peds are lacking.

These soils have developed under hydrophytic vegetation and they may be expected to produce hydrophytic vegetation if left undisturbed. They may have an organic surface layer of less than 16 inches (40 cm) of mixed peat (bulk density greater than 0.1) or up to 24 inches (60 cm) of fibric moss peat (bulk density less than 0.1). They may or may not have A and B horizons.

The color criteria listed are tentative because they have not been checked on enough soils. However, color is the most useful morphological feature known as an indicator of the oxidation-reduction status of a soil. Some accessory properties that may be useful in identifying some of these soils are:

1) Saturation to the surface for a month or more while the soil is not frozen.

2) Organic surface layers.

3) Hydrophytic vegetation.

4) Position in the landscape--undrained depressions in subhumid regions and level areas in humid regions.

An Eh of less than 100 mv within the upper 20 inches (50 cm) for a period of a week or more is a possible chemical criterion for these soils, but only a few data are available.

The inclusion of "under reducing conditions" in the definition of the order is necessary because some soils that are saturated with water for a month or more each year are not gleyed. Two examples are soils on slopes that are saturated with aerated water, and some soils in depressions that are flooded only in the spring when the temperature is only a few degrees above freezing. Temperatures high enough (above about 5 C) to permit microbial activity and hence depletion of oxygen are thought to be essential to the gley process. Some Podzols and Humic Podzols are saturated with water for several months each year, yet they are not considered to be Gleysolic soils.

7.1 Humic Gleysol Great Group

These are Gleysolic soils that, when virgin, have an Ah horizon more than 3 inches (8 cm) thick. When cultivated to a depth of 6 inches (15 cm), they have an Ap layer with more than 3% organic matter and a rubbed color value as follows:

a) 3.5 or lower moist or 5.0 or lower dry; and

b) at least 1.5 units of value (moist) lower than that of the next underlying horizon, either B or C, if the value of the underlying horizon is 4 or more; or

c) at least 1 unit (moist) lower than that of the next underlying horizon if the value of the underlying horizon is less than 4.

Examples of color values of cultivated soils:

$$\frac{\text{Ap}}{\text{B or C}} \quad \frac{3.5 \text{ or less}}{5.0} \text{ or } \frac{2.0 \text{ or less}}{3.0}$$

All of the subgroups may have organic surface layers, up to 16 inches (40 cm) of mixed peat with bulk density greater than 0.1, or up to 24 inches (60 cm) of fibric moss peat with bulk density less than 0.1.

7.11 Orthic Humic Gleysol   Profile type: (L-H), Ah, (Ahe), (Aeg), Bg or Btjg, Cg or C or Ckg, etc.

These are Humic Gleysol soils with a noneffervescent[1] Ah horizon or Ap layer with a gleyed B horizon. They lack the characteristics specified below for Saline, Cryic, and Lithic subgroups. The C horizon may or may not appear to be strongly gleyed.

7.12 Rego Humic Gleysol   Profile type: (L-H), Ah, Cg or Ckg or Ccag

These are Humic Gleysol soils with a noneffervescent[1] Ah horizon or Ap layer and without a B horizon. They lack the characteristics specified below for Saline, Cryic, and Lithic subgroups.

7.13 Fera Humic Gleysol   Profile type: (L-H), Ah, (Ahe), (Aeg), Bgf, (BCg), Cg or Cgj or C or Ckg, etc.

These are Humic Gleysol soils with a noneffervescent[1] Ah horizon or Ap layer and a B horizon with many prominent mottles of high chroma and an accumulation of dithionite-extractable iron[2] (at least 1% more dithionite Fe than the IC horizon) and little or no accumulation of dithionite-extractable Al (dithionite Al in the B horizon exceeds that in the IC horizon by less than 0.5%). They lack the characteristics specified below for Saline, Cryic, and Lithic subgroups.

7.1-/5 Saline Humic Gleysol

These are Humic Gleysol soils with saline horizons as specified:

a) The conductivity of the saturation extract of a horizon within 24 inches (60 cm) of the surface exceeds 4 mmhos/cm; or

b) The conductivity of the saturation extract of a horizon between 24 and 48 inches (60 and 120 cm) from the surface exceeds 6 mmhos/cm, if the soil above is nonsaline (<4 mmhos/cm).

7.1-/6 Carbonated Humic Gleysol

These are Humic Gleysol soils with an effervescent (carbonate) Ah horizon or Ap layer.

Note: As defined, 7.1-/6 includes Humic Gleysol soils having effervescent Ah horizons or an Ap layer due to either primary or secondary carbonates. It is thought that in these wet soils any A horizon containing primary carbonates would contain at least some secondary carbonates and that a distinction is not practical.

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[1] No effervescence with 1 N HCl.

[2] The method of Mehra and Jackson. 1960. 7th Natl. Conf. on Clays and Clay Minerals. pp. 317-327.

7.1-/7 Cryic Humic Gleysol

These are Humic Gleysol soils with permafrost (z) within 40 inches (1 m) of the mineral soil surface.

7.1-/9 Lithic Humic Gleysol

These are Humic Gleysol soils with a lithic contact between 4 and 20 inches (10 and 50 cm) of the mineral surface.

7.2 Gleysol Great Group

These are Gleysolic soils that, when virgin, have either no Ah horizon or an Ah horizon up to 3 inches (8 cm) thick and that, when cultivated to a depth of 6 inches (15 cm), have an Ap layer with either less than 3% organic matter or rubbed color values (moist) as follows:

a) Higher than 3.5; or

b) Less than 1.5 units of value lower than that of the next underlying horizon (Aej, B or C) if the value of the underlying horizon is 4 or more; or

c) Less than 1 unit of value lower than that of the next underlying horizon if the value of the underlying horizon is less than 4.

Examples of color values of cultivated soils:

$$\frac{\text{Ap}}{\text{Aej, B or C}} \quad \frac{\text{higher than 2.5}}{4} \text{ or } \frac{\text{higher than 2.0}}{3.0}$$

All of the subgroups may have organic surface layers as specified for 7.1.

7.21 Orthic Gleysol   Profile type: (L-H), (Ah), (Aeg), <u>Bg</u> or <u>Bgtj</u>, <u>Cg</u> or <u>Cgj</u> or <u>C</u> or <u>Ckg</u>, etc.

These are Gleysol soils with a gleyed B horizon. They lack an effervescent surface horizon and the characteristics specified for Saline, Cryic, and Lithic subgroups.

7.22 Rego Gleysol   Profile type: (L-H), (Ah), <u>Cg</u> or <u>Ckg</u> or <u>Ccag</u>

These are Gleysol soils without a B horizon. They lack an effervescent surface horizon and the characteristics specified for Saline, Cryic, and Lithic subgroups.

7.23 Fera Gleysol   Profile type: (L-H), (Ah), (Aeg), <u>Bgf</u>, (BCg), <u>Cg</u> or <u>Cgj</u> or <u>C</u> or <u>Ck</u>, etc.

These are Gleysol soils having a B horizon with many prominent mottles of high chroma and an accumulation of dithionite-extractable Fe (at least 1% more dithionite Fe than the C horizon) and little or no accumulation of dithionite-extractable Al (dithionite Al in the B horizon exceeds that in the C horizon by less than 0.5%). They lack effervescent surface horizons and the characteristics specified for Saline, Cryic, and Lithic subgroups.

7.2-/5 Saline Gleysol

These are Gleysol soils with a saline horizon as specified:

a) The conductivity of the saturation extract of a horizon within 24 inches (60 cm) of the surface exceeds 4 mmhos/cm; or

b) The conductivity of the saturation extract of a horizon between 24 and 48 inches (60 and 120 cm) from the surface exceeds 6 mmhos/cm, if the soil above is nonsaline (<4 mmhos/cm).

7.2-/6 Carbonated Gleysol

These are Gleysol soils with an effervescent (carbonate) surface horizon. See note for 7.1-/6.

7.2-/7 Cryic Gleysol

These are Gleysol soils with permafrost (z) within 40 inches (1 m) of the mineral surface.

7.2-/9 Lithic Gleysol

These are Gleysol soils with a lithic contact between 4 and 20 inches (10 and 50 cm) of the mineral surface.

7.3 Eluviated Gleysol Great Group

These are Gleysolic soils with Aeg and Btg horizons. All of the subgroups may have organic surface layers as specified for 7.1, and they may have an Ah horizon.

7.31 Humic Eluviated Gleysol Profile type: (L-H), Ah or Ahe, Aeg, Btg, (BCg), Cg or Cgj or C or Ckg, etc.

These are eluviated Gleysol soils with an Ah horizon as specified for 7.1 and with Aeg and Btg horizons. They lack lithic layers.

7.32 Low Humic Eluviated Gleysol Profile type: (L-H), (Ah), (Ahe), Aeg Btg, (BCg), Cg or Cgj or C or Ckg, etc.

These are eluviated Gleysol soils without an Ah horizon or with an Ah or Ap horizon as specified for 7.2 and with Aeg and Btg horizons. They lack lithic layers.

7.33 Fera Eluviated Gleysol Profile type: (L-H), (Ah), (Ahe), Aeg, Bgft or Bgf and Btg, (BCg), Cg or Cgj or C or Ckg, etc.

These are eluviated Gleysol soils having a B horizon with many prominent mottles of high chroma and with an accumulation of dithionite-extractable Fe (at least 1% more dithionite Fe than the C horizon) and little or no accumulation of dithionite-extractable Al (dithionite Al in the B horizon exceeds that in the C horizon by less than 0.5%). They lack lithic layers.

7.3-/9 Lithic Eluviated Gleysol

These are eluviated Gleysol soils with a lithic contact between 4 and 20 inches (10 and 50 cm) of a mineral surface.

Note: Peaty phases

As specified, Gleysolic soils may have up to 24 inches (60 cm) of fibric moss peat or 16 inches (40 cm) of mixed peat at the surface. Peaty soils are no longer separated from other soils at the subgroup level. It is suggested that Gleysolic soils having 6 to 16 inches (15 to 40 cm) of mixed peat or 6 to 24 inches (15 to 60 cm) of fibric moss peat may be designated as peaty phases of the appropriate subgroups.

REPORT OF THE SUBCOMMITTEE ON THE CLASSIFICATION OF ORGANIC SOILS

J. H. Day, Chairman

These definitions of the order, great groups, and subgroups of organic soils were adopted by the National Soil Survey Committee at its meeting in Edmonton in April 1968.

To facilitate the understanding of the classification, it is arranged in the order of the definitions of the control section, tiers and layers, morphological features and nomenclature, and classification.

DEFINITIONS AND CRITERIA

Control Section

The control section refers to the part of the soil that is considered in the classification of organic soils. The thickness of the control section is variable; it depends on the type of organic layer at the surface and on the presence of lithic, hydric, or cryic layers at shallow depths. It is assumed to include the zone of maximum microbiological activity.

The thickness of the control section in organic soils is:

a) 64 inches (160 cm) if there is on the surface 24 inches (60 cm) or more of fibric organic material (of which more than 75% of the fiber volume is derived from sphagnic or hypnic mosses), or

b) 52 inches (130 cm) if there is on the surface less than 24 inches (60 cm) of fibric organic material (of which more than 75% of the fiber volume is derived from sphagnic or hypnic mosses), or more than 16 inches (40 cm) of other kinds of organic material, or

c) to any lithic or hydric contact that occurs below a depth of 4 inches (10 cm) but shallower than either a or b, or

d) to a cryic contact plus 10 inches (25 cm) if such contact occurs at a depth shallower than either a or b, or

e) to a hydric contact only if the water extends to a depth below either 52 inches (130 cm) or 64 inches (160 cm).

Tiers and Layers

For classification purposes the control section has three tiers, surface, middle, and bottom, each of which may have one or more kinds of layers. The tiers and layers are as follows:

Surface Tier

The surface tier, exclusive of loose litter or living mosses, is 24 inches (60 cm) thick if there is on the surface 24 inches or more of fibric organic material (more than 75% of the fiber volume being derived from sphagnic or hypnic mosses); or it is 12 inches (30 cm) thick if there is on the surface less than 24 inches of fibric organic material of the kind described above or of other kinds or mixed kinds of organic material (less than 75% of the fiber volume being derived from sphagnic or hypnic mosses), or to a lithic or hydric contact if deeper than 4 inches (10 cm) or to a cryic contact plus 10 inches (25 cm) but shallower than 12 or 24 inches (30 or 60 cm).

A surface mineral horizon less than 16 inches (40 cm) in thickness, if present, is considered a part of the surface tier.

Middle Tier

The middle tier is 24 inches (60 cm) thick, or extends to any lithic or hydric contact, or to any cryic contact plus 10 inches (25 cm). This tier establishes the great group classification if no terric, lithic, hydric, or cryic substratum is present. If any substratum is present the dominant kind of organic material in this and the surface tier establishes the great group classification.

Bottom Tier

The bottom tier is 16 inches (40 cm) thick, or it extends to a lithic or hydric contact, or to a cryic contact plus 10 inches (25 cm), that occurs within a depth of between 36 and 52 inches (90 and 130 cm) or between 48 and 64 inches (120 and 160 cm). This tier may include unconsolidated mineral material, or the upper 10 inches (25 cm) of frozen organic or mineral material, but it does not include rock or water (see definition of hydric layer). The material in this tier establishes or assists in establishing the subgroup classification.

Diagnostic Layers

Fibric--The fibric layer is the least decomposed of all of the organic soil materials. It has large amounts of well-preserved fiber that are readily identifiable as to botanical origin.

A fibric layer has (i) a rubbed fiber content of more than 4/10 of the organic volume, and (ii) an unrubbed fiber content of more than 2/3 of the organic volume. Also, if the rubbed fiber content is less than 6/10 of the organic volume it yields a pyrophosphate extract, on white filter paper, that is higher in value or lower in chroma than 7/3.

This material usually has a bulk density of less than 0.1 g/cc and a maximum saturated water-holding capacity ranging from 850 to over 3,000% on an ovendry basis.

Mesic--The mesic layer is the intermediate stage of decomposition. The material has intermediate amounts of fiber, medium bulk density, and medium saturated water-holding capacity. The material is partly altered both physically and biochemically.

A mesic layer has (i) a rubbed fiber content of more than 1/10 if the unrubbed fiber content is between 1/3 and 2/3 of the organic volume, or (ii) a rubbed fiber content of between 1/10 and 4/10 if the unrubbed fiber content is greater than 2/3 of the organic volume, or (iii) a rubbed fiber content of between 1/10 and 4/10 and yields a pyrophosphate extract, on white filter paper, of color value 7 or less and chroma of 3 or more. Usually this mesic material has a bulk density between 0.1 and 0.2 g/cc and a maximum saturated water-holding capacity between 450 and 850% on an ovendry basis.

Humic--The humic layer is the most highly decomposed of the organic soil materials. It has the least amount of plant fiber, the highest bulk density, and the lowest saturated water-holding capacity. It is very stable and changes little physically and chemically with time, in comparison with the others.

A humic layer has (i) a rubbed fiber content of less than 1/10 of the organic volume, and (ii) yields a pyrophosphate extract on white filter paper that has a color value of less than 7 and a chroma of 3 or more.

This humic material usually has a bulk density of more than 0.2 g/cc and a maximum saturated water-holding capacity of less than 450% on an ovendry basis.

Other Layers

Typic--This is a dominantly mesic or humic layer throughout the middle and bottom tiers. The control section lacks any terric, lithic, hydric, cryic, cumulo, or limno layers. It is to be used only in the Mesisol and Humisol great groups.

Fenno--This is a dominantly fibric layer, derived from rushes, reeds, and sedges throughout the middle and bottom tiers. The control section is 52 or 64 inches (130 or 160 cm) deep and lacks any terric, lithic, hydric, cryic, cumulo, or limno layers. It is to be used only in the Fibrisol great group.

Hypno--This is a dominantly fibric layer, derived from hypnic mosses throughout the middle and bottom tiers. The control section is 52 or 64 inches (130 or 160 cm) deep and lacks any terric, lithic, hydric, cryic, cumulo, or limno layers. It is to be used only in the Fibrisol great group.

Sphagno--This is a dominantly fibric layer, derived from sphagnic mosses throughout the middle and bottom tiers. The control section is 52 or 64 inches (130 or 160 cm) deep and lacks any terric, lithic, hydric, cryic, cumulo, or limno layers. It is to be used only in the Fibrisol great group.

Limno--This is a layer or layers 2 inches (5 cm) thick or more of coprogenous earth (sedimentary peat), diatomaceous earth, or marl. Except for some of the coprogenous earths containing more than 30% organic matter, most of these limnic materials are inorganic in composition.

Coprogenous earth has 50% or more by volume of fecal pellets less than a few tenths of a millimeter in diameter, and dry color values less than 5. It has slightly viscous water suspensions, is slightly plastic but not sticky, and shrinks upon drying to form clods that are difficult to rewet and that often tend to crack along horizontal planes. It has very few or no plant fragments recognizable by the naked eye and has pyrophosphate extracts higher in value and lower in chroma than 10YR 7/3 or the cation exchange capacity (C.E.C.) is less than 240 meq per 100 g organic matter.

Diatomaceous earth has a matrix color value of 4 ± 1, if not previously dried, that changes on drying to the permanent, light-gray or whitish color of diatoms, which can be identified by microscopic (440x) examination. Also, it has a saturated sodium pyrophosphate extract on white filter paper that is higher in value and lower in chroma than 10YR 7/3. The layers are frequently more nearly mineral than organic in composition.

Marl has a moist color value of 6 ± 1 and effervesces with dilute HCl. It usually does not change matrix color upon drying and consequently there is no permanent color change. Marl contains too little organic matter to coat the carbonate.

Cumulo--This consists of multiple layers of mineral material (alluvium) together more than 2 inches (5 cm) thick, or one layer 2 to 12 inches (5 to 30 cm) thick. One continuous mineral layer more than 12 inches (30 cm) thick in the middle or bottom tier is a terric layer.

Cryic--This is a permanently frozen layer, or a layer in which the temperature is 0 C or lower in the control section 2 months after the summer solstice (August 21). The control section ends at a depth of 10 inches (25 cm) below the upper surface of the cryic layer.

Terric--This is an unconsolidated mineral substratum, or one continuous unconsolidated mineral layer (with less than 30% organic matter) more than 12 inches (30 cm) thick in the middle or bottom tiers underlain by organic matter, but within a depth of 52 or 64 inches (130 or 160 cm) from the surface.

Lithic--This is a consolidated mineral layer (bedrock) occurring within a depth of between 4 inches (10 cm) and 52 or 64 inches (130 or 160 cm) from the surface.

Hydric--This consists of a fluid layer thicker than about 6 inches (15 cm) occurring within a depth of between 4 inches (10 cm) and 52 or 64 inches (130 or 160 cm) from the surface. This hydric layer is designed to recognize floating bogs.

Morphological Features and Nomenclature

To characterize organic soils adequately, their morphology should be described as thoroughly and quantitatively as possible. Morphological features that seem most important in descriptions follow.

Layer Thickness

Cryic organic soils usually have very irregular surfaces with small or large mounds of variable vertical and horizontal dimensions. If the mounds are organic and are so closely spaced that the pedons are less than 5 m^2, the soil should be classified as though the mounds had been leveled. If the mounds are mineral or are so widely spaced that they do not occur in each pedon of 5 m^2, the soils should be classified as they now exist.

Definition of Size of Fibers

Fibers are the organic materials retained on a 100-mesh sieve (0.15 mm diameter), except for wood fragments that cannot be crushed in the hand and are larger than 3/4 inch (2 cm) in the smallest dimension. Reed and rush fragments are not excluded by the 3/4-inch (2 cm) limit. Wood fragments retained on the sieve should be picked out and weighed separately.

Content of Fiber

The amount of fiber and its durability (as measured by destruction on rubbing) are the most important characterizing and differentiating features among different kinds of organic soils. Estimate the fiber content for the undisturbed and rubbed states in a moist to wet condition; if the soil is dry, moisten it. For the undisturbed or unrubbed estimate, break a fragment of the layer in the vertical plane. Then scan an area of at least 4 square inches (25 cm^2) with the aid of a 10x hand lens. With practice the fiber content can be estimated to the nearest 5 to 10%. Avoid the horizontal plane in making the estimates because it may be a cleavage face, which has a concentration of a certain size of material. To determine the content of fiber after rubbing, rub a fragment of the layer between the thumb and forefinger about 10 times, or knead a ball in the palm about 10 times, using firm pressure. Then mold the material into a ball, break it in half, and scan a broken face with a lens to estimate the fiber content. Skill in estimating the correct fiber content, as with hand texturing, is enhanced by comparing the estimate with the laboratory-determined value.

Color

Determine the color in the moist or wet condition on a broken vertical face, on a mass that has been firmly pressed between the thumb and forefinger, and on the rubbed mass. These kinds of color determinations help to distinguish the different kinds of diagnostic layers. Fibric layers containing mostly sphagnum fibers exhibit a substantial change in color after being pressed compared with the color of a broken vertical face. Generally, the mesic layers have a rubbed color darker than the unrubbed color. Also, humic layers with over 50% mineral matter are unique in that the difference in color between the wet rubbed condition and the dry rubbed condition is greater than for other kinds of layers. The rubbed mass usually increases one or more units in value upon drying.

Structure

The description of structure in organic soils is a problem. In general, fibric and mesic layers have either layered or amorphous structure. Layered structure seems to result either from the stratification of different kinds of organic material or from the annual growth of the bog flora. These two situations should be differentiated if possible. Humic layers have more varieties of structure than do most other kinds of layers. Granular structure is common, particularly where the mineral content is high; blocky structure sometimes occurs; and clods are often present in cultivated surfaces.

Consistence

Notations for consistence of fibric layers should be omitted because they are meaningless. Mesic layers, having a minimum fiber content, may have slightly sticky consistence and it is suggested that only wet consistence be indicated because it varies in mesic layers. The consistence of humic layers parallels that for mineral soils, and the appropriate consistence term should be noted.

Mineral Content and Other Features

If mineral grains can be observed, estimate their size, range of sizes, and proportion of the mass. Other morphological features not described above could include such things as permafrost, artifacts, and living root content.

Reaction

In the field pH can be determined by using enough 0.01 M $CaCl_2$ solution to make a slurry. Make this determination on the peat under field moisture conditions. If the peat is very wet, squeeze a handful and reconstitute a portion with 0.01 M $CaCl_2$.

Boundary Between Layers

Generally the topography of boundaries is smooth, but the distinctness may vary appreciably. Record both the distinctness and the topography.

Nomenclature for Organic Layers

Label organic soil layers O with suffixes to indicate the degree of decomposition. Each letter combination has a unique meaning notwithstanding any other definition for each of the suffixes.

Of - fibric layer
Om - mesic layer
Oh - humic layer

Label mineral strata with the appropriate mineral horizon terminology. The suffix z for cryic layers may be used for organic layers.

Contrast Classes

The dominant diagnostic layer in the middle tier establishes the great group and the subdominant layers in the organic section of the middle

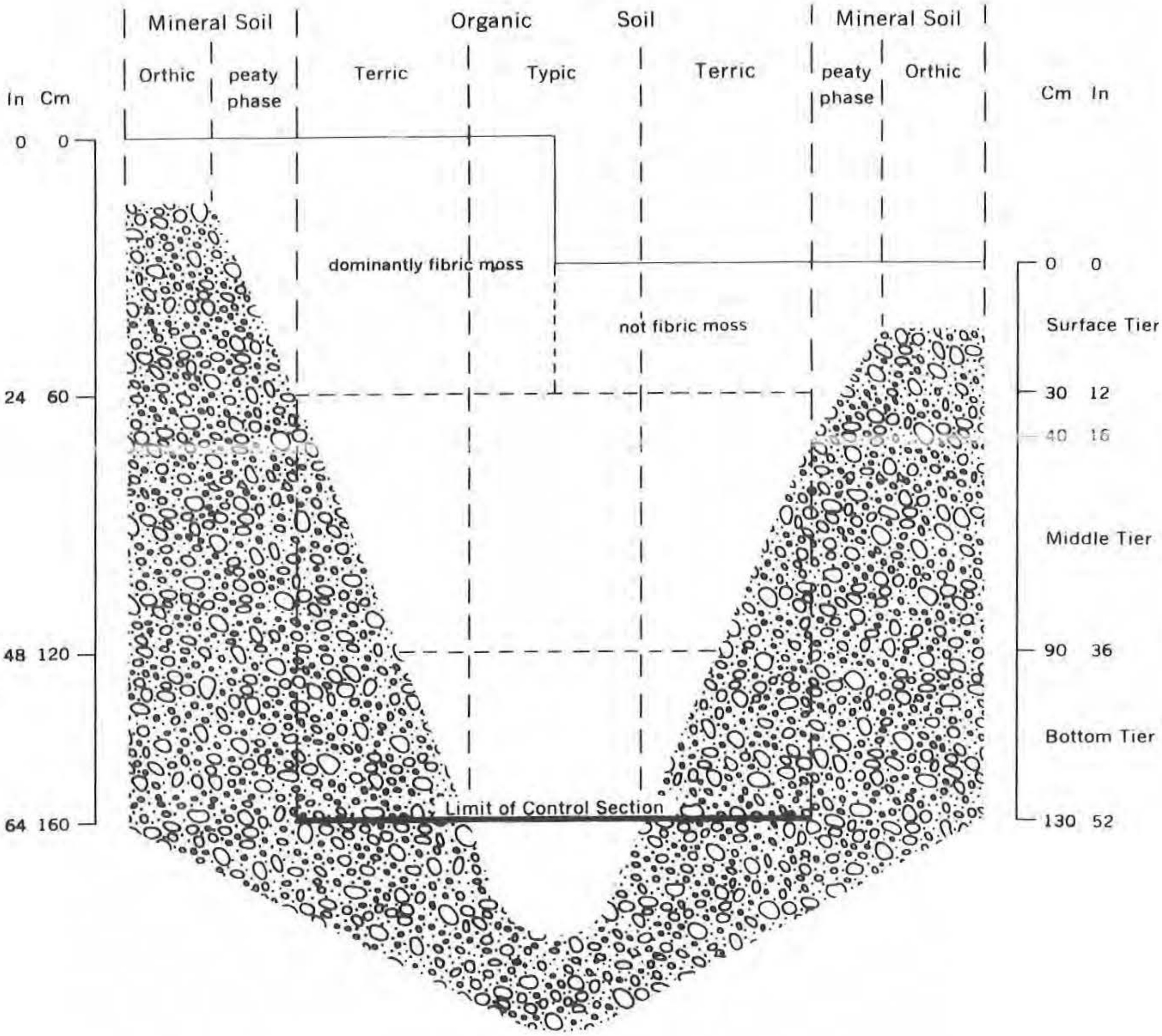

Fig. 28 A diagrammatic representation of depth relationships of tiers and control section for Typic and Terric Subgroups of Organic soils and of Mineral soils. *SRI*

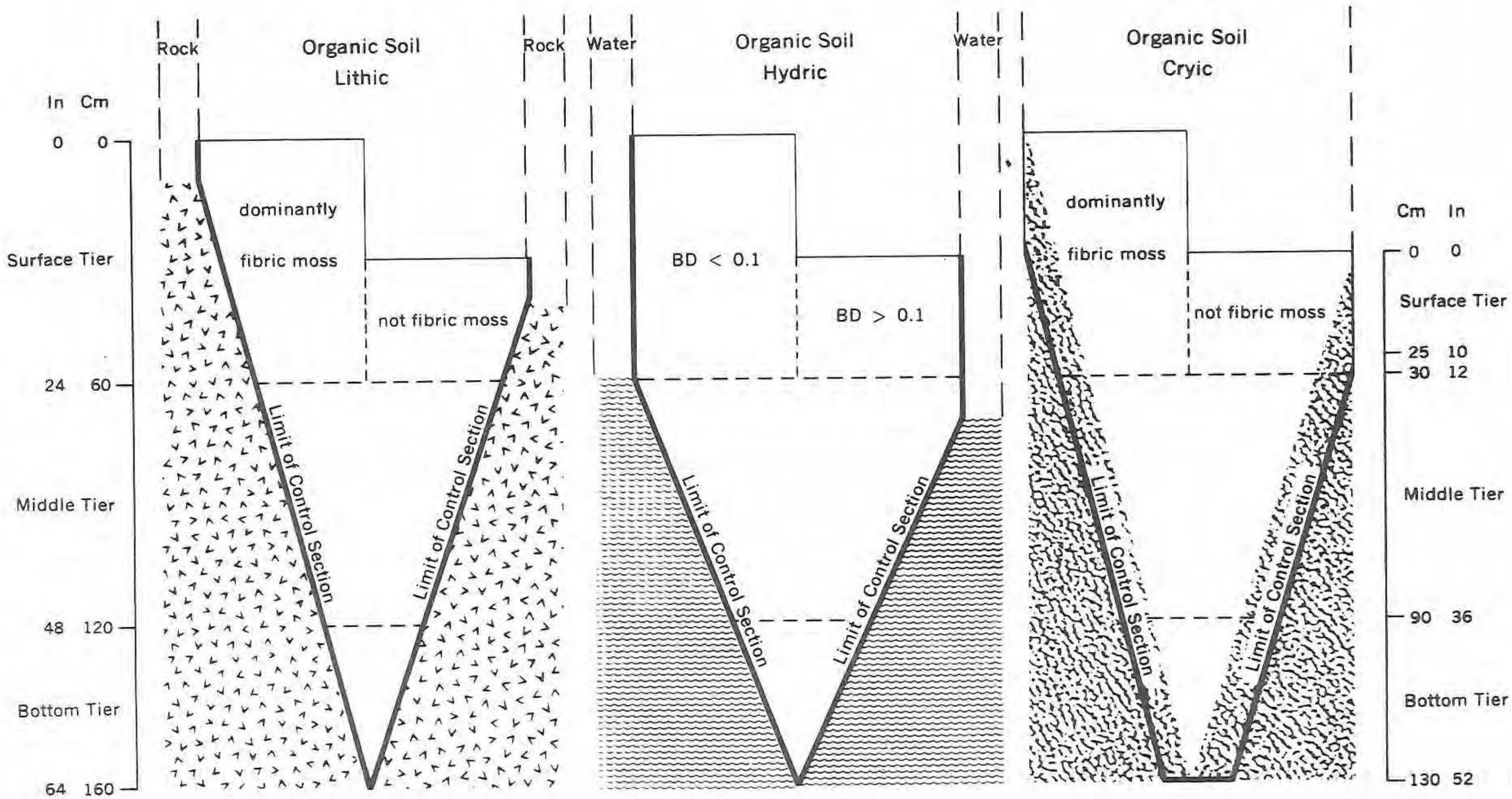

Fig. 29 A diagrammatic representation of depth relationships and control sections for Lithic, Hydric and Cryic Subgroups of Organic soils.

SRI

and bottom tiers establish the subgroup when any terric, lithic, hydric, or cryic contact occurs only within the bottom tier. The subdominant layers in the middle and surface tiers establish the subgroup when a terric, lithic, hydric, or cryic contact occurs in the middle tier. Control sections that lack subdominant organic layers and terric, lithic, hydric, cryic, cumulo, and limno layers are assigned to one of the following subgroups: Fenno-Fibrisol, Hypno-Fibrisol, Sphagno-Fibrisol, Typic Mesisol, or Typic Humisol.

The method for establishing whether or not a subdominant organic layer is to be recognized at the subgroup level is as follows: If the layers are strongly contrasting (fibric versus humic) the subdominant layer, either as a single layer or in aggregate, must be thicker than one-sixth the thickness of the organic section beneath the surface tier, or of the organic section above any terric, lithic, hydric, or cryic contact occurring in the middle tier. If the layers are weakly contrasting (mesic versus humic or fibric) the subdominant layer, either as a single layer or in aggregate, must be thicker than one-third the thickness of the organic section beneath the surface tier, or of the organic section above any terric, lithic, hydric, or cryic contact occurring in the middle tier.

Classification

Order	Great Group	Subgroup	
8. Organic	8.1 Fibrisol	8.11a	Fenno-Fibrisol
		8.11b	Hypno-Fibrisol
		8.11c	Sphagno-Fibrisol
		8.12	Mesic Fibrisol
		8.13	Humic Fibrisol
		8.1-/4	Limno Fibrisol
		8.1-/5	Cumulo Fibrisol
		8.1-/6	Terric Fibrisol
		8.1-/7	Cryic Fibrisol
		8.1-/8	Hydric Fibrisol
		8.1-/9	Lithic Fibrisol
	8.2 Mesisol	8.21	Typic Mesisol
		8.22	Fibric Mesisol
		8.23	Humic Mesisol
		8.2-/4	Limno Mesisol
		8.2-/5	Cumulo Mesisol
		8.2-/6	Terric Mesisol
		8.2-/7	Cryic Mesisol
		8.2-/8	Hydric Mesisol
		8.2-/9	Lithic Mesisol
	8.3 Humisol	8.31	Typic Humisol
		8.32	Fibric Humisol
		8.33	Mesic Humisol
		8.3-/4	Limno Humisol
		8.3-/5	Cumulo Humisol
		8.3-/6	Terric Humisol
		8.3-/7	Cryic Humisol
		8.3-/8	Hydric Humisol
		8.3-/9	Lithic Humisol

8. Organic Order

These are soils that have developed dominantly from organic deposits that are saturated for most of the year, or are artificially drained, and contain 30% or more of organic matter to:

a. a depth of at least 24 inches (60 cm) if the surface layer consists dominantly of fibric moss; or

b. to a depth of at least 16 inches (40 cm) for other kinds or mixed kinds of organic material; or

c. to a lithic contact if it occurs at depths greater than 4 inches (10 cm) but shallower than either a or b, or to a depth of 10 inches (25 cm) below that point which is at 0 C or lower 2 months after the summer solstice but shallower than either a or b; and

d. that have no mineral layer as thick as 16 inches (40 cm) at the surface, or if covered with less than 16 inches (40 cm) of mineral soil, have at least 16 inches (40 cm) (taken either singly or cumulatively) of organic soil below the mineral layer; and

e. that have no mineral layer as thick as 16 inches (40 cm) beginning within a depth of 16 inches (40 cm) from the surface of the profile; or

f. that have no mineral layer, or layers taken cumulatively, as thick as 16 inches (40 cm) within the upper 32 inches (80 cm) of the profile.

8.1 Fibrisol Great Group

These are organic soils with a dominantly[1] fibric middle tier, or middle and surface tiers if a terric, lithic, hydric, or cryic contact occurs in the middle tier.

8.11a Fenno-Fibrisol--These fibrisols consist of uniform fibric organic material, derived dominantly from rushes, reeds, and sedges, throughout the middle and bottom tiers. They lack mesic or humic subdominant[2] layers. The control section is 52 or 64 inches (130 or 160 cm) thick and lacks any terric, lithic, hydric, cryic, cumulo, or limno layers.

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[1] Dominant, in this context, means the most abundant. If only two kinds of organic materials are present, one of the materials occupies more than half the thickness. If there are three kinds of materials, e.g., fibric, mesic, and humic, the dominant one may occupy less than half the thickness, but will occupy a greater thickness than either of the other two considered separately.

[2] Subdominant means that it fulfills the requirement stated under contrast classes.

8.11b Hypno-Fibrisol--These fibrisols consist of uniform fibric organic material, derived dominantly from hypnic mosses, throughout the middle and bottom tiers. They lack mesic or humic subdominant layers. The control section is 52 or 64 inches (130 or 160 cm) thick and lacks any terric, lithic, hydric, cryic, cumulo, or limno layers.

8.11c Sphagno-Fibrisol--These fibrisols consist of uniform fibric organic matter, derived dominantly from sphagnic mosses, throughout the middle and bottom tiers. They lack mesic or humic subdominant layers. The control section is 52 or 64 inches (130 or 160 cm) thick and lacks any terric, lithic, hydric, cryic, cumulo, or limno layers.

8.12 Mesic Fibrisol--These fibrisols consist of a dominantly fibric middle tier and a subdominant mesic layer in the remainder of the organic section below the surface tier, or in the organic section above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

8.13 Humic Fibrisol--These fibrisols consist of a dominantly fibric middle tier and a subdominant humic layer in the remainder of the organic section below the surface tier, or in the organic section above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

8.1-/4 Limno Fibrisol--These fibrisols have a limno layer beneath the surface tier, or above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

8.1-/5 Cumulo Fibrisol--These fibrisols have a cumulo layer beneath the surface tier, or above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

8.1-/6 Terric Fibrisol--These fibrisols have a terric layer beneath the surface tier but within the control section.

8.1-/7 Cryic Fibrisol--These fibrisols have a cryic layer within the control section.

8.1-/8 Hydric Fibrisol--These fibrisols have a hydric layer below a depth of 16 inches (40 cm) or 24 inches (60 cm) and that extends to a depth below either 52 or 64 inches (130 or 160 cm).

8.1-/9 Lithic Fibrisol--These fibrisols have a lithic layer (bedrock) occurring within a depth of between 4 and 52 or 64 inches (10 and 130 or 160 cm) from the surface.

8.2 Mesisol Great Group

These organic soils have a dominantly mesic middle tier, or middle and surface tiers if a terric, lithic, hydric, or cryic contact occurs in the middle tier.

8.21 Typic Mesisol--These mesisols consist of dominantly mesic organic material throughout the middle and bottom tiers. The control section lacks any terric, lithic, hydric, cryic, cumulo, or limno layers.

8.22 Fibric Mesisol--These mesisols consist of a dominantly mesic middle tier and a subdominant fibric layer in the remainder of the organic section below the surface tier, or in the organic section above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

8.23 Humic Mesisol--These mesisols consist of a dominantly mesic middle tier and a subdominant humic layer in the remainder of the organic section below the surface tier, or in the organic section above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

8.2-/4 Limno Mesisol--These mesisols have a limno layer beneath the surface tier, or above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

8.2-/5 Cumulo Mesisol--These mesisols have a cumulo layer beneath the surface tier, or above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

8.2-/6 Terric Mesisol--These mesisols have a terric layer beneath the surface tier but within the control section.

8.2-/7 Cryic Mesisol--These mesisols have a cryic layer within the control section.

8.2-/8 Hydric Mesisol--These mesisols have a hydric layer below a depth of 16 inches (40 cm) or 24 inches (60 cm) that extends to a depth below either 52 or 64 inches (130 or 160 cm).

8.2-/9 Lithic Mesisol--These mesisols have a lithic layer (bedrock) occurring within a depth between 4 and 52 or 64 inches (10 and 130 or 160 cm) from the surface.

8.3 Humisol Great Group

These are organic soils with a dominantly humic middle tier, or middle and surface tiers if a terric, lithic, hydric, or cryic contact occurs in the middle tier.

8.31 Typic Humisol--These humisols have dominantly mesic organic material throughout the middle and bottom tiers. The control section lacks any terric, lithic, hydric, cryic, cumulo, or limno layers.

8.32 Fibric Humisol--These humisols have a dominantly humic middle tier and a subdominant fibric layer in the remainder of the organic section below the surface tier, or in the organic section above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

8.33 Mesic Humisol--These humisols have a dominantly humic middle tier and a subdominant mesic layer in the remainder of the organic section below the surface tier, or in the organic section above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

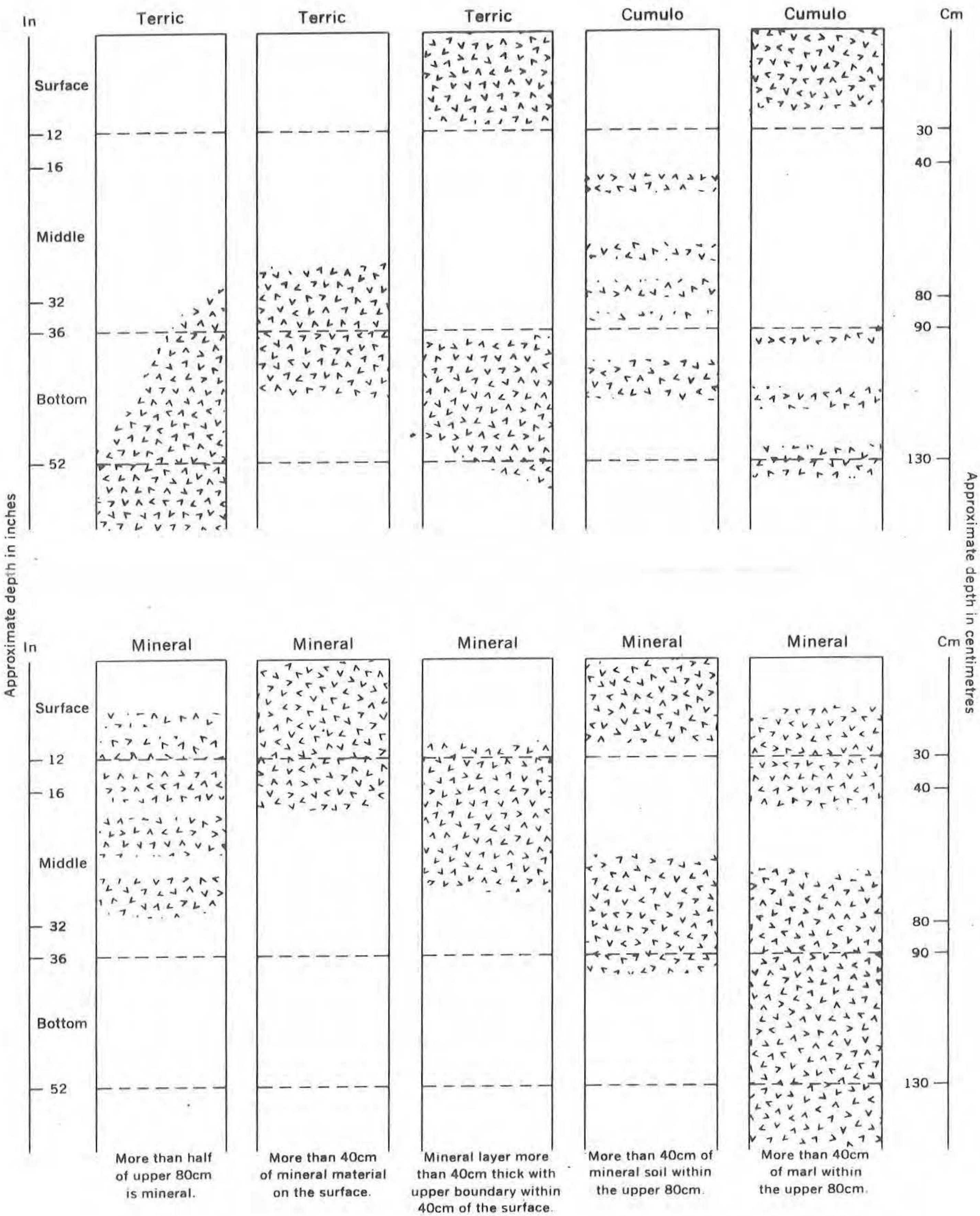

Fig. 30 A diagrammatic representation of depth relationships and the distribution of mineral layers in Terric and Cumulo Subgroups of Organic soils and in Mineral soils.

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8.3-/4 Limno Humisol--These humisols have a limno layer beneath the surface tier, or above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

8.3-/5 Cumulo Humisol--These humisols have a cumulo layer beneath the surface tier, or above any terric, lithic, hydric, or cryic contact that occurs in the middle tier.

8.3-/6 Terric Humisol--These humisols have a terric layer beneath the surface tier but within the control section.

8.3-/7 Cryic Humisol--These humisols have a cryic layer within the control section.

8.3-/8 Hydric Humisol--These humisols have a hydric layer, below a depth of 16 inches (40 cm) or 24 inches (60 cm), that extends to a depth below either 52 or 62 inches (130 or 160 cm).

8.3-/9 Lithic Humisol--These humisols have a lithic layer (bedrock) occurring within a depth between 4 and 52 or 64 inches (10 and 130 or 160 cm) from the surface.

The great group gets its name from the dominant type of organic material in the middle tier, or from the middle and surface tiers if the profile is shallow. The subgroup gets its name from the subdominant organic material or from other layers in the remainder of the organic section in the middle and bottom tiers, or in the middle and surface tiers if the profile is shallow.

The characteristics of the surface tier are used as differentiae at the family and series levels. In addition we can indicate the nature of the surface tier at categorical levels above the family by establishing types for this purpose. The following five types, indicative of both decomposition and botanical origin of the organic material in the surface tier, are proposed: sphagnic, hypnic, fennic (each being used only for fibric surface tiers), mesic, and humic.

If the surface is dominantly mineral material (cumulo) use the textural group name with the type, e.g., moderately fine type.

These types may be used after the subgroup name in the form (hyphen + name in lower case both ending in "ic" + type) in order to avoid confusion with the subgroup names Sphagno-, Hypno-, and Fenno-. For broad reconnaissance mapping the type names suggested could be used after the great group name, e.g., Mesisol-fennic type. However, these types are not to be considered as categorical units. We do have to keep some criteria for the family and series levels.

Notes on Classification Procedures

Terric, Lithic, or Hydric Substratum

A soil with less than 24 inches (60 cm) of fibric moss (75% or more of the fibers being derived from sphagnic or hypnic mosses), or less than

16 inches (40 cm) of other kinds or mixed kinds of organic material over a substratum is not a member of the Organic Order except when it is underlain by a lithic substratum. Organic soils that extend below the bottom tier or control section are classified on the basis of the concepts previously outlined except that Terric, Lithic, and Hydric are not applicable.

Fenno-, Hypno-, and Sphagno- Subgroups

These subgroups of the Fibrisol Great Group are chosen on the basis of dominance of species. It is suggested that only one of these subgroup names be used, e.g., Sphagno-Fibrisol rather than Hypno-Sphagno-Fibrisol.

Termination of the Control Section

The control section ends at a lithic contact if it occurs at a depth shallower than 52 or 64 inches (130 or 160 cm) from the surface because this substratum is deemed "not-soil". The control section ends at a hydric contact only if the water extends below a depth of 52 or 64 inches.

Fibric, Mesic, and Humic Subgroups

Using the contrast class procedure outlined previously, some difficulty may be encountered in the unusual circumstances where there are two subdominant layers, e.g., Mesic Humic Fibrisol. It is recommended that only the more decomposed subgroup name be used, e.g., Humic Fibrisol.

Mineral Soil on the Surface

Soils that have a mineral layer thicker than 16 inches (40 cm) at the surface or that have a mineral layer thicker than 16 inches (40 cm) beginning within a depth of 16 inches (40 cm) from the surface (see paragraph 1 above and 6 below), or that have a mineral layer or layers, taken cumulatively, thicker than 16 inches (40 cm) within the upper 32 inches (80 cm) of the profile, are not members of the Organic Order.

Minimum Thickness of Organic Soils

Soils with less than 4 inches (10 cm) of organic material over rock and less than 16 or 24 inches (40 or 60 cm) of organic material over water are not members of the Organic Order.

Possible Family Criteria

The following characteristics are proposed for trial as criteria for differentiation at the family level.

Characteristics of the Surface Tier

The characteristics of the surface tier may be recognized by using one of the following names for organic materials: sphagnic, hypnic, fennic (each used only for fibric surface tiers), mesic or humic, or by using one of the following names for surface mineral layers of between 6 and 16 inches (15 and 40 cm) thick: coarse, moderately coarse, medium, moderately fine, fine, and very fine.

Climatic Classes

In our classification the cold organic soils that are frozen August 21 are recognized as a subgroup. However, it is important to differentiate between the rather cold unfrozen organic soils and the rather warm organic soils in areas such as the lower Fraser Valley, in British Columbia, and southern Ontario. The selection of appropriate climate criteria will be made by another committee, but for an example let there be a boric class and a udic class of noncryic organic soils.

Reaction Classes

Euic - pH 4.5 or more (0.01 M $CaCl_2$) in at least some part of the control section.

Dysic - pH less than 4.5 (0.01 M $CaCl_2$) in all parts of the control section.

Mineral Content Classes

The classes refer to the mean mineral content of the organic material in the middle and bottom tiers, or of the organic material above any terric, lithic, hydric, or cryic contact that occurs in the middle tier. The classes are:

clastic--contain more than 55% mineral matter but less than 70%.
ferruginous--contain more than 1% of iron.
sulfurous--contain more than 1% of sulfur.
toxic elements--Al, Zn, and others, at levels sufficient to induce toxicity in forage or vegetation.

Textural Classes of the Underlying Mineral Soil

The classes apply to the average texture of the upper 1 foot of the terric layer or to that part of the layer that is within the control section, whichever is greater. These classes apply only to Terric subgroups and are: coarse, moderately coarse, medium, moderately fine, fine, very fine, skeletal (stone with voids between) and organic skeletal (stones with organic material in the interstices).

Limnic Classes

These classes apply only to limno subgroups and are: marl, diatomaceous, and coprogenous. The sequence of names should be in the order given.

Examples of family names are (i) sphagnic, boric, coarse family; (ii) humic, boric, fine, marl family; and (iii) mesic, udic, coprogenous family.

Possible Series Criteria

The following characteristics are proposed for trial as criteria for differentiation at the series level. They are divided into two groups.

Criteria for All Families

Woody: 50% or more of the fibers are woody.

Calcareous: The calcareous grades suggested are those defined weakly, moderately, strongly, very strongly, extremely.

Bulk density: Some Humisols have quite high bulk density values ($>$0.5 g/cc) and these could be separated from other Humisols on this basis.

The composition of the inorganic fraction of the organic layers is a possible criteria.

The limnic layer on the surface or in the surface tier is also a possible criteria.

Criteria for Limno, Cumulo, Cryic, Terric, Lithic, and Hydric Subgroups

Depth classes to the contact

Very shallow: lithic or cryic contact within a depth of 12 inches (30 cm).

Shallow: any contact between depths of 12 and 36 inches (30 and 90 cm).

Deep: any contact between depths of 36 and 64 inches (90 and 160 cm).

Kind of development in the underlying mineral soil; intergrades to other orders.

Reaction of the mineral soil

dysic $<$ pH 5.5 (0.01 M $CaCl_2$)
euic $>$ pH 5.5 (0.01 M $CaCl_2$)

Mineralogy of mineral soil or cumulic layers.

Texture of cumulic layers in middle and bottom tiers.

Presence of luvic (illuvial) layer in the middle or bottom tiers with more colloidal material than the underlying peat. This layer has fine materials with a greasy, glossy appearance in fractures and in root channels. To be recognized as a differentia in classification, the illuvial humus should constitute at least half the volume of a horizon at least 2 cm thick.

Phases of the soil series could be established on the presence of logs in the organic material, stones resting on a terric layer, sloping land (appropriate to some blanket peat in Newfoundland) or any other characteristic significant to use such as anthropic (burned, scalped or mined).

REPORT OF THE SUBCOMMITTEE ON SOIL FAMILIES

R. Baril, Chairman

The concept of the soil family seeks to define the mineralogical, the organo-mineral fabrics, and the pedoclimate of soil series in general terms. From these viewpoints, interesting and new relationships can be seen amongst 3,000 Canadian soil series. Furthermore, the soil family may enable us to examine critically the limits set forth in the study of soil series or soil individuals.

The concepts developed at the order, great group, and subgroups levels have been the overall and yet vaguely defined processes of soil formation such as calcification and podzolization and their relative intensities and modal expressions of them. Deliberately the choice of criteria reflecting these processes were for each of the higher categories the nature of the solum, the presence or absence of so-called diagnostic horizons and their development within arbitrary limits, which are vague in many cases. The family concept, which is closer to the soil series, soil types, and individual soils, demands more specific limits for these diagnostic horizons or their equivalents in the soil regolith.

The soil families were thought, not so long ago, to be a means of bringing soil series into useful groupings to show soil-plant relationships. It is difficult at this time to foresee that soil families will show unknown soil-plant relationships in a better way than the soil series. Soil families per se, at any level in the system, are relevant to soil-plant relationships inasmuch as the criteria chosen are significant to these objectives. In this statement the soil family is used as a taxonomic unit.

A soil family is a group of soil series, within a subgroup, that are relatively uniform in genetic horizons, or in the properties of the soil regolith if genetic horizons are thin, faint, or absent, but at a broader degree than that used in the soil series. The soil family is therefore used to define and group together the soil series of the same subgroup, which are relatively uniform in their physical and chemical composition as found or inferred by a given set of soil properties or criteria defined below.

Control Section for Soil Family

A control section[1/] is a vertical section in the soil regolith that extends from a depth of 10 to 40 inches (1 meter) or the bottom of any

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[1/] U.S.D.A. Seventh Approximation. Supplement, p. 39, 43 and 45, March 1967.

diagnostic horizons including fragipan, whichever is deeper. Attention is centered on genetic horizons if they are well expressed and not thin. If these horizons are not well expressed or are thin, or absent, attention is centered on a corresponding portion of the regolith. In either case, the portion of the soil used in differentiating series within a family of mineral soils is as follows:

Cryic--From the mineral surface to a depth of 30 inches, or to a lithic or paralithic contact, or to a depth of 10 inches below the level at which the soil temperature is 0 C about two months after the summer solstice, whichever is shallower.

Very shallow soils--From the mineral surface down to a lithic or paralithic contact if the thickness of the regolith is 14 inches or less.

All other mineral soils--From a depth of 10 inches down to (i) a lithic contact if it is within a depth of 40 inches, (ii) a depth of 40 inches if the regolith is thicker than that, but the named diagnostic horizons and subjacent Cca horizons are not, or (iii) the bottom of the named diagnostic horizons and any subjacent Cca horizon if the thickness of both the named diagnostic horizons and the regolith exceeds 40 inches, but not below a depth of 80 inches (2 meters).

Criteria

1. Texture

a) Coarse-textured group

(1) Very coarse textured: sands and loamy sands

(2) Moderately coarse textured: sandy loams and fine sandy loams

b) Medium-textured group

(1) Medium textured: loam, silt loam, and silt

(2) Moderately fine textured: sandy clay loam, clay loam, and silty clay loam

c) Fine-textured group

(1) Fine textured: sandy clay, clay, and silty clay

(2) Very fine textured: heavy clay (more than 60% clay)

Modifiers of textural classes of series within a family of mineral soils

The two terms fragmental and skeletal qualify the very coarse nature of the soil series within a family as follows:

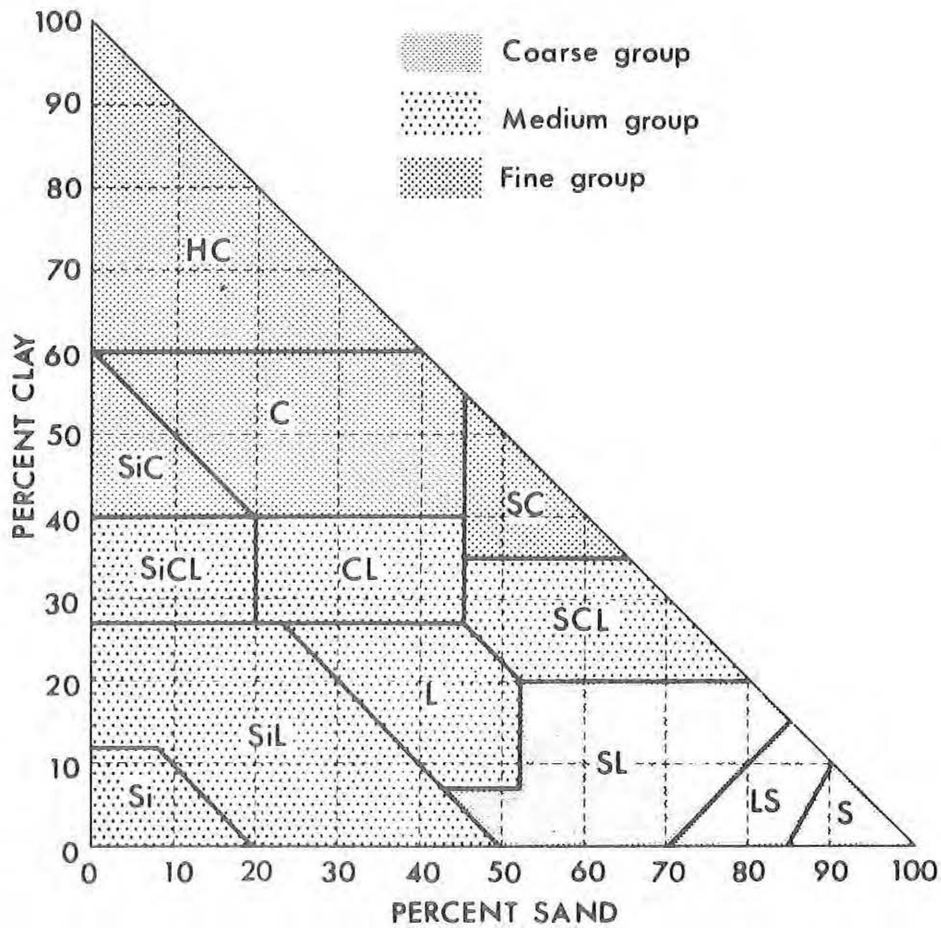

Fig. 31 The composition of family textural groups.
Percentages of clay and sand in the main textural classes of soils; the remainder of each class is silt.

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d) Fragmental: With stones (10 inches [25 cm] or more), cobbles (3-10 inches [7.2-25 cm]), gravel (1/10-3 inches [2-75 mm]) with fines too few to fill interstices larger than 1 mm. (Roughly 90% or more of coarse materials are called cobble land type.)

e) Skeletal: To modify any of the three broad textural classes given above

(1) Coarse-skeletal: having more than 35% but less than 90% by volume, coarser than 2 mm with enough fines to fill interstices larger than 1 mm; fraction less than 2 mm is defined under particle size class coarse-textured given previously.

(2) Medium-skeletal: having more than 35% but less than 90% by volume, coarser than 2 mm with enough fines to fill interstices larger than 1 mm; fraction less than 2 mm is defined under particle size class medium-textured given previously.

(3) Fine-skeletal: having more than 35% by volume, coarser than 2 mm with enough fines to fill interstices larger than 1 mm; fraction less than 2 mm is defined under particle size class fine-textured given previously.

2. Strongly Contrasting Textures or Nonconforming Layers

A nonconforming layer is one that has more than two textural classes difference within a depth of 36 inches.

The strongly contrasting textures to be recognized within the control section are given in Table 1. By definition, textures are strongly contrasting if they occur within a vertical distance of 5 inches (12.5 cm). Both textures are used in the class name, e.g., fine over coarse.

3. Mineralogy

The mineralogy classes, as reported in Table 2, are those suggested by the U.S.D.A. Seventh Approximation as amended in March 1967. An effort should be made to group soils (podzolic) according to their content in "amorphous forms of iron and aluminium oxides."

It is well to remember that: "Not all of the evidence must come from X-ray, surface, and DTA determinations. Other physical and chemical properties suggest the mineralogy of many clayey soils. Volume changes, cation exchange capacities, and consistence also are useful in estimating the nature of the clay.[2/] Mineralogy classes are based on the approximate mineralogical composition of selected size fractions of the same segment of the soil profile (control section) that is used for application of particle-size classes.

[2/] U.S.D.A. Seventh Approximation. Supplement, p. 42, March 1967.

Table 1. Possible combinations of strongly contrasting texture to be used if they occur within a vertical distance of 5 inches (12.5 cm)

	Fragmental	Coarse skeletal	Medium skeletal	Fine skeletal	Very coarse	Moderately coarse	Medium	Moderately fine	Fine	Very fine
					over					
Fragmental						X	X	X	X	X
Coarse skeletal						X	X	X	X	X
Medium skeletal										
Fine skeletal										
Coarse group	X		X	X			X	X	X	X
Medium group	X	X			X				X	X
Fine group	X	X	X		X	X	X	X		

Table 2. Key to mineralogy classes*

Class	Definition	Determinant size fraction
Fine-carbonatic	More than 1/3 of the < 0.002 mm fraction consists of carbonates and the apparent texture of the soil is fine-loamy or fine-silty or clayey. Particle-size classes are not used with this mineralogy.	< 0.002 mm
Serpentinitic	More than 40% (weight) serpentine minerals (antigorite, chrysotile, fibrolite, and talc).	Whole soil < 2 mm
Classes applied to sandy, silty, and loamy soils		
Glauconitic	More than 40% (weight) of glauconite.	Whole soil < 2 mm
Carbonatic	More than 40% (weight) carbonates (as $CaCO_3$) and gypsum, and carbonates are more than 65% of the sum of carbonates and gypsum.	Whole soil smaller than 2 mm, or whole soil smaller than 20 mm
Gypsic	Gypsum is more than 35% of the sum of carbonates and gypsum and carbonates and gypsum are more than 40% by weight.	Whole soil smaller than 2 mm, or whole soil smaller than 20 mm
Ashy	More than 60% (weight†) volcanic ash, cinders or pumice, and dominantly smaller than 2 mm.	0.02 - 20 mm
Cindery	Cindery if dominantly larger than 2 mm.	0.02 - 20 mm
Micaceous	More than 40% (weight†) mica.	0.02 - 20 mm
Siliceous	More than 90% (weight†) of silica minerals (quartz, chalcedony, opal) and other minerals with hardness of 7 or more in the Mohs scale.	0.02 - 2 mm

*Supplement to Soil Classification System (Seventh Approximation) Soil Survey Staff-SCS, U.S.D.A., Chap. 6, p. 43, March 1967. The classes: Ferritic, Gibbsitic and Oxidic are not given because they do not apply to Canadian soils.

†Weight percentages as estimated from grain counts; usually, a count of one or two dominant size fractions of conventional mechanical analysis is sufficient for the placement of the soil.

Class	Definition	Determinant size fraction
Mixed	All others, with less than 40% of any one mineral other than quartz.	
Classes applied to clayey soils		
Halloysitic	More than half by weight of halloysite with smaller amounts of allophane or kaolinite or both.	<0.002 mm
Kaolinitic	More than half by weight of kaolinite, dickite and nacrite, and with smaller amounts of other 1:1 or nonexpanding 2:1 layer minerals or gibbsite.	<0.002 mm
Montmorillonitic	More than half by weight of montmorillonite and nontronite, or a mixture with more montmorillonite than any other single clay mineral.	<0.002 mm
Illitic	More than half by weight of illite (hydrous mica) commonly with $>3\%$ K_2O.	<0.002 mm
Vermiculitic	More than half by weight of vermiculite or more vermiculite than any other single clay mineral.	<0.002 mm
Mixed	Other soils.‡	<0.002 mm

Mineralogy subclasses

Mineralogy subclasses are used in addition to mineralogy classes in some groups of soils.

Sulfureous (tentative)	Soils containing either iron sulfates, commonly jarosite (straw-colored), if the pH after oxidation is less than 3.5; or more than 0.75% sulfur in the form of polysulfides if the soil contains less than three times as much carbonate (as $CaCO_3$ equivalent) as sulfur (less than Ca^{++} than $SO_4^{=}$ if all sulfur is oxidized).	Whole soil <2 mm Histosols and Aquents only

‡Sepiolitic, more than half by weight of sepiolite, attapulgite and palygorskite, should be used if found in soils that are not fine-carbonatic.

Class	Definition	Determinant size fraction
Calcareous	Continuous presence of free carbonates in all parts of the fine earth fraction between depth of 10 and 20 inches (25 cm and 50 cm). (Use in Aquepts other than Fragiaquepts, in Aquolls, and in Entisols other than Psamments and Psammaquents.)*	Whole soil <2 mm

*As applied in the American System.

4. Depth Classes

Although the relative importance of depths of soils could vary in various provinces, the following classes for mineral soil families are used:

Micro: soils having a solum thickness of less than 7 inches (18 cm).

Shallow: soils having a solum thickness more than 7 inches (18 cm) but less than 20 inches (50 cm) to the upper boundary of a lithic or cryic contact (ice contact or <0 C two months after the summer solstice).

Lithic contact means a layer of hard rock (hardness of 3 or more on the Mohs scale). A paralithic contact is one where the rock hardness is 3 or less on the Mohs scale.

5. Pedoclimate (Inferred from Temperature and Moisture Air Data)

In order to qualify soil families with respect to temperature, either Boughner's growing degree-days during the effective growing season[3/] or the climatic zone listed by Chapman and Brown[4/] may be used.

Some provinces, such as Manitoba, have combined Chapman's climatic zones into four broad regions that appear to correlate reasonably well with major soil type changes, particularly in the transitional zones between

[3/]Boughner, C.C. 1964. Growing degree days during the effective growing season. Can. Meteor. Memoir 17.

[4/]Chapman, L.J., and D.M. Brown. 1966. The Canada Land Inventory. Report No. 3.

Chernozemic and Podzolic soils. Because of insufficient meteorological and soils data the relationship was not as good in the northern areas.

At present, Chapman and Brown's climatic zones for air temperatures are recommended. They infer that the soil temperature and moisture regimes must have a relationship with temperatures. The sandy soils would be warmer and drier than the clayey soils and the clayey soils would be cooler and more humid than the sandy soils. This is called an inferred pedoclimate.

Tables 3, 4, and 5 follow Chapman and Brown's report[5] and are used to infer the pedoclimate including temperature and moisture.

Table 3. Temperature zones

1. More than 4,000 degree-days (42 F).
2. 3,500 to 4,000 degree-days.
3. 3,000 to 3,500 degree-days.
4. 2,600 to 3,000 degree-days.
5. 2,200 to 2,600 degree-days and more than 90 frost-free days in Alberta and Saskatchewan.
6. 1,800 to 2,200 degree-days and 75 to 90 frost-free days in Alberta and Saskatchewan.
7. Less than 1,800 degree-days and less than 75 frost-free days in Alberta and Saskatchewan.

[5] Chapman, L.J., and D.M. Brown. 1966. Canada Land Inventory. The Climate of Canada. Report No. 3, p. 13-15.

Table 4. Moisture classes

Moisture class	Water deficiency (inches)	May to September Precipitation (Inches) Over 2,600 degree-days	Under 2,600 degree-days
C	Over 12	Under 6	---
D	12 - 9	6 - 8	---
E	9 - 7	8 - 11	8 - 9
F	7 - 5	10 - 12	9 - 11
G	5 - 3	12 - 13	10 - 13
H	3 - 1	13 - 15	12 - 15
K	1 - 0	15 - 16	14 - 18
L	0	---	16 - 20
M	0	---	Over 20

Table 5. All possible combinations of temperature zones and moisture classes

1. C, G
2. C, F, G, H
3. C, D, E, F, G, H, K, L, M
4. C, D, E, F, G, H, K, L, M
5. E, F, G, H, K, L, M
6. E, F, G, H, K, L, M
7. G, H

6. Reaction Classes

Three reaction classes based on the pH in 0.01 M $CaCl_2$ are suggested temporarily:

a) Acid: pH lower than 5.0 in control section.

b) Acid to neutral: pH 5.0-7.5 in at least some part of the control section.

c) Alkaline: pH higher than 7.5.

Calcareous Classes (See also Carbonatic Classes under Mineralogy Criteria)

a) Weakly calcareous: 1 to 6% $CaCO_3$ equivalent.

b) Moderately to very strongly calcareous: 6 to 40% $CaCO_3$ equivalent.

c) Extremely calcareous soil: more than 40% $CaCO_3$ equivalent.

Special Horizons

These horizons are the fragipans and the compacted layers that may occur below the solum. If fragipans are not classified in the subgroup or higher levels, they would have to be considered at the family level. The adjective fragic should be used whenever applicable at the family level.

Other Characteristics

Slope should be used as phases of families. Depending on the climatic conditions, the slope phases could vary regionally.

Stoniness is treated also as a phase separation of families. The particle-size classes given previously by using the term fragmental and skeletal cover most conditions.

Consistent Nomenclature

To have consistent nomenclature in qualifying soil families, the adjectives modifying the subgroup name are used in the following order: texture, mineralogy class and subclass, reaction, climate, depth, slope, consistence, and the name of the soil family underlined. Examples: Degraded Dystric Brunisol, coarse - skeletal, mixed, acid, climate 3L, St. Nicolas. Depth, slope, and consistence are normal, that is, without relative aberrant properties. Degraded Dystric Brunisol, coarse, mixed, climate 4K, strongly sloping, fragic, Gatineau.

REPORT OF THE SUBCOMMITTEE ON CRITERIA FOR SOIL SERIES AND TYPES

D. E. Cann, Chairman

The concept of the soil series[1] has changed considerably since soils were first mapped and classified. At the beginning of the century soils were considered to be a geological phenomenon, even though both Hilgard and Shaler had earlier recognized the soil as a natural body. In 1906 the soil series was defined as consisting of material similar in many characteristics, but grading in texture from gravel to clay. In a report of field operations for 1900 by the U. S. Bureau of Soils, Whitney reported "only such conditions as are apparent in the field such as texture as determined by feel and appearance, the depth of the soil and subsoil, the amount of gravel, the conditions as to drainage, and the native vegetation or known relation to crops, are mapped." The unit of classification, called the type, had a definite geographical expression. The grouping of types into series was based on a common geologic origin of the parent material. This led to a grouping of soil types that had few true characteristics in common. In 1912, Coffey preceded Marbut in realizing that it was necessary to recognize the inherent differences in the soil itself and consider the soil as an independent natural body.

The present concept of the soil series was developed after Marbut became head of the U. S. Bureau of Soils in 1913. He examined soils in many parts of the continent and was greatly influenced by his translation of Glinka's work[2]. He adopted the concept of the soil as an independent natural body and proposed, in 1921, that, exclusive of the texture of the surface soil, the units or groups of units based on features of the soil profiles should be soil series. Each soil series would be similar in the number, color, texture, structure, relative arrangement, chemical composition, and thickness of horizons and in the geology of the soil material. Later, he added thickness of the true soil and character of the soil material to the list of differentiating criteria.

The application of these proposals led to the recognition of the soil as a three-dimensional body occupying a geographical position on the landscape. The development of improved techniques for examining soils resulted in the substitution of "mineralogical and chemical composition" for "geology of the soil material." More recently, consistence of the soil horizons was added to the list of differentiating criteria for series.

The application of these criteria in the examination and observation of the landscape gives a mental concept of the number of series present and the differences between them. The U.S. Dep. Agr. Soil Survey Manual states (p.24) that in our minds we comprehend soils by comparison. Because the soil is a continuum, there

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[1] Much of the historical discussion was taken from Ableiter, J.K. 1949. Soil Classification in the United States. Soil Science 67: 183-192.

[2] Glinka, K.D., 1915. Pedology. St. Petersburg, 1st ed.

are no sharp boundaries between series, but the concept represents a real body that is useful as a unit in soil classification. In other words, it is not necessary to have boundaries on a map in order to use the soil series as a categorical unit in the classification system. However, we need to identify, sample, and describe these bodies so that their properties can be compared and predictions can be made about their use and management. This requires that some limit be placed on the range allowed in the characteristics, or combination of characteristics, that differentiate between one series and another. Taxonomically these limits can be as narrow as we wish, but this would create a very large number of series and difficulties in mapping them. Experience has indicated that the limits must be wide enough to permit reasonable uniformity over a practical-sized area. Thus, they must be narrow enough to keep the series as taxonomically homogeneous as possible and, at the same time, wide enough to create bodies that are of a size that can be readily identified and delineated on a map. No single characteristic can be allowed a range that would alter significantly the morphology, genesis, or use capability of the series from place to place.

Once the limits have been established, the boundaries between soil series may be delineated on a map. But, because the soil is a continuum, it is usually impractical, because of time and scale, to draw exact boundaries between the limits of one soil series and another. Usually each delineated area contains small segments of contiguous soil series. Thus, the soil series as a taxonomic unit is related to, but usually not the same as, the area delineated on a map and designated as a soil series mapping unit.

The size of a soil series on the landscape is determined by the range allowed in the differentiating characteristics. Some series have a very limited geographical extent and in the past it has been the practice to ignore these areas rather than create a new series. Recently, it has been considered desirable to have some minimum limit below which the series would not be recognized. It would serve as a unit for sampling, describing and studying the properties of the soil series. The pedon was devised for this purpose.

The pedon is the smallest volume that can be called a soil. It is a three-dimensional body large enough to permit the sampling and study of horizons. If the horizons are cyclic or intermittent within a linear distance of 2 to 7 m, the pedon may range from 1 to 10 m^2. If the horizons are continuous and the cycle is less than 2 m, the pedon occupies approximately 1 m^2. Thus the ultimate minimum size of a soil body representing a soil series would be the pedon. For practical purposes the pedon is too small an area to be represented on a map, and the soil series is regarded as being composed of a number of contiguous pedons or polypedons. The polypedon is termed a soil individual. Its size depends on the range allowed in the characteristics used to separate series, but all of its pedons have characteristics lying within the defined range. There may be one or several separate polypedons on the landscape whose differentiating properties lie within the range defined for a given series. The same soil series name would be applied to one or several collectively.

A soil series may be one or several soil bodies. Its differentiating characteristics do not have to be similar or essentially uniform in every part so long as they do not exceed the limits defined for the series. Consequently, the following definition is proposed for the soil series.

A soil series is a soil body[3] such that any profile within the body either has a similar number and arrangement of horizons whose color, texture, structure, consistence, thickness, reaction, and composition, or a combination of these, are within a defined range or, in soils without horizons, any profile has the differentiating properties, except thickness, within specified depth limits.

Guidelines for Separating Soil Series

It is difficult to establish limits between which the differentiating characteristics are allowed to range, because the taxonomic significance of a given property is not the same for all series. Nevertheless, a few guidelines for separating soils at the series level have been established. Hue, texture, coarse fragments, consistence, and mineralogy are the properties most commonly used to separate series within families.

Generally, appreciable differences in any property, or combination of properties, that have at least limited significance in soil genesis, or influence the growth of plants, and are mappable, are a basis for separating series. If the differences are significant to soil use but not to soil genesis, two or more types or phases are recognized within a series.

A distinct difference in one property, such as color of the B horizon, may be sufficient basis for recognizing another series, but usually a change in one property is accompanied by a change in others.

The range of variability of the differentiating characteristics should be somewhat narrower for the series than for the family. As a rule, moderately narrow ranges are allowed for the characteristics having the greatest number of covarying or accessory properties. Relatively small changes in these differentiae frequently produce significant changes in morphology or adaptability to plant growth. For example, texture, structure, or pH have a number of covarying properties such as exchange capacity, base saturation, water-holding capacity, or permeability.

The parent materials of all pedons in a soil series should be reasonably similar in texture and mineralogical composition.

A given series should be homogeneous, within rather narrow limits, in genesis and in all its properties, with the following main exceptions:

1. The texture of the plow layer and layers below the solum may vary, particularly in soils developed in stratified sediments.

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[3] Muir defines a soil body as a three-dimensional natural object that occurs under a cover of living vegetation and is characterized by the presence of horizons, the A horizon being in direct contact with the vegetation.

2. Properties affected by plowing and by the use of soil amendments may vary. Soils that are acid in the natural environment may be limed, changing the reaction of the surface horizon.

3. The slope may vary within limits that are highly significant to the use of the soil.

4. Salinity is permitted to vary because changes can be very rapid and drastic under irrigation.

Additional Guidelines Suggested for Consideration

Color--One of the most easily determined characteristics for differentiating between soil series is color. It is indirectly related to the organic matter content and iron and manganese oxides and may reflect properties inherited from the parent material. It is suggested that a difference of more than 2.5 units in hue between corresponding horizons should be a basis for separating series.

Texture--The range in texture allowable within a series depends on the effects of the texture on other properties of the soil. As a guideline, it is suggested that a difference of preferably one textural class, but not more than two classes, on the textural chart, should be differentiating between series.

Soil type--The members of the subcommittee were divided on whether or not the soil type should be retained as a taxonomic category, but most members favored retaining it as a useful expression. Because the properties of the plow layer can be changed at will by man, the soil type is subject to variation from place to place. It is defined as follows:

> The soil type is a subdivision of the soil series based on significant variations in the properties of the plow layer. It is the soil unit that recognizes the maximum number of differentiating characteristics of the soil profile.

REPORT OF THE SUBCOMMITTEE ON CRITERIA FOR PHASES

D. W. Hoffman, Chairman

Soil phase is a subdivision of any class in the taxonomic system but not in itself a category of the system. The basis of this subdivision may be any soil characteristic or combination of soil characteristics potentially significant to man's use or management of the land apart from the properties used in the taxonomic classification.

When used as a subdivision of a soil type for which it is most commonly used, the phase is defined and shown on the soil map on the basis of all the characteristics of the soil type, but with a narrower definition in certain features of importance to soil use than is needed for the genetic soil type. The soil type when classified and named, e.g., Fox sandy loam, stands for all its types and for the phase within the type. Therefore, if Fox sandy loam normally occurs only on one particular slope (phase) or has one particular degree (phase) of stoniness, the word phase does not appear in the type name. However, if there are a few areas where slope or stoniness differ sufficiently from the normal to affect use or management, such areas would be designated Fox sandy loam - sloping or stony phase. The phase of a soil type on detailed maps is the unit about which the greatest number of precise statements and predictions can be made concerning soil use, management, capability, and productivity.

Soil Slope Phases

Soil slope phases are named and defined in the Report on the Sixth Meeting of the National Soil Survey Committee, and are modified here. It is recommended that these phases be used as they appear in the report, with descriptive terms applied to the slopes as shown. In increasing order of slope gradient the classes and names are as follows:

Single slopes		Complex slopes		
Class	Name	Class	Name	Slope (%)
A	level	a	nearly level	0.0 to 0.5
B	very gently sloping	b	gently undulating	0.5+ to 2
C	gently sloping	c	undulating	2+ to 5
D	moderately sloping	d	gently rolling	5+ to 9
E	strongly sloping	e	moderately rolling	9+ to 15
F	steeply sloping	f	strongly rolling	15+ to 30
G	very steeply sloping	g	hilly	30+ to 60
H	extremely sloping	h	very hilly	over 60

Water-erosion Phases

The following water-erosion classes as defined in the U.S. Dep. Agr. Soil Survey Manual p. 261-264, and adopted at the 1965 N.S.S.C. meeting, have been accepted as phases:

Class W1

This is a slightly eroded phase. The soil has a few rills or places with thin A horizons that give evidence of accelerated erosion but not to an extent to alter greatly the thickness and character of the A horizon. Except for soils having very thin A horizons (less than 8 inches), the surface soil (Ap) consists entirely of an A horizon throughout nearly all of the delineated area. Up to about 25% of the original A horizon, or original plowed layer in soils with thin A horizons, may have been removed from most of the area. In most soils, areas with this class of erosion are not significantly different in use capabilities and management requirements from the uneroded soil. In a few soils having very shallow soda over a nonconforming layer, or in a few having a shallow A horizon over a claypan or hardpan, a significant difference may exist.

Class W2

This is a moderately eroded phase. The soil has been eroded to the extent that ordinary tillage implements reach through the remaining A horizon, or well below the depth of the original plowed layer in soils with thin A horizons. Generally, the plow layer consists of a mixture of the original A horizon and underlying horizons. Mapped areas of eroded soil usually have patches in which the plow layer consists wholly of the original A horizon and others in which it consists wholly of underlying horizons. Shallow gullies may be present. Approximately 25 to 75% of the original A horizon or surface soil may have been lost from most of the area.

Class W3

This is a severely eroded phase. The soil has been eroded so that all or practically all of the original surface soil, or A horizon, has been removed. The plow layer consists essentially of materials from the B or other underlying horizons. Patches in which the plow layer is a mixture of the original A horizon and the B horizon or other underlying horizons may be included within mapped areas. Shallow gullies, or a few deep ones, are common on some soil types. More than about 75% of the original surface soil, or A horizon, and commonly part or all of the B horizon or other underlying horizons, have been lost from most of the area.

Class W4

This is a gullied land phase. The land has been eroded until it has an intricate pattern of moderately deep or deep gullies. Soil profiles have been destroyed except in small areas between the gullies. The land in its present condition is not useful for crops. Reclamation for crop production or for improved pasture is difficult, but may be practicable if the other characteristics of the soil are favorable and erosion can be controlled.

Wind-erosion Phases

The following wind-erosion classes as defined in the U.S. Dep. Agr. Soil Survey Manual p. 267, and adopted at the 1965 N.S.S.C. meeting, have been accepted as phases:

Class D1

This is a wind-eroded (or blown) phase. Wind has removed from the soil a sufficient amount of the A horizon that ordinary tillage will bring up and mix the B horizon or other lower lying horizons with surface soil in the plow layer. Rarely is this condition uniform throughout a mappable area, however. Usually the plow layer consists mainly of the original A horizon in some patches, whereas in others the original A horizon is removed. Generally, about 25 to 75% of the original A horizon (or surface soil in soils with thin A horizons) may have been removed.

Class D2

This is a severely wind-eroded (or blown) phase. Wind has removed all of the A horizon and part of the B or other lower lying horizon. The plow layer consists mainly of the original horizons below the A (or below the original plowed layer in soils with thin A horizons), although some patches having much of the original A horizon remain in the area. An occasional blow-out area may be included.

Class D3

This is a blown-out land phase. The wind has removed most of the soil profile and the land is classified as a miscellaneous land type. Use of the land for ordinary agriculture is not feasible without extensive reclamation. Blow-out holes are numerous and deeply carved into the lower soil or parent material. Areas between blowouts are deeply buried by soil material from the blowouts.

Soil Deposition Phases

The phases for depositions as described by the U.S. Dep.Agr. Soil Survey Manual, p.295-296, have been suggested for trial. The two phases proposed are defined as follows:

Overblown Phase

The deposit of wind-removed material on the soil is great enough to influence management but not great enough to destroy the essential characteristics of the soil series.

Overwash Phase

Deposits from water erosion lie thick enough on the soil to influence management requirements significantly, but are not deep enough to destroy the essential characteristics of the soil series.

Stoniness and Rockiness Phases

Classes of stoniness and rockiness as defined at the 1965 N.S.S.C. meeting are phase distinctions.

The phases of stoniness are defined as follows:

Stony 1

This is a slightly stony phase, having some stones, which offer only slight to no hindrance to cultivation.

Stony 2

This is a moderately stony phase, having enough stones to cause some interference with cultivation.

Stony 3

This is a very stony phase, having sufficient stones to constitute a serious handicap to cultivation; some clearing is required.

Stony 4

This is an exceedingly stony phase, having sufficient stones to prevent cultivation until considerable clearing is done.

Stony 5

This is an excessively stony phase, being too stony to permit any cultivation (boulder or stone pavement).

The phases of rockiness are defined as follows:

Rocky 1

This is a slightly rocky phase, having sufficient bedrock exposures to interfere with tillage but not to make intertilled crops impracticable. Depending on how the pattern affects tillage, rock exposures are roughly 100 to 300 feet apart and cover about 2 to 10% of the surface.

Rocky 2

This is a moderately rocky phase, having sufficient bedrock exposures to make tillage of intertilled crops impracticable, but the soil can be worked for hay crops or improved pasture if other soil characteristics are favorable. Rock exposures are roughly 30 to 100 feet apart and cover about 10 to 25% of the surface, depending on the pattern.

Rocky 3

This is a very rocky phase, having sufficient rock outcrop to make all use of machinery impracticable, except for light machinery where other soil characteristics are especially favorable for improved pasture. The land may have some use for wild pasture or forests, depending on the other soil characteristics. Rock exposures, or patches of soil too thin over rock for use, are roughly 10 to 30 feet apart and cover about 25 to 50% of the surface,depending on the pattern.

Rocky 4

This is an exceedingly rocky phase, having sufficient rock outcrop, or insufficient depth of soil over rock, that makes all use of machinery impracticable. The land may have some value for poor pasture or for forestry. Rock outcrops are about 10 feet apart or less and cover some 50 to 90% of the area.

Rocky 5

This is an excessively rocky phase. Over 90% of the surface of the land is exposed bedrock (rock outcrop).

Soil Thickness Phases

The need for soil thickness phases is recognized, but because the definitions for these phases are vague and could conflict with the ranges permitted in series and types, it was considered best to delay recommendations until firmer criteria are obtained.

Overflow or Flooded Phases

The use of phases for overflow and flooded areas was discussed, but did not receive general approval because it was felt that flooding was a capability limitation, not a subdivision of a type or series.

Climatic Phases

The need for climatic phases has been recognized for some time and is mentioned in the U. S. Proceedings of the National Technical Work-Planning Conference of the Cooperative Soil Survey, Chicago, Ill., 1963. Such phases will be useful, but before criteria are set out for them, more information about soil moisture and soil temperature is required.

Peaty Phases

The term peaty phase should be applied to any mineral soil with a surface covering of 4 to 24 inches of fibric moss peat or 4 to 16 inches of other kinds of peat (see Gleysolic soils).

REPORT OF THE SUBCOMMITTEE ON INTERNATIONAL SOIL CORRELATION

J. S. Clayton, Chairman

An interim report on the work of this committee was presented at the sixth meeting of the National Soil Survey Committee (N.S.S.C.) held at Laval University in 1965. The report included a section on correlation of criteria for horizon identification, and a correlation table of the American and Canadian taxonomic classification systems to the subgroup level. These correlations were based on the Canadian criteria and taxonomy established at the fifth meeting of the N.S.S.C. in 1963, and the American definitions and criteria as published in 1960 and amended in 1964.

Because of the significant changes made in the Canadian system in 1965, and in expectation of revisions to the American system, the report of this subcommittee was not included in the report of the N.S.S.C. meeting in 1965. The American classification system was amended after trial use and the latest text was issued in March 1967. Subsequently additional changes have been made, including a draft classification of Histosols. A revised classification of Organic soils in the Canadian system has been prepared. Both revisions followed successful study tours and working conferences on these soils made jointly by American and Canadian pedologists.

A further development in this field has been the international correlation studies related to the production of the Soil Map of North America under the sponsorship of the FAO/UNESCO World Soil Map project. This has involved two extensive correlation tours on this continent, one in Canada in 1966, and the other in the southern United States in 1967. These studies have resulted in further modifications of the American classification of Mollisols to meet certain suggestions made by Canadian pedologists and to assist in relating the two systems to the proposed definitions of soil units, phases, and horizon designations for the World Soil Map. The latest draft of these definitions was prepared in April 1968.

We have prepared our first draft of the Canadian section of the North American map, and are in a position to assess the degree of correlation at the working level which has been achieved between the Canadian, American, and World systems, and also to indicate some of the similarities and differences.

Correlation between the Canadian, American, and World Systems

Reference Material

The Canadian definitions and criteria for horizons and taxonomic units are those contained in the Proceedings of the Seventh Meeting of the N.S.S.C., 1968.

The American criteria for mineral soils are those given in the supplement to the publication, Soil Classification, a Comprehensive System, 7th Approximation, March 24, 1967, and in a draft of changes in criteria for spodic horizons and for Borolls as received in April 1968. A preliminary classification for Histosols was issued in August 1968.

The draft definitions of soil units, soil phases, and criteria for diagnostic horizons as used for the FAO/UNESCO World projects are those proposed for use in World Soil Resources Report No. 33, April 1968, with minor revisions agreed on by correspondence, January 1969.

Comparisons and correlations have been made of criteria for horizon identification, and diagnostic horizons as used for classification in the higher taxonomic categories down to the subgroup levels of pedon identification.

Criteria of classification for families, series, and phases are not discussed in this report. The taxonomic units as given in the tables are correlated to a general modal concept for practical use rather than to an absolute correlation at the outer limits of intergrade interpretation. An attempt has been made to indicate whether the correlations are identical, closely related, or only broadly related. In some instances alternative correlations are indicated where the units as defined are inclusive within broader concepts in the alternate system.

Fundamentally, soil units in different systems can only be directly correlated when the mechanisms for horizon identification are similar. Criteria for individual horizon definitions and for diagnostic horizon combinations are the building blocks for the identification of individual profiles or pedons. These are, therefore, the most important factors basic to soil correlations and when this is achieved it is not as important that we group these individuals in precisely the same "boxes" or "shelves" in our classification or filing systems. In fact, we realize that it is impossible to do this, because it is in these respects that our classification systems differ most widely. The Americans make use of seven categories by including an Order, Suborder, Great Group, and Subgroup at the higher levels of abstraction, whereas in Canada we use six groups by not having a Suborder. At the present stage of development the World System makes use of two category separations above the map unit level. Because of local preference or significance, a soil unit may be recognized or grouped at a higher or lower level of abstraction in one or another system. This is not serious for correlation as long as we can recognize the place of the individual soil unit across all systems. With these points in mind the tables of comparisons were prepared, beginning with the comparison of criteria for horizon identification (Tables 1 and 1a) and following with tables of comparisons and correlation of the taxonomic units within the Canadian, American, and World systems (Tables 2 and 2a).

Table 1. Correlation of horizon definitions and designations[a,b,c]

1. Canadian	2. American	3. World	Comments on criteria
Of Om Oh	Oi Oe Oa	O1 Of Oh	1. Can. limits, Organic horizon >30% OM. 2,3. Amer. and World limits, lower limit of Organic horizon ranges proportionately from 20% OM with 0% clay to 30% OM with >50% clay.
L-F L-H F-H	O1 O O2	O1f O1h Ofh	1,2,3. Can., Amer., and World definitions specify dominantly aerobic accumulations and exclude peaty and Histic horizons.
A Ah Ahe	A A1 inclusive in A1	A Ah (Ah-E)	1. Limit, <30% OM. 2,3. Upper limit of OM ranges proportionately from 20% OM with 0% clay to 30% OM with clay >50%.
Ae	A2	E	3. Designation of Ae as a master E horizon.
Ap	Ap	Ap	1. 6 in. (15 cm). 2,3. Ap 7 in. (18 cm). 2. Occasionally specifies 6 in. (15 cm).
AB BA	A3 B1	AB or EB EB or BE	1,2,3. Gradual transition.
A & B	A & B	A/B	1,2,3. Indicates interfingered horizons.
AC	AC	AC	
B	B	B	1. B includes specifically alteration by reduction; 2,3, include it by inference.
Bt	B2t	Bt	1. Thickness limits, >2 in. (5 cm) or if in lamellae with total thickness >4 in. (10 cm) in upper 60 in. (150 cm). 2,3. Limits are 1/10 of all overlying horizons or >6 in. (15 cm) if eluvial-illuvial sequum is >60 in. (150 cm).
Bf	Bir	Bfe	1. Definition designates Bf as a horizon enriched with hydrated iron, not necessarily illuvial. 2. Specifies accumulation of illuvial iron as coatings. 3. Specifies accumulation of illuvial iron. 2,3. Criteria for spodic horizons are identical. 1. Criteria for f by chemistry differ from spodic criteria and are specifically defined with B combinations of h & f and f & g.
Bfh	B2hir	Bfeh	1. Can. >5% and <10% OM.
Bf			1. Bf alone <5% and with OM/oxalate Fe <20%.
Bhf	B2hir	Bhfe	1. Can. >10% OM.
Bgf	B2gir	Bgfe	1. Dithionite Fe is less than in 1C by 1% and Dithionite Al exceeds that in 1C by less than 0.5%.

a. Proceedings of Seventh Meeting of N.S.S.C. 1968.
b. U.S. Dep. Agr. Soil Survey Manual, Supplement No. 18, 1962.
c. International Society of Soil Science. Commission 5. Working Group. I.S.S.S. Bull. No. 31. 1967.

Table 1. Correlation of horizon definitions and designations Cont.

1. Canadian	2. American	3. World	Comments on criteria
Bh	Bh or B2h	Bh	1. Bh >2% OM & OM/oxalate Fe >20(Cf, Bfh). 2. Amer. >3% in spodic Ap. Specifically illuvial. 3. Specifically illuvial, criteria similar to Amer. spodic B. 3. Also used for illuvial h in peat.
Bn	B2 (natric)	Bna	1. Criteria, prismatic or columnar with exchangeable Ca/exchangeable Na <10. 2,3. Criteria similar. Prismatic or columnar with Na + Mg >Ca + H if C horizon is >15% exchangeable Na.
Bm	B2 (cambic)	Bs(cambic)	1. Bm would qualify as inclusive within Amer. and World concepts for cambic B. 1. Note Can. use of (m) differs from Amer. and World use of m (concretionary).
Bg	Bg B2g	Bg	1,2,3. Criteria are similar, indicating strong mottling and distinctive chroma but without specific chemical criteria.
C	C	C	3. World system proposes a specific designation for a master G horizon, otherwise 1,2,3 are identical conventions.
IIC	IIC	IIC	
Cca	Cca	Cca	1. Limits 4 in. (10 cm). 2,3. Limits 6 in. (15 cm) for calcic C horizon.
Csa	Csa	Csa	1. sa includes gypsum. 2,3. sa does not include gypsum.
-	Csi	-	2. Silica cementation. 1,3. No equivalent.
-	Cs	Cs	2,3. Accumulation of $CaSO_4$. 1. No Can. equivalent.
R	R	R	1,2,3. Similar convention for consolidated bedrock.
Other suffixes			Other suffixes that are used similarly for all horizons: A, B, or C.
b	b	b	1,2,3. Buried horizons.
c	m	m	1. Symbol different from 2 and 3 for cementation.
cc	cn	cn	1. Symbol different from 2 and 3 for cemented pedogenic concretions.
g	g	g	1,2,3. Similar. Characteristics of gleying.
j	-	-	2,3. No equivalent for weakly expressed characteristic failing to meet specific limits.
k	-	-	1. No equivalent in 2 and 3 for occurrence of CO_3 detectable by visible effervescence with HCl.
s	-	-	1. No equivalent in 2 and 3 for visible occurrence of soils not meeting specifications for sa.

Table 1. Correlation of horizon definitions and designations Conc.

1. Canadian	2. American	3. World	Comments on criteria
sa	sa	sa	1. Limits include soluble gypsum and thickness >4 in. (10 cm) and mmhos/cm 4 or >4. 2,3. Based on horizon >6 in. (15 cm) and >2% salts more soluble than gypsum. Cf salic horizon.
ca	ca (calcic)	ca (calcic)	1. Limits calcic >4 in. (10 cm). 2,3. Limits calcic >6 in. (15 cm).
x	x	x	1,2,3. Fragipan. Similar characteristics.
z	f	-	1. Permanently frozen layer. 2. Thought to be permanently frozen. 3. No symbol.
-	-	ox	3. Residual accumulation of sesquioxides as in Latosols. 1 & 2, no equivalent.
-	-	s	3. Accumulation of clay by alteration in situ with change in structure. 1,2. No direct equivalent although it would be included in Can. Bm or Amer. Cambic B2.

Table 1a. Correlation of American and World diagnostic horizons and combinations with Canadian equivalents

1. American	2. World	3. Canadian	Comments
Mollic Epipedon	Melanic A	Chernozemic A	With high base status.
Anthropic A	Melanic A	Ah	
Umbric Epipedon	Sombric A	Ah	With low base status.
Histic Epipedon	Histic A	Of, Om, Oh	3. cf Can. Peaty phase.
Ochric epipedon	Pallid A	Thin or Weak A	3. As defined.
Plaggen	-	-	3. Included in Ap.
Albic horizon	Albic E	Ae	
Argillic horizon	Argilluvic B	Bt	
Agric horizon	Argilluvic B	Illuvial B	1,2,3. Formed under cultivation.
Natric horizon	Natric B horizon	Bn	cf definitions. 1. Not identical with 2 and 3.
Spodic horizon	Spodic B horizon	Bf,Bfh,Bhf,Bh,Ap	3. Can. criteria not identical with 2 and 3.
Cambic horizon	Cambic B horizon	Bm, Bg, Btj	
Oxic horizon	Oxic B horizon	-	3. No Can. equivalent.
Duripan	Duripan	c	3. c if cemented by Ca.
Durinodes	-	cc	3. cc cemented concretions.
Fragipan	Fragipan	Bx or Cx	
Calcic horizon	Calxic horizon	Bca or Cca	3. If Bca or Cca >6 in. (15 cm). 3. Can. limits >4 in. (10 cm).
Petro-calcic	Petro-calcic horizon	Bcac or Ccac	
Gypsic	Gypsic	Asa, Bsa, Csa	3. Only if sa horizon is dominantly $CaSO_4$.
Salic	Salic	Asa, Bsa, Csa	3. If sa horizon >6 in. and >2% salts. 3. Can. limits >4 in. (10 cm).
Placic	Placic	Bfc or Bfhc	
Plinthite	Plinthic horizon	-	3. No Can. equivalent.
Lithic contact	Lithic & Paralithic grouped together	R	3. Consolidated bedrock.
Paralithic contact	Lithic & Paralithic grouped together	IICc	-
g	Gleyic horizon	g	1,3. Equivalent to g subscript.

Table 2. Taxonomic correlation[1]

1. Canadian	2. American	3. World	Comments on criteria
1. Chernozemic	Borolls (minor Rendolls)	Castanozems Chernozems (minor Rendzinas)	1. Chernozemic Ah 2. Mollic Epipedon 3. Melanic A
1.1 Brown (Light Chestnut)	Aridic Boroll subgroups	Castanozems (aridic)	3. Borustic aridic climate
1.11 Orthic Brown Bm, Btj Orthic Brown Bt	Aridic Haploboroll Aridic Argiboroll	Haplic Castanozem Luvic Castanozem	1. Bm, 2 & 3. cambic B 1. Bt, 2 & 3. textural B
1.12 Rego Brown Ah,Ck,C Rego Brown Ahk,Cca,C	Entic Aridic Haploboroll Aridic Calciboroll	Haplic Castanozem Calcic Castanozem	1,2,3. No cambic B 1,2,3. With calcic horizon
1.13 Calcareous Brown Ah,Bmk,Ck,C Ah,Bmk,Cca,C	 Typic Aridic Haploboroll Haplic Aridic Calciboroll	 Haplic Castanozem Calcic Castanozem	 2,3. With cambic B 2,3. With cambic B & calcic Ca
1.14 Eluviated Brown Ah,(Ahe),Ae,Bt,C Ah,(Ahe),AB,Bt or Btj,C (cumulic type)	 Albic Aridic Argiboroll Pachic Aridic Argiboroll	 Luvic Castanozem Luvic Castanozem	 2. Albic, 3. E horizon 2. Cumulic A or AB >20 in.
1.11/2.11 Solonetzic Brown Ah,Bnjt,C	 Aridic Argiboroll	 Luvic Castanozem	 2,3. Bnjt will not meet limits of natric B or Bna
1.14/2.21 Solodic Brown Ah,(Ahe),Ae or AB,Bnjt	 Albic (Aridic) Argiboroll	 Luvic Castanozem	
1.1-/5 Saline Brown	Add Salic to above groups	Add Saline phase	1. S or Sa, 2 & 3. Sa horizons
1.1-/6 Carbonated Brown	Calciboroll or Aquic Calciboroll	Calcic Castanozem	2. Aquic if mottled

[1] Only diagnostic horizons pertinent to the appropriate correlation are underlined.

Table 2. Taxonomic correlation Cont.

1. Canadian	2. American	3. World	Comments on criteria
1.1-/7 Grumic Brown	Ustertic Haploboroll	Chromic Vertisol	2. Dry value >4.5, >35% clay with cracking 3. If moist chroma >1.5 with cracking
1.1-/8 Gleyed Brown	Add Aquic to group	No equivalent	2. With slight mottling
1.2 Dark Brown (Dark Chestnut)	Typic Boroll subgroups	Castanozems (typic)	3. Borustic typic climate
1.21 Orthic Dark Brown			
Bm,Btj	Typic Haploboroll	Haplic Castanozem	1. Bm, 2 & 3. with cambic B
Bt	Typic Argiboroll	Luvic Castanozem	1. Bt, 2 & 3. textural B
1.22 Rego Dark Brown			
Ah,Ck,C	Entic Haploboroll	Haplic Castanozem	1,2,3. No cambic B
Ahk,Cca,C	Typic Calciboroll	Calcic Castanozem	1,2,3. With calcic horizon
1.23 Calcareous Dark Brown			
Ah,Bmk,Ck,C	Typic Haploboroll	Haplic Castanozem	2,3. With cambic B
Ah,Bmk,Cca,C	Haplic Calciboroll	Calcic Castanozem	2,3. With cambic B & calcic Ca
1.24 Eluviated Dark Brown			
Ah,(Ahe),Ae,Bt,C	Albic Argiboroll	Luvic Castanozem	2. Albic, 3. E. horizon
Ah,(Ahe),AB,Bt or Btj,C cumulic type	Pachic Argiboroll	Luvic Castanozem	2. Cumulic A or AB >20 in.
1.21/2.11 Solonetzic Dark Brown			
Ah,Bnjt,C	Typic Argiboroll	Luvic Castanozem	2,3. Bnjt will not meet limits of natric B or Bna
1.24/2.21 Solodic Dark Brown			
Ah,(Ahe),Ae or AB,Bnjt	Albic Argiboroll	Luvic Castanozem	

Table 2. Taxonomic correlation Cont.

1. Canadian	2. American	3. World	Comments on criteria
1.2-/5 Saline Dark Brown	Add Salic to above groups	Add Saline phase	1. S or Sa, 2 & 3. with Sa horizon
1.2-/6 Carbonated Dark Brown	Calciboroll or Aquic Calciboroll	Calcic Castanozem	2. Use Aquic if mottled
1.2-/7 Grumic Dark Brown	Vertic Haploboroll	Chromic Vertisol	2. Dry value <4.5, $>35\%$ clay with cracking 3. Moist chroma >1.5 with cracking
1.2-/8 Gleyed Dark Brown	Add Aquic to group	No equivalent	2. With slight mottling
1.3 Black	Udic Boroll subgroups (minor Rendolls)	Chernozem (minor Rendzinas)	3. Borudic climate 2,3. Rendolls & Rendzinas if C horizon $>40\%$ CO_3
1.31 Orthic Black Bm,Btj	Udic Haploboroll	Haplic Chernozem	1. Bm, 2 & 3. with cambic B
Orthic Black Bt	Udic Argiboroll	Luvic Chernozem	1. Bt, 2 & 3. with textural B
1.32 Rego Black Ah,Ck,C	Entic Udic Haploboroll (minor Cryic Rendoll)	Haplic Chernozem (minor Rendzina)	1,2,3. No cambic B 2,3. C horizon $>40\%$ CO_3
Rego Black Ahk,Cca,C	Udic Calciboroll	Calcic Chernozem	1,2,3. With calcic horizon
1.33 Calcareous Black			
Ah,Bmk,Ck,C	Udic Haploboroll	Haplic Chernozem	2,3. With cambic B
Ah,Bmk,Cca,C	Haplic Udic Calciboroll	Calcic Chernozem	2,3. With cambic B & calxic Ca
1.34 Eluviated Black			
Ah,(Ahe),Ae,Bt,C	Albic Udic Argiboroll	Luvic Chernozem	2. Albic, 3. E horizon
Ah,(Ahe),AB,Bt or Btj,C (cumulic type)	Pachic Udic Argiboroll	Luvic Chernozem	2. Cumulic A or AB >16 in.
1.31/2.12 Solonetzic Black Ah,Bnjt,C	Udic Argiboroll	Luvic Chernozem	2,3. Bnjt will not meet limits of natric B or Bna

Table 2. Taxonomic correlation Cont.

1. Canadian	2. American	3. World	Comments on criteria
1.34/2.22 Solodic Black Ah, (Ahe), Ae or AB, Bnjt	Albic Udic Argiboroll	Luvic Chernozem	
1.3-/5 Saline Black	Add Salic to above groups	Add Saline phase	1. S or Sa, 2 & 3. with Sa horizon
1.3-/6 Carbonated Black	Udic Calciboroll or Aquic Calciboroll	Calcic Chernozem	2. Use Aquic if mottled
1.3-/7 Grumic Black	Udertic Haploboroll	Pellic Vertisol	2,3. Moist Chroma < 1.5, > 35% clay with cracking
1.3-/8 Gleyed Black	Add Aquic to group	No equivalent	2. With slight mottling
1.4 Dark Gray	Boralfic Boroll subgroups	Chernozem	Borudic-udoboric transitional climate
1.41 Orthic Dark Gray			
(L-H), Ah, Ahe, Bm, Btj, C	Boralfic Haploboroll	Haplic Chernozem	1. Bm, 2,3. with cambic B
(L-H), Ah, Ahe, Ae, Bt, C	Albic Boralfic Argiboroll	Luvic Chernozem	1. Bt, 2,3. with textural B 3. May include Haplic & Luvic Phaeozems if lacking a Cca
1.42 Rego Dark Gray			
L-H, Ah, Ahe, Ck, C	Entic Boralfic Haploboroll	Haplic Chernozem	1,2,3. No cambic B
L-H, Ah, Ahe, Cca, C	Boralfic Calciboroll	Calcic Chernozem	1,2,3. With calcic horizon
1.43 Calcareous Dark Gray			
(L-H), Ah, Ahe, Bmk, Ck, C	Boralfic Haploboroll	Haplic Chernozem	2. Dry value < 5 with some
(L-H), Ah, Ahe, Bmk, Cca, C	Haplic Boralfic Calciboroll	Calcic Chernozem	expression of albic horizon
1.41/2.12 Solonetzic Dark Gray (L-H), (Ah), Ahe, (Ae), Bnjt, C	Boralfic Argiboroll	Luvic Chernozem	2,3. Bnjt will not meet limits of natric B or Bna

Table 2. Taxonomic correlation Cont.

1. Canadian	2. American	3. World	Comments on criteria
1.41/2.22 Solodic Dark Gray (L-H),(Ah),Ahe, Ae or AB,Bnjt	Boralfic Argiboroll	Luvic Chernozem	
1.4-/6 Carbonated Dark Gray	Boralfic Calciboroll	Calcic Chernozem	2. Use Aquic if mottled
1.4-/8 Gleyed Dark Gray	Add Aquic to group	No equivalent	2. With slight mottling
2. Solonetzic	Natric great groups	Solonetz	1. Bn. Ratio Ca/Na <10 + Csa 2,3. Natric B & Saline C
2.1 Solonetz Bnt,Cs,Csa	Natric great groups	Humic, Haplic, and Gleyic Solonetz	1. Presence of Bn,Cs,Csa 2. Presence of Natric B & Csa 3. Presence of Bna & Csa
2.11 Brown Solonetz Ah or Ahe and/or Ae,Bnt,Csa,Cs	Aridic Natriboroll Typic Natriboroll	Humic Solonetz Humic Solonetz	1,2,3. If Ap >4.5 dry 1,2,3. If Ap >3.5 dry 3. Melanic A
2.11/er. Eroded phase (Ahe),(Ae),Bnt,Csa	Mollic Natrargid or Typic Natrargid	Haplic Solonetz Haplic Solonetz	2,3. Ap>4 moist & >6 dry 2,3. Ap<4 moist & <6 dry
2.12 Black Solonetz	Udic Natriboroll Typic Natriboroll	Humic Solonetz	3. Melanic or Sombric A with Bna 2. Udic if chroma <1.5 Typic if chroma >1.5
2.13 Gray Solonetz L-H,(Ah),(Ahe),Ae, Bnt,Csa	Natriboralf	Haplic Solonetz	3. In udoboric climate phase with Pallid A
2.14 Alkaline Solonetz (Ah),Bn or Bntj,Cs,Csa	Natriboroll or Natrargid	Humic Solonetz or Haplic Solonetz	2,3. If with Mollic or Melanic A 2,3. If with Pallid A

Table 2. Taxonomic correlation Cont.

1. Canadian	2. American	3. World	Comments on criteria
2.1-/8 Gleyed Solonetz	Add Aquic or Aquic subgroup of Natraquolls Natralbolls	Gleyic Solonetz	2. If without Aeg 2. If with Aeg
2.2 Solod	Glossic Natribolls or Natralbolls	Solodic Planosols	3. If with E, EB, & Bt horizons 2. Natralbolls if with Aeg or Bng
2.21 Brown Solod Ah, Ahe, Ae, AB, Bnt, Cs, Sa	Glossic Aridic Natriboroll Glossic Natriboroll	Solodic Planosols (Humic)	2. Aridic, dry value >4.5 2. Typic dry value <4.5 moist chroma >1.5
2.22 Black Solod	Glossic Udic Natriboroll	Solodic Planosols (Humic)	2. With moist chroma <1.5 Ap
2.23 Gray Solod	Glossic Natriboralf	Solodic Planosols (Haplic)	3. An EB, has an eluviated columnar structure
2.2-/8 Gleyed Solod	Natralboll	Solodic Planosol	2. Solods are not fully worked out in Amer. and World systems
3. Luvisolic	Alfisols Boralfs, Udalfs	Luvisols Albic Luvisols	2,3. Boreal climates 2,3. Temperate climate Udic
3.1 Gray Brown Luvisol (Gray Brown Podzolic) Ah, Ae, Bt, C	Hapludalfs or Glossudalfs	Albic Luvisol	2,3. Ae or interfingered AB 2. With tonguing, AB or EB
3.11 Orthic Gray Brown Luvisol (L-H), Ah, Ae, (AB), BA, Bt, C	Typic Hapludalf or Mollic Hapludalf	Albic Luvisol	2. Ap moist color value >4 or dry color >6 2. Ap moist color <4, dry <6
3.12 Brunisolic Gray Brown Luvisol	Ochreptic Hapludalf	Albic Luvisol	2,3. Udic climate 3. Intergrading to Cambisol

Table 2. Taxonomic correlation Cont.

1. Canadian	2. American	3. World	Comments on criteria
3.13 Bisequa Gray Brown Luvisol	Orthodic Hapludalf	Albic Luvisol	3. Intergrading to Podzol
3.1-/8 Gleyed Gray Brown Luvisol	Add Aquic to group	Gleyic Albic Luvisol	
3.2 Gray Wooded (Gray Luvisol)	Boralfs. a Eutroboralfs b Cryoboralfs c Pergelic Cryoboralfs	Albic Luvisol	2. Boreal climates, MAST <47 F 2a. MSST >59 F 2b. MSST <59 F 2c. MAST <32 F
3.21 Orthic Gray Wooded (Orthic Gray Luvisol)	Typic Cryoboralf	Albic Luvisol	2. Ap moist value >3.5 dry value >5.0
3.22 Dark Gray Wooded (Dark Gray Luvisol)	a Typic Cryoboralf b Mollic Cryoboralf	Albic Luvisol	2a. Ap dry value >3.5 & <5.0 2b. Mollic if Ap moist color value <3 or Ap 6 in. moist color value <3.5
3.2-/3 Brunisolic Gray Wooded (Brunisolic Gray Luvisol)	a Dystrochreptic Cryoboralf b Dystrochreptic Mollic Cryoboralf	Albic Luvisol	3. Intergrading to Cambisol 3. Intergrading to Cambisol
3.2-/4 Bisequa Gray Wooded (Bisequa Gray Luvisol)	Orthodic Cryoboralf	Albic Luvisol	3. Intergrading to Podzol
3.2-/8 Gleyed Gray Wooded (Gleyed Gray Luvisol)	Add Aquic to group	Gleyic Albic Luvisol	
3.2-/2.23 Solodic Gray Wooded (Solodic Gray Luvisol)	Glossic Cryoboralf	Albic Luvisol	2. With EB or AB

Table 2. Taxonomic correlation Cont.

1. Canadian		2. American	3. World	Comments on criteria
4.	Podzolic	Spodosols a. Humods b. Orthods	Podzols	1. With illuvial Bh,Bhf,Bfh,Bf 2,3. With Spodic B horizons
4.1	Humic Podzol Bh	Humods a. Cryohumods b. Haplohumods	Humic & Placic Podzols	1,2,3. B does not turn redder on ignition 2a. Boreal climate. 2b. Udic
4.11	Orthic Humic Podzol Bh	2a. Cryohumod 2b. Typic Haplohumod	Humic Podzol	
4.12	Placic Humic Podzol Bh,Bc	Placohumod	Placic Podzol	
4.1-/8	Gleyed Humic Podzol Bg	Add Aquic to group	Gleyic Podzol	
4.2	Ferro-Humic Podzol Ae,Bhf	2a. Humic Cryorthod 2b. Humic Haplorthod	Humo-Ferric Podzol	1. Bhf >10% OM, turns red on ignition 2a. Boreal. 2b. Udic climate
4.21	Orthic Ferro-Humic Podzol Ae,Bhf	Humic Cryorthod Humic Haplorthod	Humo-Ferric Podzol	
4.22	Mini Ferro-Humic Podzol Aej,Bhf	Haplic Humic Cryorthod	Humo-Ferric Podzol	
4.23	Sombric Ferro-Humic Podzol Ah,Aej,Bhf	Umbric Humic Cryorthod	Humo-Ferric Podzol	
4.21-/4	Placic Ferro-Humic Podzol Ah,Aej,Bhf,Bc	(Humic) Placorthod	Placic Podzol	

Table 2. Taxonomic correlation Cont.

1. Canadian	2. American	3. World	Comments on criteria
4.2-/8 Gleyed Ferro-Humic Podzol	Add Aquic to group	Gleyic Podzol	
4.3 Humo-Ferric Podzol Bfh or Bf	Cryorthod or Haplorthod	Humo-Ferric Podzol	1. Bfh,Bf with <10% OM turns red on ignition
4.31 Orthic Humo-Ferric Podzol	Typic Cryorthod or Haplorthod	Humo-Ferric Podzol	
4.32 Mini Humo-Ferric Podzol Aej	Haplic Cryorthod	Humo-Ferric Podzol (Ochric Podzol)	1. Minimal Aej 3. (Definition under consideration)
4.33 Sombric Humo-Ferric Podzol Ah	Umbric Haplorthod	Humo-Ferric Podzol	2,3. Udic climate
4.31-/4 Placic Humo-Ferric Podzol Bfh,Bf,Bc	Placorthod	Placic Podzol	
4.3-/5 Bisequa Humo-Ferric Podzol	Boralfic Cryorthod or Alfic Haplorthod	Humo-Ferric Podzol	1,2. With Bt
4.3-/8 Gleyed Humo-Ferric Podzol	Add Aquic to group	Gleyic Podzol	
4.31 or 4.32 Cryic Humo-Ferric Podzol	Pergelic Leptic Cryorthod	Humo-Ferric Podzol	1,2,3. Cryic climate
5. Brunisolic	Inceptisols	Cambisols	1,2,3. Bm or cambic B excluding Mollisols
5.1 Melanic Brunisol (Brown Forest)	(Mollic) Eutrochrepts	Eutric Cambisols	2. Ap value <4 moist, <6 dry or Ah >6 in. value <3.5 moist

Table 2. Taxonomic correlation Cont.

1. Canadian	2. American	3. World	Comments on criteria
5.11 Orthic Melanic Brunisol	(Mollic) Eutrochrept	Eutric Cambisol	
5.12 Degraded Melanic Brunisol (Degraded Brown Forest) Ah,Aej,Bm,Btj,Ck	(Mollic) Alfic Eutrochrept	Eutric Cambisol	
5.1-/8 Gleyed Melanic Brunisol	Add Aquic to group		
5.2 Eutric Brunisol (Brown Wooded) L-H,(Ah),Bm,Ck	2a. Eutrochrepts 2b. (Eutric) Cryochrepts	Eutric Cambisols	2a. Udic temperature 2b. Boreal climate
5.21 Orthic Eutric Brunisol L-H,(Ah),Bm,Ck	2a. Typic Eutrochrept 2b. (Eutric) Cryochrept	Eutric Cambisol	
5.22 Degraded Eutric Brunisol			
L-H,Ae,Aej,Bm,Ck	2a. Alfic Eutrochrept 2b. Alfic Cryochrept	Eutric Cambisol	
L-H,(Ah),Ae,Bfj*, Ck	2b. Spodic Cryopsamment 2a. Spodic Udipsamment	Dystric Cambisol	*Bfj used to indicate some spodic characteristics of Bm
L-H,(Ah),Ae,Btj,C	2b. Alfic Dystric Cryochrept 2a. Alfic Dystrochrept 2c. Alfic Eutrochrept	Dystric Cambisol	2c. If base sat. >60% and with CO_3 in some horizon
5.23 Alpine Eutric Brunisol	2a. (Eutric) Cryochrept or 2b. Lithic Pergelic Cryochrept	Eutric Cambisol	2a. Cryic climate 2b. With lithic contact <20 in.
5.2-/7 Cryic Eutric Brunisol	Pergelic Cryochrept	Tundric Cambisol	Cryic with permafrost
5.2-/8 Gleyed Eutric Brunisol	Add Aquic to group	Eutric Cambisol	

Table 2. Taxonomic correlation Cont.

1. Canadian		2. American	3. World	Comments on criteria
5.3	Sombric Brunisol (Acid Brown Forest)	2a. Umbric Dystrochrept 2b. Typic Eutrochrept 2c. Dystric Eutrochrept	Humic Cambisol	2a. Base sat. $< 60\%$ with no CO_3 in any horizon 2b. Base sat. $> 60\%$ with CO_3 in some horizon 2c. Base sat. $\geq 60\%$ with no CO_3 in any horizon
5.31	Orthic Sombric Brunisol	Umbric Dystrochrept	Humic Cambisol	
5.31-/8	Gleyed Sombric Brunisol	Add Aquic to group		
5.4	Dystric Brunisol (Acid Brown Wooded)	2a. Dystrochrepts 2b. Dystric Cryochrepts	Dystric Cambisol	2a. Udic temperate climate 2b. Boreal climate
5.41	Orthic Dystric Brunisol	2a. Typic Dystrochrept 2b. Typic Dystric Cryochrept	Dystric Cambisol	
5.42	Degraded Dystric Brunisol L-H, Aej, Ae, Bm or Bmcc, C	2b. Orthodic Cryochrept 2a. Orthodic Dystrochrept	Dystric Cambisol	2a. Spodic Cryopsamment if texture is LS or S
5.43	Alpine Dystric Brunisol	2a. Dystric Cryochrept or 2b. Lithic Pergelic Cryochrept	Dystric Cambisol	2a. Cryic climate 2b. With lithic contact ≤ 20 in.
5.4-/7	Cryic Dystric Brunisol	Pergelic Dystric Cryochrept	Tundric Cambisol	Cryic with permafrost
5.4-/8	Gleyic Dystric Brunisol	Add Aquic to group		
6.	Regosolic	Entisols	Fluvisols & Rhegosols	
6.1	Regosol	Entisols	Fluvisols & Rhegosols	

Table 2. Taxonomic correlation Cont.

1. Canadian		2. American	3. World	Comments on criteria
6.11	Orthic Regosol	2a. Udorthents 2b. Cryorthents 2a. Udipsamments 2b. Cryopsamments	3a. Dystric Rhegosols 3b. Eutric Rhegosols	2a. Temperate climates 2b. Boreal climate 3a. pH (KCl) <4.2 3b. pH (KCl) >4.2
6.12	Cumulic Regosol	2b. Cryofluvents 2a. Udifluvents	3b. Eutric Fluvisols 3a. Dystric Fluvisols	
6.1-/5	Saline Regosol	Add Salic	Salic Phase	
6.1-/7	Cryic Regosol	Add Pergelic	Rhegosol (Tundric)	Cryic climate with permafrost 3. (Definition under consideration)
6.1-/8	Gleyed Regosol	Add Aquic to group		
6.1-/9	Lithic Regosol	Add Lithic to group	3a. Lithosol or 3b. Rhegosol	3a. If lithic contact <25 cm 10 in.
7.	Gleysolic	Aqu- suborders	Gleysols & Planosols	Characteristics associated with wetness
7.1	Humic Gleysol	2a. Aquolls 2b. Humaquepts	3a. Humic & Calcic Gleysols 3b. Humic Gleysol	2a-3a. High base status, Mollic Melanic 2b-3b. Low base status, Umbric Sombric
7.11	Orthic Humic Gleysol Ah, Bg, Cg	2a. Haplaquoll 2b. Cryaquoll 2c. Humaquept	Humic Gleysol Humic Gleysol	2a. Temperate 2b. Boreal climate 2c. Low base status, Umbric
7.12	Rego Humic Gleysol a. Ah, Cg or b. Ah, Ckg	a. Typic Aquoll or Typic Humaquept b. Calcic Aquoll	Humic Gleysol	2a. Cryaquoll or Haplaquoll

Table 2. Taxonomic correlation Cont.

1. Canadian		2. American	3. World	Comments on criteria
7.13	Fera Humic Gleysol Ah,Bgf,Cg	2a. Sideric Humaquept or 2b. Sideric Aquoll	Humic Gleysol	2ab. Assuming that Bgf is cambic, not spodic
7.1-/5	Saline Humic Gleysol	Add Salic to group	Saline phase	
7.1-/6	Carbonated Humic Gleysol	2a. Calciaquoll 2b. Calcic Cryaquoll	Calcic Gleysol	2a. Temperate 2b. Boreal climate
7.1-/7	Cryic Humic Gleysol	2a. Pergelic Cryaquoll	Humic Gleysol	2a. Cryic with permafrost
7.2	Gleysol	Aquents, Fluvents, Aquepts	Fluvic or Haplic Gleysols	Ochric Epipedon or Pallid A Fluvents or Fluvic if coarse texture
7.21	Orthic Gleysols	Typic Cryaquept or Typic Haplaquept	Haplic Gleysol	Boreal or Temperate climate
7.22	Rego Gleysol	Entic or Calcic Cryaquept or Haplaquept	Haplic Gleysol	Boreal or Temperate, no cambic B
7.23	Fera Gleysol	2a. Sideric Cryaquept 2b. Sideraquod or Sideric Cryaquod	Haplic Gleysol	2a. Bgf cambic 2b. Bgf illuvial, spodic
7.2-/5	Saline Gleysol	Add Salic to group	3a. Salic Gleysol 3b. Sodic Gleysol	3a. With Cg Sa 3b. With Cn-natric horizon
7.2-/6	Carbonated Gleysol	Calcic Cryaquent or Calcic Haplaquent	Calcic Gleysol	
7.2-/7	Cryic Gleysol	Add Pergelic to group	Tundric Gleysol	Cryic climate with permafrost
7.3	Eluviated Gleysol	2. Albolls, Aquolls, Aqualfs	3. Planosols	2,3. Occurrence of albic or E horizons

Table 2. Taxonomic correlation Cont.

1. Canadian		2. American	3. World	Comments on criteria
7.31	Humic Eluviated Gleysol	2a. Typic Argialboll 2b. Argic Cryaquoll or Cryic Argialboll 2c. Mollic Albaqualf	Humic Planosol	2a. With abrupt textural B 2b. Boreal climate 2c. With Mollic Ap moist value <4
7.32	Low Humic Eluviated Gleysol	Typic Albaqualf or Glossaqualf	Haplic Planosol	
7.33	Fera Eluviated Gleysol	2a. Sideric Cryaquod 2b. Sideric Glossaqualf or Sideric Albaqualf	Haplic Planosol	If illuvial Bgf with Btgf
Peaty Phases of Gleysols		Add Histic to above groups	Histic Gleysols	
8.	Organic Order	Histosols	Histosols 3a. Dystric 3b. Eutric	 3a. pH in KCl <4.2 3b. pH in KCl >4.2
8.1	Fibrisol	Fibrist 2a. Medifibrist 2b. Borofibrist 2c. Cryofibrist		 2a. Temperate 2b. Boreal 2c. Cryic with MAST <0 C
8.11a	Fenno-Fibrisol	Fibrist		
8.11b	Hypno-Fibrisol	Fibrist		
8.11c	Sphagno-Fibrisol	Fibrist		
8.12	Mesic Fibrisol	Hemic Fibrist		
8.13	Humic Fibrisol	Sapric Fibrist		

Table 2. Taxonomic correlation Conc.

1. Canadian	2. American	3. World	Comments on criteria
8.1-/4 Limno	Add Limnic		
8.1-/5 Cumulo	Add Fluventic		
8.1-/6 Terric	Add Terric		
8.1-/7 Cryic	Pergelic Cryofibrist		Cryic with permafrost
8.1-/8 Hydric			
8.1-/9 Lithic	Add Lithic		
8.2 Mesisol	Hemist		
8.21 Typic Mesisol	Typic Hemist		
8.22 Fibric Mesisol	Fibric Hemist		
8.23 Humic Mesisol	Sapric Hemist		
8.2-/4,-/5,-/6,-/7,-/8,-/9	As above		
8.3 Humisol			
8.31 Typic Humisol	Typic Saprist		
8.32 Fibric Humisol	Fibric Saprist		
8.33 Mesic Humisol	Hemic Saprist		
8.3-/4,-/5,-/6,-/7,-/8,-/9	As above		

Table 2a. Taxonomic correlation at great group level

1. Canadian	2. American	3. World	Comments
1. Chernozemic	Borolls	Castanozems 3a Chernozems 3b	Boreal semi-arid Boreal sub-humid
1.1 Brown (Light Chestnut)	Aridic Borolls	Aridic Castanozems	Borustic - aridic
1.2 Dark Brown (Dark Chestnut)	Typic Boroll	Typic Castanozems	Borustic - typic
1.3 Black	Udic Boroll	Chernozem	Borudic climate
1.4 Dark Gray	Boralfic Boroll	Chernozem	Borudic - Udoboric
2. Solonetzic	Natric great groups	Solonetz	Boreal and
2.1 Solonetz	Natric great groups	Humic, Haplic, and Gleyic Solonetz	Ustic climates
2.2 Solod	Glossic Natribolls and Natralbolls	Solodic Planosols	
3. Luvisolic	Alfisols	Luvisols	
3.1 Gray Brown Luvisol	Udalfs	Albic Luvisols	Moist temperate Udic climate
3.2 Gray Luvisol	Boralfs	Albic Luvisols	Boreal climate
4. Podzolic	Spodosols	Podzols	Boreal and
4.1 Humic Podzol	Humods	Humic & Placic Podzol	Udic climates
4.2 Ferro-Humic Podzol	(Humic) Orthods	Humo-Ferric Podzol & Placic Podzol	
4.3 Humo-Ferric Podzol	Orthods	Humo-Ferric Podzol & Placic Podzol	
5. Brunisolic	Inceptisols	Cambisols	Boreal and
5.1 Melanic Brunisol	(Mollic) Eutrochrept	Eutric Cambisol	Udic climates
5.2 Eutric Brunisol	Eutrochrepts and Cryochrepts	Eutric Cambisols	
5.3 Sombric Brunisol	Umbric Dystrochrept	Humic Cambisol	
5.4 Dystric Brunisol	Dystrochrept	Dystric Cambisol	
6. Regosolic	Entisols	Fluvisols & Rhegosols	All climates
6.1 Regosols	Fluvents, Orthents, & Psamments	Fluvisols & Rhegosols	
7. Gleysolic	Aqu- suborders	Gleysols & Planosols	All climates
7.1 Humic Gleysols	Aquolls and Humaquepts	Humic and Calcic Gleysols	
7.2 Gleysols	Aquents, Fluvents, and Aquepts	Fluvic and Haplic Gleysols	
7.3 Eluviated Gleysols	Albolls, Aquolls, Aqualfs, and Aquods	Planosols	
8. Organic Order	Histosols	Histosols	Boreal and Udic
8.1 Fibrisols	Fibrist	Eutric and Dystric	temperate climates
8.2 Mesisols	Hemist	Histosols	
8.3 Humisols	Saprist		

REPORT OF THE SUBCOMMITTEE ON SOILS UNDER FOREST

J. S. Rowe, Chairman

The committee concentrated its study on an examination of the report by Dr. B. Bernier, "A forest humus-form classification", which had been presented in 1967 to the National Committee on Forest Land. That body recommended that the report be submitted to the National Soil Survey Committee for their consideration.

The Committee on Soils under Forest examined and commented on Dr. Bernier's original report prior to the National meeting. They considered that as the approach is morphological it might prove a useful supplement to the N.S.S.C. classification system, and that the classification would serve a good purpose in directing attention to the different kinds and degrees of intermixing of organic and mineral materials, and might lead to a more critical appraisal of the Ah and H layers. They recommended that the report be considered by the National Committee.

During the Plenary Session, Dr. Bernier gave an exposition of the classification and this was followed by a useful discussion. Dr. Bernier suggested that he would consider modifications of his report in the light of this discussion. Dr. Stobbe moved the adoption for trial of this classification as amended and this was seconded by K. Langmaid. The motion was carried.

The following report represents the revised classification as subsequently prepared by Dr. Bernier.

DESCRIPTIVE OUTLINE OF FOREST HUMUS-FORM CLASSIFICATION*

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Introduction

The term humus form, introduced by Müller (1879), designates those natural, biologically-active units formed at the soil surface by plant debris and animal residues in all stages of decomposition and arranged into organic or organo-mineral horizons. The concept of humus form is, therefore, one of an organized natural body like the soil of which it is a part. Although it may be formed of a single horizon, it generally refers to a humus profile formed of successive horizons which are linked together genetically. The composition and sequence of such horizons, which reflect a particular animal and microbial life, are important characteristics of humus forms.

Because they have a far-reaching, differential influence on soil genesis and play an important role in many aspects of silviculture, especially in relation to run-off, erosion control, tree nutrition and establishment of natural regeneration, humus forms are important criteria of forest ecosystems and must be adequately classified.

Since Müller first described mull and mor in 1879, many research workers have contributed to the knowledge of humus forms and their classification. However, over the years the concepts of humus forms have varied widely so that many designations now exist for the same humus form. This has led to considerable confusion in the nomenclature and to misinterpretations of the roles of these biologically-active layers in soil genesis. Classification of humus forms is possible only if agreement is reached on the basic principles of their identity. The following scheme, although it includes a new approach to classifying mor humus, is essentially based upon those particular features, now firmly established internationally, which permit the separation of the various forest humus forms. It is intended as a reference framework for more detailed studies of their role and significance in soil and site classification as well as in silviculture.

The basis of humus-form classification

For classification purposes, forest humus forms are grouped into two broad classes: (1) those developed under well drained to imperfectly drained conditions (so-called terrestrial or upland humus forms), (2) those developed under poorly-drained conditions or under conditions leading to saturation most of the year (so-called hydromorphic or semi-terrestrial humus forms).

* For a discussion on grassland humus-form classification, see Barratt (1964).

From a forestry viewpoint, the humus forms of the latter class have received little attention since they seldom develop on sites supporting commercial forests. Their classification is still only tentative. Classification of upland humus form is, on the other hand, more universally accepted. It is essentially based on those primary morphological features that reveal fundamental differences in their genesis. These are (1) the presence or absence of diagnostic organic horizons; (2) the degree of incorporation of fine humus (humified organic matter) into the mineral soil and the intensity of binding between organic and mineral fractions. Further subdivision is based on secondary morphological features (structure, relative thickness and particular composition of horizons, etc.) and on distinctive chemical characteristics.

Definition of diagnostic organic horizons

Even though the litter (L layer) i.e. freshly fallen leaves and other plant debris (outwardly unchanged) is an organic horizon, it is not considered as diagnostic since it occurs on all upland humus forms and is transitory. Diagnostic organic horizons (o.m. > 30 percent) include the following:

a) The F horizon: an organic horizon formed by slightly decomposed plant remains, the structures or origin of which are still recognizable to the naked eye. It occurs both in moder where it is formed by loose leaf debris, partly fragmented or comminuted by the soil fauna, and in mor where it is formed by matted, partly decomposed debris of leaves or mosses and other plant remains often permeated by fungal hyphae.

b) The H horizon: an organic horizon with advanced decomposition of plant remains (i.e. rich in fine humus) so that the structure or origin of the original plants are for the most part impossible to identify.

It may be sharply delineated from the mineral soil as in mor where humification is chiefly dependent upon fungal activity, although microanimal activity may have some importance in the most active forms. - Horizon designation: H

It may be partially incorporated into the mineral soil as in moder, chiefly by the action of shallow-burrowing micro-arthropods. It then occurs as an accumulation of spherical or cylindrical organic granules (animal droppings) with considerable intermixing, at least at the bottom, but frequently throughout, with mineral particles. - Horizon designation: H_i (i = incorporation or intermixing with mineral soil).

N.B. The designations Hm (for mycogenous) and Hz (for zoogenous) can be used to stress the dependence of humification processes, but in practice it is preferable to stress the degree of incorporation or intermixing of organic matter and the mineral soil.

In soils with a dense population of deep-burrowing organisms such as the Lumbricidae, litter undergoes such a rapid disintegration that even the H horizon is generally absent as in mull.

In the case of organic humus forms developed under waterlogged conditions or under conditions leading to saturation most of the year (peaty or hydromorphic humus forms), the symbols F and H are inappropriate for horizon designation. The designation O (for organic) should be used with suffixes indicating the degree of decomposition (vide infra)

Definition and classification of the main humus forms encountered under forests*

1. HUMUS FORMS DEVELOPED UNDER WELL DRAINED AND IMPERFECTLY DRAINED CONDITIONS (SO-CALLED "TERRESTRIAL" OR "UPLAND" HUMUS FORMS)

1.1 Humus forms of well drained to imperfectly drained sites with rapid, extensive decomposition of forest litter and intimate association of colloïdal organic matter with mineral soil; diagnostic organic horizons are lacking: MULL (Müller, 1879)

Mull is a humus form lacking diagnostic organic horizons; it consists of a dark grey to black, porous, crumbly mass characterized by a mechanically inseparable complex of colloïdal humus and mineral soil (known as the clay-humus complex**). It has an organic matter content ranging from 5 to 25 percent, commonly 12-18 percent (table 1). Transition to the horizon beneath is gradual. Horizon designation: Ah

Mull usually contains little sand, but when it occurs, the sand is cemented within a clay-humus complex, and it is not present in loose grains as in moder.

Forest mull ideally occurs under temperate deciduous forest yielding easily decomposable litter on soils sufficiently rich in clay and nutrients, where balanced conditions of moisture and aeration favor the development of an active, burrowing soil-fauna, especially Lumbricidae. Optimum development of forest mull also implies a steady state of faunal activity with regular passage of organic matter and mineral particles through the guts of earthworms. Otherwise a gradual structural decay follows the continuous mineralization of organic matter. Lumbricidae are capable of absorbing great quantities of mineral substances with their food, closely blending clay with organic matter so that practically all granules of forest mull are earthworm casts or their remains. Individual excretions, which vary with the size of earthworms, coalesce to form porous aggregates giving the horizon a spongy structure.

Mull properties, including structure, deteriorate with a decrease in

* This chiefly applies to northeastern North America; reference to European literature is to stress strong similarities with humus forms described in Europe.

** This term "clay-humus complex" must be taken in a broad sense to include materials that adhere to each other and that are not adequately separated by chemical and physical methods; it does not refer to definite chemical bonding at the molecular level.

base saturation and there is evidence that mull rarely forms where base saturation is lower than 35 percent (Sjörs, 1961; Wittich, 1964). Acid mull (pH around 4.5) does occur but is stable only when other ecological conditions are very favorable.

Table 1. Some chemical characteristics of upland humus forms

	MULL	MODER H_1 horizon	MOR H horizon
O.M. (%)	5 - 25 (12 - 18)*	20 - 60 (40 - 50)	75 - 90
C/N	12 - 18	20 - 25	20 - 35
pH (water)	4.0 - 8.0 (5.0 - 7.0)	4.0 - 5.5 higher in calcareous variants	3.0 - 4.5 exceptionally up to 7.0
C.E.C. (me/100g)**	20 - 40 higher in clayey variants	50 - 80	75 - 130
B.S. (%)	35 - 100 (60 - 100)	15 - 50	10 - 35

* Figures in parentheses are values most commonly found
** Ammonium acetate method

Sub-types of mull

Subdivision of forest mull into sub-types is primarily based on structure class since granular structure is a characteristic feature of all mulls. Further subdivisions (variants) may be based on texture, prevalent humidity, reaction and depth (table 2).

Coarse mull: (Heiberg & Chandler, 1941)
Syn. crumb mull (Romell & Heiberg, 1931)
earthworm mull (Wilde, 1954, 1958)
vermiol (in part) (Wilde, 1966)

Coarse crumb or granular structure with most of the aggregates between 5-10 mm. In the richer coarse mull variants, the autumn leaf-fall is entirely disintegrated and incorporated into the mineral soil by the next leaf-fall period. Thickness may attain 40 cm. It occurs mostly in the melanic and sombric brunisols, and in the humic gleysols, and generally supports a rich herbaceous vegetation with geophytes as characteristic elements.

Medium mull: (Heiberg & Chandler, 1941)
Syn. grain mull (Romell & Heiberg, 1931)
vermiol (in part) (Wilde, 1966)

Medium crumb or granular structure with most of the aggregates between 2-5 mm.

This mull usually develops in sites somewhat dryer than those of coarse mull and the larger earthworms are either few in number or absent. It is relatively thin, as compared to coarse mull, and generally shows a less rapid destruction of forest litter than the latter. In such cases, a thin F may be present and the humus is sometimes referred to as a litter-rich mull (Minderman, 1960).

Fine mull:

Mull is only occasionally found with most of the aggregates <2mm. and is referred to as fine mull. Not to be confused with the fine mull of Heiberg & Chandler (1941) and Hoover & Lunt (1952) which is in fact a moder (vide infra).

Compact mull: Syn. firm mull (Bornebusch & Heiberg, 1935)
post mull (Jongerius & Schelling, 1960)

This is a degraded form of mull characterized by compactness and high bulk density; organic matter content is lower than normal (often less than 5 percent) and the humus is poor in soil fauna activity. Firm mull is sometimes seen on calcareous ridges and exposed sites but, in most cases, it results from grazing and compaction of surface horizons.

The various stages of mull decay have been combined under the term "post mull" by Jongerius & Schelling (1960).

Variants

Criteria proposed for differentiation of mull sub-types at the variant level are listed in table 2. To further simplify designation, only extremes of properties need be mentioned. The following are examples of designations at the variant level:

coarse mull - hydric, clayey: thick (as in humic gleysols)
medium mull - calcareous: thin (as in regosols over limestome).

1.2 Humus forms of well drained to imperfectly drained sites with impeded litter decomposition and with diagnostic organic horizons. Organic matter and mineral soil may be intermixed, at least in part, or sharply delineated.

1.21 Humus forms of well drained sites with diagnostic organic horizons and partial to advanced intermixing of organic matter and mineral soil: organic matter and mineral particles occur as distinct elements but not as a clay-humus complex. - MODER* (Ramann, 1906)

Typical moder has an F horizon, generally thin, formed of leafy plant remains partially disintegrated and comminuted by the soil fauna, grading into a prominent and characteristic H_1 horizon made of organic granules intermixed with loose mineral grains.

* Moder is taken here in a sense which differs from Ramann's original concept but which is now firmly established internationally.

Table 2. Criteria used to distinguish variants and thickness phases of upland humus forms*

Texture classes (for mulls only): to stress extremes of texture.

- clayey : for a high clay content, very sticky when wet.
- loamy : medium texture need not be mentioned, thus simplifying designations.
- sandy : for high content of sand: characterized by a certain rawness and loose consistency.

Humidity classes : to stress prevalent conditions of extreme wetness or dryness.

- hydric : in the capillary fringe over a shallow water table or in sites with abundant telluric moisture.
- mesic : well drained and moderately well drained conditions: mesic conditions are normal for upland humus forms and need not be mentioned.
- xeric : in very dry sites.

Acidity classes :

acid (or oligotrophic**)	pH (water)	<5.0
mesotrophic**	"	5.0 - 6.0
neutral (or eutrophic**)	"	6.0 - 7.5
calcareous	"	>7.5 or effervescence upon treatment with HCl

Depth classes : to stress extreme thickness or shallowness of the humus profile; should be considered as a phase.

- thick : overall thickness >20 cm. (8 in.)
- thin : overall thickness <5 cm. (2 in.)

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* Not all these criteria need be mentioned: in general only those which depart from conditions normal for a given humus form. For instance acid need not be mentioned for mors since most have a pH <4.5. Variant adjectives follow humus name; depth class always comes last and is separated from the preceding adjectives by a colon, e.g. coarse mull - hydric, clayey: thick.

** These terms refer to base saturation rather than to acidity as such; mesotrophic is suggested in the absence of a more appropriate term. Perhaps the terms euacid (pH <5.0) and oligacid (pH 5.0-6.0) could be used.

The process of moder formation resembles that of mull in that both are chiefly zoogenous humus forms, but there are two very striking differences: the incorporation of humus into mineral soil is considerably slower in moder and there is no evidence of a clay-humus complex.

Moders are of widespread distribution under mixed or hardwood forests, especially under the northern hardwoods. Characteristically they occur in soils whose surface horizons contain little clay and are periodically droughty. The mixing of organic and mineral particles, which is purely mechanical with no formation of true organo-mineral complexes, may be caused by creep, as in slope moder or alpine moder, but in most cases results from the action of micro-arthropods. These organisms consume very little mineral material so their casts consist almost exclusively of organic matter. Since none of the organisms concerned with moder formation have an important burrowing activity, incorporation of organic matter into the mineral soil, although intense, is shallow. Organic matter in the H_i , except in mull-like moder, is usually from 40-50 percent (table 1). Moder is most frequently acid and low base saturated. Calcareous moder is, however, a common humus-form over shallow and droughty soils on ridge tops of crystalline limestone*.

Sub-types of moder

Based on the relative importance and other characteristics of the F and H_i horizons, moder can be subdivided into three sub-types: typical moder and two forms which are transitional either to mull (mull-like moder) or to mor (raw moder). Typical moder and raw moder are the most widespread forms under forest cover in eastern Canada.

Typical moder (to be called simply Moder)
(H_i prominent).

Syn. silicate moder (Kubiena, 1953, 1955)
fine moder (Hartmann, 1944, 1951)
fine mull (Heiberg & Chandler, 1941; Hoover & Lunt, 1952)
arthropod mull (Wilde, 1954)
insect mull and mull-like mor (Müller, 1879)

This is the prototype of moder and is characterized by the prominence of an H_i horizon (5-10 cm. thick) made of cylindrical or spherical fine humus granules (generally casts of microarthropods), resembling black sawdust, mechanically mixed with mineral particles for the most part. The F horizon is formed by comminuted leaf fragments and is thin (1-3 cm.). Typical moder is generally referred to as fine mull in the American literature.

* In extreme cases such moders may attain a considerable depth (up to 50 cm.) as seen at Anticosti island under open stands of white spruce with ericaceous shrubs in sites exposed to wind dessication. Such humus forms have been described in Europe which are called "Tangelhumus" (Kubiena, 1953) or "Alpenhumus" (Ehwald, 1956).

In eastern Canada it occurs mostly in the orthic dystric brunisols and is frequent beneath yellow birch-sugar maple stands.

Raw moder
(F prominent)

Syn. coarse moder (Hartmann, 1944)
mor-like moder (Ehwald, 1956, 1958)
dystrophic moder (Manil, 1956)
twin mull* (in part) (Romell & Heiberg, 1931)
duff mull (Heiberg & Chandler, 1941; Hoover & Lunt, 1952)
amphimorph (Wilde, 1954)
velor (in part) (Wilde, 1966).

Raw moder has a comparatively thick F horizon which makes it resemble raw humus, to which it is actually a transition form. It has a shallow but distinct horizon of intermixed organic granules and mineral particles (H_i horizon).

Under dystrophic conditions where raw moder develops, the droppings of arthropods apparently have little stability; they may disintegrate to give dispersed humus which sometimes forms more or less amorphous clots. Occurs mostly in the degraded dystric brunisol and some of the minimal podzols.

Mull-like moder (Hartmann, 1944)

Syn. sand mull (in part) (Hoover & Lunt, 1952)

Mull-like moder has a close resemblance to mull to which it is a transition form, but the intimate association of colloïdal organic matter with clay is lacking because clay, as a binding agent is either scarce or absent. Organic matter content rarely exceeds 35 percent and various soil organisms, often earthworms and large arthropods, may be dominant. Mull-like moder has a very thin F horizon and is featured by a prominent H_i horizon (Ah if o.m. is <30 percent) consisting of intermixed sand grains and organic granules or crumbs as distinct elements or partly bound together in loose fashion. The crumbs may also contain imbedded sand grains very weakly bound to organic matter. Calcinated crumbs of mull-like moder are almost entirely burnt to ashes whereas mull crumbs harden due to their clay content. Occurs in sites where the absence of clay appears to be the sole factor preventing true mull formation.

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* Twin mull (Romell & Heiberg, 1931) used to refer to "a complex type of humus layer, consisting of one upper stratum with the characteristics of matted detritus mull or root duff, underlain by grain or sometimes crumb mull". Hoover & Lunt (1952) give it, however, a more restricted definition: they describe it as "a complex formed by a fine mull (equivalent here to typical moder) underlain by a coarse or medium mull". This should be treated as superimposed humus forms, since the two have no genetic affiliation. It should not either be confused with the mull-like moder.

Variants

Criteria proposed for differentiation of moder sub-types into variants are listed in table 2. The following are examples of moder designations at the variant level:

typical moder - xeric, calcareous: thin (in droughty sites on limestone)

mull-like moder - hydric, neutral (in the capillary fringe over a shallow water table in sites where lack of clay prevents mull formation).

1.22 Humus forms of well drained to imperfectly drained sites and consisting of organic horizons sharply delineated from the mineral soil. - MOR or RAW HUMUS (Müller, 1879)

Apart from the litter (L layer), mor essentially has two horizons: 1) the F horizon, formed by partly decomposed but recognizable remains of all strata of vegetation, including mosses and lichens, strongly matted or packed and often interwoven with fungal hyphae; 2) the H horizon in which the state of decomposition of organic matter, except in the very fibrous forms, is generally so advanced as to make the identification of most plant debris impossible. Mor lies unmixed over the mineral (bleached) soil, unless the latter has been blackened by the washing-in of organic matter. The relative importance of F and H horizons and their characteristics vary considerably giving rise to many varieties having a widespread range of biological activity and nutritional conditions.

With the exception of some granular mors, animal droppings are scanty to absent and show incomplete decomposition and humification of organic matter. Some chemical characteristics of mors are shown in table 1.

Mor commonly occurs on a variety of parent materials in the coniferous forest zone because of climatic conditions. They also occur in the temperate zone of the mixed deciduous forest, especially on the fringe of the coniferous forest zone, under mixed or even hardwood stands. In much warmer climatic conditions mors may develop where the edaphic environment (low base content, coarse-textured parent material and lack or excess of moisture) is unfavorable to other types of humus formation. They may also result from anthropogenic interference on soils normally having mulls or moders.

It is difficult to make a general separation between the mors of the boreal-alpine coniferous forest and those of more temperate regions on basis of morphological characteristics, although it is well accepted that the former are generally much thicker than the latter. Boreal raw humus has a far-reaching influence on stand growth since the effective rooting of trees is frequently confined to the humus profile.

The present classification of mors

Combining the proposals made by Hoover & Lunt (1952) and their predecessors, and by Wilde (1954, 1958), the present classification of mors broadly includes the following sub-types:

Felty mor (Hoover & Lunt, 1952). Syn. fibrous mor (Bornebusch & Heiberg, 1935; Heiberg & Chandler, 1941); mycelial mor and ligno-mycelial mor (Wilde, 1954, 1958); lantar (Wilde, 1966).

Felty mor is characterized by an abundant development of fungal hyphae in both F and H horizons. The F horizon is prominent and the H is only slightly humified, sometimes making the distinction between F and H difficult.

Granular mor (Hoover & Lunt, 1952), including the former matted mor, laminated mor and granular mor of Heiberg & Chandler (1941). Syn. root mor (Wilde, 1958).

The main morphological feature of this mor is the granular structure of the H horizon. Granules may be to some extent coprogenic but they are generally formed following individualization of humus fragments as a result of a strong development of rootlets.

Greasy mor (Bornebusch & Heiberg, 1935): also used by Heiberg & Chandler (1941) and by Hoover & Lunt (1952).
Syn. greasy duff (Romell & Heiberg, 1931).

Greasy mor has an H horizon which is amorphous and greasy; it occurs mostly in sites characterized by high base status and abundant telluric moisture conditions.

Crust mor (Wilde, 1954, 1958).
Syn. xeromor (Duchaufour, 1960)
crustar (Wilde, 1966).

Thin raw humus developed from crust lichens in very dry sites of unregenerated burnt-over areas.

Hydromor (Lafond, 1952).
Syn. sog mor (Wilde, 1958)

Hydromor occurs on soils with a ground water table at a shallow depth. It is largely derived from sphagnum moss and frequently accumulates in layers up to 35 cm. thick.

Thin mor (Hoover & Lunt, 1952)

Mor humus with an H layer less than 1.3 cm. (0.5 in.) thick.

Imperfect mor (Hoover & Lunt, 1952)
Syn. lean mor, embryonic mor, felt (Wilde, 1954, 1958);
Velor (Wilde, 1966).

The H horizon of imperfect mor is absent or sporadically present as a thin film, especially in depressions.

This classification has been used for many years and is found to have many limitations. Mors which differ strikingly in morphological and biological properties are often given the same name because they have in common some morphological feature which is a criterion of humus nomenclature. For instance, mor humus with a granular H horizon may differ considerably in overall morphology. In some instances the H horizon is coarse granular and makes up most of the humus profile, as is frequently encountered under northern hardwoods. In rich sites under coniferous forests, the H horizon is often fine granular and, to some extent, coprogenous (zoogenous); it is frequently much thinner than the associated F horizon. The name greasy mor is also ambiguous since many mors which vary in overall morphology possess an H layer which is greasy when wet. Thin mor also shows much variation in morphology and botanical origin. In many instances thin mor is a temporary successional phase of a particular mor humus following drastic disturbances, especially by fire. There are also a great variety of forms encountered in forested areas which are referable only with great difficulty to definite types of the present classification.

This emphasizes the need for a revision of the existing classification. It is felt that an appropriate classification of mors requires a thorough, quantitative appreciation of morphological characteristics of both F and H horizons. The following scheme is intended as a first step towards such a revision.

A proposed new approach to classifying mors

The proposed outline of mor-humus classification is a simple hierarchal system including groups, subgroups and variants. The categories are differentiated on the basis of easily observable characteristics.

(a) Groups

Four groups are recognized on the basis of relative importance of the two diagnostic organic horizons, F and H, more specifically by the percentage thickness of the H horizon in the humus profile (table 3). This stresses mineralization and humification processes, aspects which must not be underestimated in site productivity.

Table 3. Groups of mor humus according to the relative importance of the H horizon

Percent thickness of H*	Group name
< 10	Fibrimor
10 - 50	humi-Fibrimor
50 - 80	fibri-Humimor
> 80	Humimor

*with reference to the whole humus profile, irrespective of its overall thickness.

(b) Subgroups

Subgroup names consist of the name of the appropriate group modified by one or more adjectives descriptive of either the F or the H horizon.

Subgroups of Fibrimor and humi-Fibrimor

Because of the dominance of the F horizon in Fibrimors and humi-Fibrimors, subgroup adjectives indicate the botanical origin of the prevailing plant debris. A list of proposed adjectives is indicated in table 4.

Table 4. Suggested adjectives used at the subgroup level to describe the dominant botanical origins of the F horizons of Fibrimors and humi-Fibrimors*.

hypno	:	predominantly derived from feather mosses
sphagno	:	predominantly derived from sphagnum mosses
licheno	:	predominantly derived from lichens
ericaceo	:	featured by a tenacious mat of roots (rhizomes) of ericaceous dwarf shrubs
conifero	:	predominantly derived from needles of conifers
deciduo	:	predominantly derived from leaves of deciduous trees.

* The list is not exhaustive and could be enlarged as required.

Subgroup names should normally include a single adjective preceding the group name, although composite adjectives could occasionally be used to stress two dominant features, e.g. "sphagno-ericaceo Fibrimor".

Subgroups of Humimor and fibri-Humimor

Humimor and fibri-Humimor subgroup names stress the morphological characteristics of the H horizon which is dominant. Adjectives at the subgroup level (table 5) pertain to the structure of the H horizon or to other pertinent morphological features such as networks of fungal hyphae or rootlets.

Table 5. Suggested adjectives used at the subgroup level to describe the dominant characteristics of the H horizon of Humimors and fibri-Humimors*.

granulo	:	granular H horizon
amorpho	:	amorphous H horizon
mycelio	:	H horizon characterized by a strong development of fungal hyphae forming a felt mat
rhizo	:	H horizon strongly permeated by rootlets as a network.

*The list is not exhaustive and could be enlarged as required.

NOTE Whenever F and H horizons are of equal or near-equal thickness (percent thickness of H between 35 and 65) subgroup names could include prominent features of both F and H horizons. The adjective applying to the group name should then come immediately before it as in "granulo-hypno humi-Fibrimor" or "hypno-granulo fibri-Humimor". This permits a more precise description of mor humus in which neither F nor H horizons are especially prominent and eliminates recognition of a fifth group.

(c) Variants

Subgroups can be divided into variants as required to stress other features that influence nutritional conditions in humus profiles (table 2). The following are examples of designations, at the variant level, of the present greasy mor:

amorpho Humimor - hydric
amorpho fibri-Humimor - hydric: thick

It should be understood that humus names can be used at any level of classification; in many instances the group name (e.g. Fibrimor) or subgroup name (e.g. hypno Fibrimor) would be sufficiently descriptive without indication as to variant.

2. HUMUS FORMS DEVELOPED UNDER POORLY DRAINED CONDITIONS OR UNDER CONDITIONS THAT LEAD TO SATURATION MOST OF THE YEAR (SO-CALLED HYDROMORPHIC OR "SEMI-TERRESTRIAL" HUMUS FORMS).

Humus forms developing under the influence of stagnant water have been studied very little in Canada, so their classification is still tentative. They are, however, divided into two categories: peaty organic horizons, called peaty mors, and organo-mineral humus forms (o.m. <30 percent) known as anmoors.

Tentative classification

2.1 Peaty mors

Although peaty mors are transitional to organic soils they are not always the initial stages of peat formation; frequently they constitute stable natural units.

Peaty mors are distinguished from organic soils mainly on the basis of thickness. With reference to the established limits for organic soils, permissable thickness of humus over mineral soil is up to 60 cm (24 in.) of fibric moss of which 75 percent or more of the fibers are derived from Sphagnum or Hypnum, or up to 40 cm (16 in.) of other kinds or mixed kinds of organic materials. Thickness over a lithic contact must be less than 10 cm (4 in.). Organic matter content must be higher than 30 percent, but is usually over 60 percent. Peaty mors show little horizon differentiation although the degree of organic matter decomposition may increase downward in a continuous fashion. Compared to well-drained raw humus, peaty mors are frequently less sharply separated from mineral soil, which may be blackened by the washing-in of organic matter. As with organic soils, three groups are recognized according to the degree of decomposition of organic matter.

Fibric peaty mor
Horizon designation: Of

Fibric peaty mor is an organic, "hydromorphic" humus form composed predominantly of mosses, slightly decomposed and spongy, together with numerous, structurally-preserved remnants of woody plants and more or less important mat of sedges and rhizomes of heath shrubs. It has a fiber content greater than 2/3 of the total mass before rubbing or more than 40 percent after rubbing.

Botanical composition would supply useful guidelines for a more detailed classification (composed primarily of sphagnum, feather mosses, ericaceous rhizomes, remnants of sedges and reeds, etc.).

Fibric peaty mor develops on gleysols or gleyed podzols, in sites with nutrient-poor (oligotrophic) water; such sites most frequently support the open stands of black spruce or even stunted balsam fir.

Mesic peaty mor
Horizon designation: Om

Mesic peaty mor is an organic,"hydromorphic" humus form in which the organic matter has reached a moderately advanced state of decomposition. Fiber content is 1/3 to 2/3 of the total mass before rubbing or between 10 and 40 percent after rubbing.

Occurs as mosaics beneath the same forest associations as the fibric peaty mor, also in bog borders influenced by seepage water.

Humic peaty mor
Horizon designation: Oh

Humic peaty mor is an organic,"hydromorphic" humus form in which the organic matter has reached an advanced state of decomposition; the structure of original plant material is not discernable for the most part, although it may contain considerable woody debris. It has a fiber content of less than 1/3 of the total mass before rubbing or less than 10 percent after rubbing.

Humic peaty mor generally develops under the influence of calcium-rich seepage water; it is common under white cedar stands in the eastern Appalachian region of Quebec, where it grades into or occurs as a mosaic in humisols.

2.2 Anmoor (Kubiena, 1953)
Horizon designation: Ah
Syn. mineral muck (colloquial), fen mull (Wilde, 1954, 1958); sapronel (Wilde, 1966).

Anmoor is a "hydromorphic", organo-mineral humus form (o.m. < 30 percent) consisting of a dark grey or black, structureless blend of loose mineral soil enriched with finely-dispersed, well-humified organic matter and some coprogenous residues. It has a muddy structure in conditions of excessive wetness but becomes earthy in a moderately wet state. It shows no accumulation of plant remains as a distinct layer, except for sparse forest litter. Such humus with more than 30 percent organic matter should be classified as humic peaty mor or, if thickness exceeds 40 cm. over mineral soil, as a humisol.

Anmoors are associated with gleysols (humic) in sites almost permanently waterlogged as on river flats or on lowland soils with ground water enriched in bases. Its reaction is mildly acid to neutral. The low content of organic matter of anmoor and the absence of a distinct organic horizon apparently result from the intense activity of anaerobic bacteria together with important in-washing and silting.

The term "fen mull" sometimes used to designate this humus form is inappropriate because anmoor has nothing in common with mull except low organic matter content.

References

Barratt, B.C. (1964). A classification of humus forms and micro-fabrics of temperate grasslands. J. Soil Sci., 15, 432-356.

Bornebusch, C.H. & Heiberg, S.O. (1935). Report of the subcommission for forest soils. Trans. 3rd Int. Cong. Soil Sci., 3 259-260.

Duchaufour, P. (1960). Précis de Pédologie. Masson & Cie, Paris, 1st ed. 481 pp.

Ehwald, E. (1956). Uber einige Probleme der forstlichen Humusforschung insbesondere die Entstehung und die Einteilung der Waldhumusformen. Sitzungsber. deutsch. Akad. Landwirt. zu Berlin, 5, 44 pp.

Ehwald, E. (1958). Die Einteilung der Waldhumusformen. Forst. Stand. Landwirt. BMBH, Hiltrup bei Munster, pp. 23-30.

Hartmann, F. (1944). Waldhumusformen. Z. ges. Forstwes. 70, 39-70.

Hartmann, F. (1951). Der Waldboden. Humus-,Boden-und Wurzeltypen als Standortsanzeiger. Osterreichisches Productivitäts-Zentrum, Wien, 152 pp.

Heiberg, S.O. & Chandler, R.F. (1941). A revised nomenclature of forest humus layers for the Northeastern United States. Soil Sci., 52, 87-99.

Hoover, M.D. & Lunt, H.A. (1952). A key for the classification of forest humus types. Soil Sci. Soc. Am. Proc., 16, 368-370.

Jongerius, A. & Schelling, J. (1960). Micromorphology of organic matter formed under the influence of soil organisms, especially soil fauna. Trans. 7th. Int. Cong. Soil Sci., Madison, vol. 2, 702-710.

Kubiena, W. (1953). The soils of Europe. Thomas Murby & Co., London, 318 pp.

Kubiena, W. (1955). Animal activity in soils as a decisive factor in establishment of humus forms. In D.K.M. Kevan: Soil Zoology, Proceedings of the University of Nottingham, Second Easter School in Agricultural Science, Acad. Press Inc. N.Y. pp. 73-82.

Lafond, A. (1952). La conservation de l'humus. Compt. Rend. Ass. Can. de Conservation, pp. 23-30.

Manil, G. (1956). L'humus forestier. I. Considérations générales. Bull. Soc. Roy. For. Belgique, 63, 449-462.

Minderman, G. (1960). Mull and mor (Müller-Hesselman) in relation to soil water regime of a forest. Plant and Soil, 13, 1-27.

Müller, P.E. (1887). Studien über die natürlichen Humusformen und deren Einwirkung auf Vegetation und Boden. Springer Berlin, 324 pp. Danish original: 1879.

Ramann, E. (1906). Z. Forst-u. Jagdwesens, p. 657, in Kubiena (1953).

Romell, L.G. & Heiberg, S.O. (1931). Types of humus layer in the forests of northeastern United States, Ecology, 12, 567-608.

Sjörs, H. (1961). Some chemical properties of the humus layers in Swedish natural soils. Kungl. Skogs. Skrifter, Bull. no. 37, 51 pp.

Wilde, S.A. (1954). Forest humus: its genetic classification. Wisc. Acad. Sci. Arts and Letters, 43, 137-163.

Wilde, S.A. (1958). Forest Soils, their properties in relation to silviculture. The Ronald Press, N.Y. 537 pp.

Wilde, S.A. (1966). A new systematic terminology of forest humus layers. Soil Science, 101, 403-407.

Wittich, W. (1964). Die Bedeutung der Humusformen für die Ernährung des Waldes und die Entwicklung seiner Böden. Allgemeine Forstz., 3, 29-33.

REPORT OF THE SUBCOMMITTEE ON LAND FORMS

L. J. Chapman, Chairman

The Subcommittee on Land Forms presented the following modifications and recommendations:

After some discussion on the inconsistency in the limits of the slope classes, a motion was made and adopted that some of the slope class limits be modified and set forth in the following consistent pattern:

Slope (percent)
0.0 to 0.5
0.5+ to 2
2+ to 5
5+ to 9
9+ to 15
15+ to 30
30+ to 60
over 60

A first draft of a glossary on terms relating to land forms and to soil materials has been prepared, but a review of the definitions by selected personnel before submission for use was recommended by the subcommittee. The method of presentation of the glossary was discussed and a motion was made and adopted "that the terms and definitions after being reviewed be sent to Dr. J. A. McKeague, Chairman, Glossary of Soil Terms, who would include these terms with the glossary his committee prepared for the Canadian Society of Soil Science."

No agreement was reached by the members of the subcommittee on the classification of land forms. Some members expressed the opinion that there was little need for change, whereas others contended that a new classification was very much needed. Several members submitted classification outlines but only in preliminary form. Some persons showed a preference for the genetic viewpoint that included materials and surface morphology, whereas others preferred a simpler classification of terrain forms. Because no scheme appeared suitable at this time, the subcommittee advised the N.S.S.C. of this decision and moved "that the Subcommittee on Land Forms should continue working towards a classification or alternative classifications of land forms considered either as (a) terrain surfaces, or (b) deposits having distinctive surface form, structure, and genesis. In each case the position of the types in a hierarchical system of land forms should be shown." The motion was carried.

Mr. K. Valentine is planning to survey a small selected area in British Columbia with a wide variety of land forms and he recommended that others should classify and map land forms of sample areas. This recommendation received general approval. Some approval also was expressed for field tours to see and discuss land forms and their relation to soil mapping.

REPORT OF THE SUBCOMMITTEE ON CHEMICAL AND PHYSICAL ANALYSIS

J. S. Clark, Chairman

Many chemical and physical properties of soils are now being included in the definitions of soil horizons. The soil order subcommittees have assumed responsibility for defining these chemical and physical properties and for specifying their limits. There has been no "official" involvement of the Subcommittee on Chemical and Physical Analysis in the development of these specifications, but individuals on the Soil Analysis Subcommittee have been consulted. In view of these facts, it was considered desirable to review the role of the Subcommittee on Chemical and Physical Analysis in the N.S.S.C.

The members of the subcommittee felt that although they have performed a useful function in the past by attempting to encourage the use of chemical and physical properties in the classification of Canadian soils, this function is not required at present. Because the definitions of soil horizons are now based to a large extent on their chemical and physical properties, it was felt that the specification of the chemical and physical properties should be the responsibility of the soil order subcommittees rather than the Subcommittee on Chemical and Physical Analysis. Specification of chemical and physical properties by the soil order subcommittees also involves the specification of methods so that there is no useful function to be played by the Chemical and Physical Analysis Subcommittee in this regard.

The Subcommittee on Chemical and Physical Analysis, therefore, recommends that:

1) The activities of the Subcommittee on Chemical and Physical Analysis be suspended but that a chairman should be retained so that the committee can be reactivated when this is desirable.

2) The other members of the subcommittee should be appointed to other subcommittees where their knowledge and interests can be used effectively.

3) The definitions of soil horizons should specify the acceptable chemical and physical determinations and the limits of the various properties should be specified as well, if applicable. These methods should be considered the "official" methods of analysis of the N.S.S.C.

REPORT OF THE SUBCOMMITTEE ON CLIMATE IN RELATION TO SOIL CLASSIFICATION

W. Earl Bowser, Chairman

This is the first report of a climate subcommittee of the National Soil Survey Committee and therefore it is exploratory in nature. The study was divided into two parts, (i) climate as related to land classification, and (ii) climate as related to soil classification.

The first of these, land classification, has received considerable study and there is a fairly large body of information. All of the soil survey reports that have been published have contained climatic data, practically all of which have been oriented towards crop growth and soil management. The possible exceptions to this are the zonal separations made in the Prairie Provinces on the basis of the moisture regime. Temperature data has been reported; however, it has been interpreted primarily in terms of its effect on crop growth.

Through our involvement in the land capability for agriculture study, Chapman and Brown made an effort to combine moisture and temperature data in terms of their effect on growth and maturity and to designate geographic areas over which the climate is uniform. This has proven to be a very useful guide. In some cases it has been used as is; in other places it has been modified in the light of the soil surveyors' experience and knowledge of the area. In all cases it has prompted a more critical look at climatic data. One of the results is that the requests to the Agrometeorology Section of the Research Branch, C.D.A. for data and assistance have increased greatly.

Various suggestions were made relative to the type of data that could be of value in land classification. These included:

a) The greater value of probability data over absolute or average data.

b) An expansion of the use of the Hopkins - Williams formula for estimating temperatures and temperature derivatives to cover the remainder of Canada. Also, continued research to refine this formula.

c) The need for more precise data on the effect of slope, aspect, elevation, bodies of water, muskegs, etc. on local climate.

d) Climatic crop zonation for wheat, coarse grains, corn, forage crops, etc. The factors that might be considered in this include summer temperature, moisture distribution, winter temperatures, frost incidence, effect of spring soil temperature on growth, and the relation of peak summer rainfall to the incidence of fall frost.

e) Soil heat degrees over threshold value of 41 F (or some other base figure); this related to soil texture and color. Such a value could be related to soil microbiological activity.

In the field of soil classification, the effect of total climate on soil formation and genesis, we have done very little of a specific nature such as establishing benchmark criteria, and attaching more precise climatic parameters to soil regions or great group categories. For example, it is stated that the Brown Chernozemic Great Group has been formed under a mean annual rainfall of about 12 inches; certainly this cannot be termed a complete climatic characterization. There are many climatic criteria that could be used to more completely characterize the great groups. Among these are:

a) More complete average and probability temperature and moisture data.

b) Soil temperature data related to microbiological activity and decomposition.

c) The amount and temperature of the water available for leaching.

d) The frequency and duration of conditions of deficit moisture.

The preparation of the World Soil Map and the necessity of correlating along our international boundary has focussed attention on two of these climatic parameters, namely: (i) the separation of soils with permanently frozen subsoils from those that annually thaw, and (ii) the separation of soils that have frozen subsoils for a period of the year from those that never, or rarely, freeze.

There is a dearth of soil temperature data; however, the amount available is rapidly increasing. In most cases the mean annual soil temperature (MAST) at the 20-inch depth is extrapolated from the mean annual air temperature (MAAT). For example, MAAT plus 5 or 6 F has been used to get the soil temperature. Available data suggest that this figure varies from air plus 3 to air plus 12. In attempting to establish the freeze - nonfreeze line the figure of 47 F MAST at 20 inches has been suggested; or 42 MAAT plus 5. However, there are soils with a MAST of 43 to 45 F that never, or rarely, freeze at 20 inches, and there are soils that do freeze when the MAST is 48 or 49 F. Some of the factors that determine this are (i) the influence of summer maximums on the average, (ii) the severity of the winter temperatures, and (iii) the depth, duration, and insulating capacity of the snow cover.

There appears to be a majority opinion that the "so-called" 47° line is significant and that there are recognizable soil differences north and south of this line; however, some members expressed doubts about this. It should be recognized, however, that the line dividing these regions is at least 50 miles, and possibly 100 miles, wide.

Furthermore, it is recognized that soils were formed under native conditions and therefore temperatures taken in cultivated or otherwise disturbed areas may not give the pertinent data. We suggest that where possible data be obtained concurrently from geographically associated disturbed and undisturbed sites.

The MAST may have value in soils that do not freeze. However, in soils that do freeze the mean summer soil temperature is much more significant. Surface freezing and thawing in the top 10 cm may have an effect on structure; this may occur much more frequently in some areas than in others.

It appears that both the 20° and 25° MAAT lines are significant as related to permafrost. The first one, the 20° line, represents the southern boundary of continuous permafrost; the 25° line represents the northern practical limit of agriculture. It would appear that a mixed zone lying between the 20° and 25° lines should be recognized. The 30° line may also have some significance in the mountain areas.

Various suggestions have been made regarding the terminology for these three regions. It would appear that Cryic, Boric, and Udic have semiofficial sanction.

In summary, this report is necessarily of an exploratory nature. We think there is much of value that could and should be done. With few exceptions there is a large body of observational data available. Because we have at our disposal sophisticated methods for analysing these data and for presenting them in much more meaningful terms than heretofore, it would seem logical to suggest that geographic areas and soil groups should now be defined in much more precise climatic attributes. Extensive testing and manipulation, however, will be required if useable formulas are to be obtained.

We therefore recommend that a climatic subcommittee be continued; that the personnel of this committee be expected to spend a significant amount of time on the work related to this subject, and that provisions be made accordingly. It is further suggested that it is the responsibility of the pedologists on the committee to (i) define the problems, and (ii) determine the areas of study. Conversely, the Agrometeorology Section is a necessary part of this study, but the members should not be expected to define the problems. Their contribution will be to supply workable formulas and meaningful criteria.

REPORT OF THE SUBCOMMITTEE ON CROP YIELD ASSESSMENTS

A. O. Ridley, Chairman

The demand for more interpretive work based on soil survey information has increased rapidly, particularly because of A.R.D.A. projects, but also because of the need for soil productivity ratings, land assessment, land use planning and marketing analysis. It has been suggested that more meaningful interpretations of technical soil survey data be a part of future soil survey reports. It is the purpose of this subcommittee to examine the feasibility of Crop Yield Assessments for soil survey reports and to suggest means of making such assessments.

The first thing the subcommittee did was to propose a change of title from Crop Yield Predictions to Crop Yield Assessments. The word "predictions" implied the establishment of yields for some level of management not yet attained and was therefore in a sense restrictive. Crop Yield Predictions are commonly considered at three management levels: (1) average management, i.e. the level of management including tillage practises, fertilizers, weed control, etc.,that have been used up to the present time, (2) good management, i.e. the practises used by the better than average farmers at the present time, and (3) superior management, which would include that level practised by a small percentage of farmers who use the most up-to-date recommendations for varieties, fertilizers, herbicides, etc., or that level of management likely to be practised in the future. When establishing yields for "average" and "good" management, it was difficult to think of these as "predictions". The word assessments appeared to better describe what we were attempting.

Crop yield assessment involves the assigning of yield data to mapped soil units. This data is largely estimated, except for some soils on which considerable data is available, and these then become the reference or "benchmark" soils. Yields attached to mapped soils to date, have generally been at the "average" management level. This was due to the need to go back a number of years to collect data that would average out climatic variations. Because the use of fertilizers, herbicides, etc. has been accepted relatively recently, past yields have reflected a management level considered only average by today's standards. This "average management data" has nevertheless been of considerable value. It has been used by agencies such as the Manitoba Crop Insurance Corporation, Manitoba Farm Credit Corporation, Land Assessment, and their counterparts in other provinces.

In order to fulfill the objectives of the subcommittee on Crop Yield Assessments the members were asked several months ago to provide their opinions on this subject and indicate possible solutions. The following part of this report deals with the questions asked, the answers provided, and the results of the subcommittee meeting.

1. Can meaningful crop yield assessments be made?

Subcommittee members from the Prairie Provinces were generally in agreement that crop yield assessments can be established, based on past records and "average" to "good" management. Indeed, much work has been done in the

Prairie Provinces to establish crop yields for various soil types. Generally, it has involved the establishment of yields for "benchmark" soils. These were obtained by analysis of Sanford-Evans data from shipping points located in homogeneous soil areas. Other mapped soils were compared to the benchmarks in respect to profile characteristics, and were assigned yields.

It is necessary to realize that the limited success with establishing crop yield assessments in this manner in Western Canada is due to one outstanding feature. For example, wheat has been the dominant crop and has probably been grown on every soil. Because wheat is not used in large quantities as a feed on the farm, and is marketed through controlled channels, it is relatively easy to obtain wheat yield data. Yield data for other crops are, however, much more difficult to obtain. Members from the eastern provinces indicated that soil productivity rating was difficult to do because a variety of special crops are produced. A lack of data from sufficient acreage is one of the major limitations to successful productivity ratings in Eastern Canada.

In Western Canada, additional factors have appeared that will likely make the establishment of crop yield assessments at the "good" level of management feasible. These include:

a) Provincial and University Soil Testing Laboratories.

Considerable progress has been made in recent years whereby the requirements for N, P, and K to produce good yields can be assessed by chemical soil tests. This service has been widely accepted by farmers. About 10% of the land devoted to annual crops and tame hay in Manitoba was soil tested in 1967. In Saskatchewan, samples from more than 10,000 fields were analysed in 1967. Because these programs are computerized, and the information sheets that farmers submit are comprehensive, much data should be available in a few years to characterize yields from soils under "good" management. (The "good" management level is suggested because farmers who are progressive enough to test soil are probably overall good managers.)

b) Crop Insurance Corporations.

Some provinces now have crop insurance programs available to farmers. In Manitoba the farmers, with the assistance of insurance agents, submit a statistics sheet to the agency. The data is computerized to aid in future yield and premium adjustments. Since about 50% of Manitoba farmers buy crop insurance, much yield data is collected. This can be useful for soil productivity ratings, provided soil types and management practises are recorded along with the yield data.

Some members of the subcommittee suggested that crop yield assessments could be related to the capability classification. Indeed, this has been done for some municipalities in Saskatchewan. The Soil Capability Classification is, however, primarily a land use classification. It is difficult and possibly misleading to relate productivity to it. This may be illustrated using stoniness (Subclass P) as an example. A soil may be classified at 2P or 3P because of stones interfering with the management of the land, or restricting its use for crops like potatoes. It may, however, produce as much wheat at class 1 land. Similarly land with a 4% slope would be classified as class 2t because of limitations of crops that could safely be produced without damaging the soil by erosion. It also could produce as much wheat as class 1 land. We do not suggest, however, that relationships do not exist for some subclasses. Saskatchewan workers have shown that a relationship exists between yield of wheat and climate (which is indicated by capability subclass c). Black soils can be rated class 1, but Dark Browns are rated no higher than 2c and Browns no higher than 3c. Obviously the texture of soils within the major zones is also important because of the relationship to moisture retention.

The subcommittee was in agreement that we have probably gone as far as we can in characterizing the productivity of our soils with the information now available. It appears that efforts to determine the "superior" management level for crop yield assessments are not likely to be fruitful in the near future. There are various reasons why this might be so.

a) Variable crop response to fertilizer.

Yield data obtained from farm records has provided a measure of yields as influenced by a variety of factors. The data therefore can be valid only under similar management conditions. One factor in particular has affected crop production significantly in recent years, and this is the use of high rates of fertilizer. It is unlikely that past data can be used to predict future yields, because in most cases adequate fertility was not present (a likely exception would be yields of wheat on fallow land in Western Canada). This can be illustrated by some fertility work on the Pelan Association in Manitoba (Gleyed Dark Gray, developed on sandy deposits; capability classification 4mf; soil productivity index rating of 30 to 40 represented by long time wheat yields of 14 to 16 bushels). This soil was obviously considered to be unproductive. The fertility trials in 1965 showed that barley yields on the check plots were 18.7 and 12.7 bushels per acre. With adequate N, P, and K, yields were 65 and 46 bushels per acre. Similar results could be cited for Almasippi and other mapped soils in Manitoba. This illustrates the uncertainty and even futility of rating soils on the basis of what we might expect under management levels that might be practised in the future.

b) Soils not classified on experimental sites.

Several members of the subcommittee also gave examples of spectacular increases in yield beyond what might have been expected when fertilizers were applied. Even though the yield increases have been documented, often the soil type or even the characteristics of the plot sites were not recorded. The data is therefore of doubtful value for projections.

c) Our understanding of the importance of soil features other than fertility on the type of crop grown and on yields obtained is not complete.

No doubt climate and soil physical features including texture, parent material, organic content, drainage, etc. influence yields obtained even when fertility is adequate. These have been studied in a general way, so that after experimentation we know that one soil differs in its productive capacity from another. Unfortunately, we cannot determine why it did. Therefore, projecting yields without an understanding of the possibility of interactions is risky. Again, some data from field work in Manitoba illustrates this point. Wheat has been grown on fallow and on stubble for 6 years on the Wellwood Association (Orthic Black). This is class 1 land. However, even with high rates of fertilizer, the yields of wheat on fallow have not exceeded 30 bushels per acre, and on stubble they have not exceeded 20 bushels. Other soils, considered to be poorer when opinions are based on profile characteristics (e.g. Almasippi, Pelan) have consistently yielded more with adequate fertility.

This problem also exists for special crops in other areas. Work with processing peas in New Brunswick has shown considerable variation in yield between these crops growing on different soil series. But there is no evidence to indicate whether the differences were due to climate, soil type, or other factors.

d) Management practices have been changing too quickly to provide adequate data.

In areas like southern Ontario, special crops are extremely important. Not only are new crops and varieties being introduced, but there has been a spectacular increase in the use of fertilizer. These factors have combined to increase yields to a level not previously considered likely. As a result of the changes in technology, no consistent data is available on which to make projections for "superior management" yields.

In Western Canada, the proportion of land devoted to fallow each year is decreasing. This has been attributed to advances in technology and a realization by farmers that good crops can be grown on stubble land. We may find that yields per acre may just remain constant or even decline, even with increases in technology, due to the fact that crops like wheat may be grown more often on stubble.

e) Crop quality consideration.

In areas where special crops like potatoes are produced, the farmers are naturally concerned with quality and hence, marketability. Top yields may not be the objective unless it is consistent with a high degree of marketability.

f) Variability of soils within mapped units.

Mapped soil units include a range of closely related soils. From the fertility standpoint, however, they may vary considerably. This has been shown by a review of the available nutrient status of soils analysed by the Manitoba Soil Testing Laboratory. (The variability in available N and P is generally greater than the variability of K.)

It is therefore difficult to characterize the fertility level of individual soil types.

The subcommittee members agreed that crop yield assessments for "superior" management are not practical at this time. Although assessments undoubtedly could be made, their validity would be in serious doubt. We should, however, strive to obtain data to make assessments at the superior level in the future.

Several approaches have been suggested by the subcommittee:

(1) Field trials should be established whereby various crops could be tested on a number of soils, under various conditions. This would involve the measuring of many characteristics including yield, available nutrient status, soil physical characteristics, climatic data, etc. Data would be programmed in a computer with the objective of arriving at crop yield prediction equations:

Yield = f(climate + soil characteristics + plant characteristics + ... + ...)

(2) By field trials, the effect of specific factors may be determined. In this approach, the factors other than the one under investigation are eliminated or minimized by adding nutrients, etc.

Much of our research is oriented this way. It provides answers to specific problems. This information must then be projected along with all other sources of information (Crop Insurance Corporation data, Soil Testing Laboratory data, etc.) to arrive at yield estimates.

(3) Collection of data from farmers and use of data from computerized programs of Crop Insurance Agencies and Soil Testing Laboratories.

Some projects involving data collected from farmers have been attempted and have been beneficial. These projects, however, rely on the cooperation of farmers (which cannot always be depended on) and furthermore provides data on "what is happening now." It is not likely to provide sufficient information for estimating yields at the "superior" level of management.

(4) Use of present data for specific crops.

Whereas, in general, crop yield assessments cannot be made at the "superior" level for most crops, there are still some special crops in small areas that may be yielding at a maximum economic level. It was suggested that yields of potatoes in New Brunswick may now be in this category or approaching it. Similarly, yields of corn in Ontario may be optimum for some soil types and also irrigated sugar beets in Alberta. If workers in these specific areas are reasonably sure of the yields obtained, then they should be made available.

These possible approaches should be considered with regard to: (i) Will the project or new approach provide data of a useful nature or will it just provide more data? (ii) Will the data collected be out of date too quickly to be of any value, particularly if a number of years of repetition are required? (iii) Are crop yield assessments at the "superior" level of management important enough to justify the time of researchers and the expenses involved?

2. Whose responsibility is it to make crop yield predictions?

In the past, this type of characterization of soils was done by surveyors. In recent years much of the soil productivity interpretation work has been done jointly by pedologists and soil fertility specialists. If we are to attempt to obtain the "superior" management level yields for crop assessments, this work will have to be done by pedologists, fertility specialists, agrometeorologists, and economists. Although economists should not be involved at the characterization level, they should be involved in determining the optimum economic level of production. This optimum level is of course influenced by markets, selling price of agricultural products, and costs of inputs. The responsibility for initiating the projects lies firstly with pedologists if the data is to be included in soil reports. If it is to be published or made available in other forms, then agronomists have a responsibility. Regardless of who initiates the project, it should be done by a group of experts from related fields.

3. Are soil survey reports the place to publish crop yield assessments?

Not all members of the subcommittee agreed, but it was the general opinion that soil survey reports should contain the best information on the productivity of soils that is available at the time of publication. The type of data available, and the validity of it, will vary between provinces and even between areas in provinces.

The provincial groups should therefore determine whether suitability classes for crops, productivity indices or crop yield assessments should be published, or indeed if any practical interpretations should be included. If improved assessments can be made after reports are published, they could be made available on a provincial or local basis.

In summary, the following recommendations are offered by this subcommittee:

1) That the name of this subcommittee be changed to Crop Yield Assessments.

2) Data on soil productivity, where it is available and considered valid, should be published in soil survey reports, to help characterize mapped soils. The extent of practical published interpretations (i.e. suitability classifications, soil productivity indices, and crop yield assessments) should be left to the discretion of provincial groups, because they are most aware of local problems.

3) Crop yield assessments for the "superior" management level are difficult to attain and may be of limited value because they are subject to rapid changes in technology. We can, at best, project yields only on the basis of presently known technology.

4) Several problems are evident. These are:

   (a) making crop yield assessments for mapped soils under "good" and "average" management,

   (b) making crop yield predictions for "superior" management.

   In view of these problems, two approaches are suggested:

   (a) Extensive research - the collecting and analysing of data from past research, Soil Testing Laboratories, Crop Insurance Corporations, etc.

   (b) Intensive research - detailed experimental research in the field. This may involve:

      (i) a small number of sites, but include a large number of observations conducted over a period of time, or

      (ii) small plot research designed to solve specific problems.

   The approach taken to obtain the required information must be left to the discretion of the workers in the various provinces.

5) Crop yield assessments have been considered by many to be largely an economic concept. This is probably true of assessments for the "superior" level of management, where inputs and outputs are to be measured. A team approach is therefore necessary and recommended. The team should consist of pedologists, soil management specialists, soil fertility specialists, agrometeorologists, and economists.

REPORT OF THE SUBCOMMITTEE ON SOIL SURVEY INTERPRETATION FOR ENGINEERING PURPOSES

S. Pawluk, Chairman

The recommendations presented here come from several sources of information. Questionnaires were circulated among various professional groups to determine their specific needs and priorities. Considerable data were obtained from U.S. Government agencies that are presently involved in similar interpretations. Suggestions from members of the subcommittee have been incorporated as well.

In order that a logical approach may be taken to presenting concepts that will provide optimum information for meeting the objective, it is essential to first set forth the following premises:

1) All interpretations basically involve the use of soils for two specific purposes, namely for growing plants and for construction (foundations, highways, canals, etc.).

2) The latter use is of specific interest to the engineering sciences but not specifically limited to that discipline (may be of interest to town planning, recreation, etc.).

3) The application of soil survey information to engineering needs depends upon the integration of measured as well as inferred properties and characteristics of the soil body.

4) The application deals with both natural and remoulded soils.

Required Information

Consideration must be given firstly to the properties and characteristics that are required for engineering interpretations although not necessarily specific to this need. These are listed as follows according to the order of priority:

	Measured Properties and Characteristics		Inferred Properties and Characteristics	
	Specific to construction	Required for plant growth also	Specific to construction	Required for plant growth also
Most Essential	Atterberg limits Particle size distribution by engineering standards Shrinkage limit Moisture-densities (optimum moisture for compaction) Maximum dry densities Field moisture content Electrical conductivity	Undisturbed structure Consistency	"A" values Corrosion potential Plasticity index Shrinkage index	

	Measured Properties and Characteristics		Inferred Properties and Characteristics	
	Specific to construction	Required for plant growth also	Specific to construction	Required for plant growth also
Useful if available and may be required for applications to specific projects	Bearing strength Frost action In sity hydraulic conductivity	Undisturbed pore space 0.33 bars and 15 bars moisture Depth to water table) where feasible Depth to bedrock) Maximum depth of frost penetration Clay mineralogy Exchangeable cations and cation exchange capacity Organic matter content Ca and Mg carbonates and pH		Trafficability Erodibility Drainability Moisture retention

Field Information

Field information that may be collected during the normal course of the survey and added to the report, if possible, is as follows:

1) Present vegetation sustained.
2) Detailed information regarding drainage patterns (streams, rivers, etc.).
3) Lithological map 1:250,000 scale.
4) Location of materials suitable for earth structures (gravel or fill).
5) Location of areas of unstable ground (mudflow, slumps, etc.).
6) More detailed landform information.

Alterations to the present report to make it more useful to the engineer are as follows:

a) Correlation of engineering, pedological, and geological terminology.
b) Relation of pedological classification to engineering classification including the unified and the AASHO classifications.

Comments on Soil Characteristics and Properties

If the above suggestions were incorporated into the present soil survey reports they would help to meet the needs of the engineer. On the basis of consultations with engineers from private and government organizations, we recommend that as many of the properties listed be included as possible, an effort should be made to provide at least the essential ones. The majority of engineers feel that there would be little difficulty in making their own interpretations if necessary and that the above information should be incorporated into the main body of survey reports. Any interpretations that are to be included should be in a separate section, perhaps an appendix, and be prepared in cooperation with an engineer.

Many different arrangements for conducting analyses may be employed. In many regions of the country it may be possible to have the analyses conducted in cooperation with local engineering laboratories (e.g. in Alberta, the Dep. of Highways, consulting labs, etc.) that are presently able to handle a large number of samples quite routinely. Some consulting labs have offered their services in their spare time on an "at cost" basis, which is quite nominal. In some instances it may be essential to establish "regional laboratories" to handle the additional analyses for interpretive classifications. This problem will likely have to be solved on a local basis because each case is unique and limited to its specific area.

Analytical procedures would be those followed by the engineers. All analyses should represent the major soil types, be conducted in replicate, and reported as averages with standard deviations. The data should be set forth in table or map form where the grouping of soil types may be conducted on the basis of similarities in properties and characteristics. (See attached maps; also "Soil Surveys and Land Use Planning" published by A.S.A.). Any grouping should be designed to provide the information in its most useful form. This, however, is not a soil survey interpretation.

Application

Interpretations of soil survey data for engineering applications may have many uses and may take on many forms. Generally, the approach will vary with local needs and facilities available. However, the prime objective is to group the pedological units on the basis of similarities in one or several of their properties and characteristics into interpretive units that are of direct use in tables or map form or both and may be conducted manually or, if available, with a computer. The use of the computer provides many advantages, the most significant of which is the integration of data on weighted properties and characteristics in the computation of interpretive classes. Proper programming will be essential, but once established may have applicability on a national basis. In addition, the program would be useful for other interpretations. It is therefore recommended that this matter be considered by a subcommittee acting on behalf of the National Soil Survey Committee.

It is important to emphasize that the interpretation must be conducted by pedologists only in consultation with professional engineers. The pedologist not only has a basic knowledge of the model concepts that define the soil body, but also an appreciation of how they actually exist in reality. The engineering scientist can best categorize the criteria that define classes for any specific use.

Although a format may be prepared on a national basis, the actual properties considered for different applications will vary with regional differences in climate, vegetation, geology, and soils as well as with the objectives. Because much of the engineering classification at present is of an empirical nature, it does not lend itself readily to categorization. For these reasons, the committee is not able to recommend definitions for interpretive classes on a national scale. This should be left to local or regional bodies. As an example, definition of interpretive units and classes that categorize the suitability of soil materials for roadbed construction will certainly be different for the Great Plains region where soft bedrock occurs at depth, than for the Precambrian Shield where granitic rock is close to the surface or for the Maritimes where moisture regimes, resulting from climatic variations, may be much higher. Furthermore, there are obvious differences in criteria that will be required for establishing classes within the southern and northern Great Plains region where frost action and moisture regime will vary in their significance.

In the preparation of tables or maps or both for interpretive groupings there are essentially two approaches that must be considered in setting up the format.

The first and very useful type is one based on limitations of the defined soil properties and characteristics with respect to application. An example of a table form is given below (Engineering Sections of Soil Survey Reports, U.S. Dep. Agr.).

Limitation Classes for Septic Tank Filter Fields

Soil Properties	Limitation Class		
	Slight	Moderate	Strong
Permeability	>1.0 in./hr	1.00 to 0.63 in./hr	<0.63 in./hr
Groundwater level, etc.	>4.0 ft below surface	<4.0 ft occasional high water	<4.0 ft frequent high water

In the interpretation of the data some soil bodies may, for example, exhibit strong limitations with respect to permeability and slight limitations with respect to groundwater level. The interpreter must then decide upon its suitability for application to the specified purpose. As the engineers have indicated this has been done in the past in rather an empirical fashion where little or no categorization was considered.

The second approach and most desirable, if at all feasible, is the categorization of the mapping units on the basis of their characteristics and properties rather than on the basis of individual properties. In this case a rating system similar to that presently used in agriculture may prove to be useful, however the limiting factors should be defined. Each of the factors must be properly weighted in order to emphasize the restrictions imposed with respect to the use of the soil for the desired purpose. In this instance, each of the units within any class would be defined in terms of all the significant features of the soil body. Therefore, the working aggregates would be the mapped units rather than their individual characteristics and properties as in the first instance.

Rating Soils for Dikes and Levies

Limiting Soil Factors*	Soil Types BhL	DuSiC
Stability	10	6
Shrink-swell potential	10	6
Cracking hazard	10	5
Presence of rock	8	10
Susceptibility to piping	8	6
Presence of organic matter	8	8
Final rating**	50	9

*Range of limitations - 1-very highly restricting, 10-non restricting.

**Final ratings: 0-10 unsuitable, 10-25 suitable but only with special precautions, 25-45 moderately suitable, 45-70 good construction material, 70-100 excellent construction material.

Final ratings may be arrived at by various means and depend to a great extent upon the engineering scientist participating in the interpretation. It may be necessary to arrive at the actual final evaluation by utilizing more complex equations than suggested in the above table, however, this may be readily done with a computer. It should be emphasized that any map sheet programmed for computer analyses would be useful for other interpretive classifications.

A suitable format that may be considered is essentially that proposed by the U.S. Dep. Agr. (Soil memorandum SCS-45) with slight modification and may be outlined as follows:

A. Introductory statement

1. Indication of significance to engineering
2. etc.

B. Statement of limitations on applicability and use of information

1. Limitations in scale of mapping
2. Need for more detailed investigation in on-site projects, etc.
3. etc.

C. Statement on how information can be used

1. Use for preliminary evaluation for highway planning, site, development, etc.
2. Locate sources of construction material
3. Development of recreational facilities, etc.
4. etc.

D. Reference to soil science terminology

1. Correlation of terms relating to pedology, engineering, and geology
2. Definitions
3. etc.

E. Narrative statements to clarify the meaning of items in tables or maps

1. Errors in accuracy as related to methods of analyses
2. Variability in application as related to field sampling
3. Methods of integrating properties for defining specific application
4. If computers employed, method of programming, plotting, etc. should be outlined
5. etc.

F. Tables and maps outlining the interpretation of properties and characteristics for specific engineering application

This would vary with the specific needs of the area and of necessity would include only some of the following:

information required on a regional base for general use	1. highway construction 2. pipeline and buried telephone line corrosion
detailed information limited to specific sites under investigation	3. airports, earth structures, e.g. embankments, dikes or levies, reservoirs 4. septic tank construction 5. foundation construction 6. pollution control
information required on a regional base for specific use	7. factors related to canal construction a. irrigation b. drainage c. waterways d. terraces and diversions

G. A short narrative statement covering general soil conditions, unusual site factors, problem areas, geology, groundwater, or other supplemental information

A number of useful references to consult are available from the U.S. Dep.Agr.

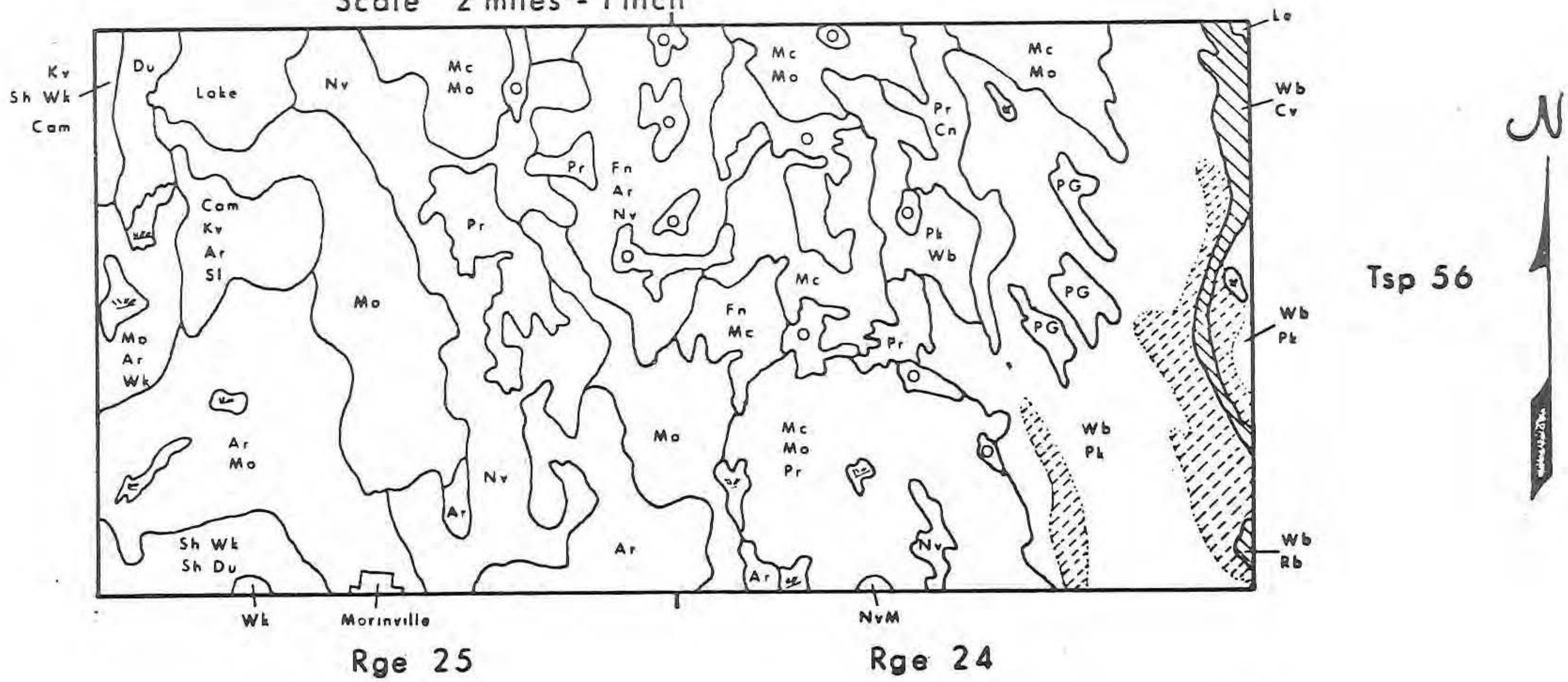
1. "Engineering Sections of Soil Survey Reports" (a general guide).
2. "Soil Surveys and Land Use Planning". Soil Sci. Soc. of Amer.
3. "Soil Memorandum SCS-45". U.S. Dep. Agr.

Soils Map

Tsp 56, Rge 24, W 4 th Meridian

Tsp 56, Rge 25, W 4 th Meridian

Scale 2 miles = 1 inch



Legend

Soils

Till

Angus Ridge	Ar
Falun	Fn
Camrose	Cam

Residual

Kavanagh	Kv

Lacustrine

Duagh	Du
Wetaskiwin	Wk
Malmo	Mo
Mico	Mc
Navarre	Nv

Lacustrine

Navarre Meadow	NvM
Prestville	Pr
Peaty Gleysol	PG

Deltaic

Ponoka

Winterburn

Leith

Miscellaneous

Organic	O
Marsh	
Slough	Sl

Topography

Undulating	0 - 5 % slopes
Gently Rolling	5 - 9 % slopes
Rolling	10 -15 % slopes

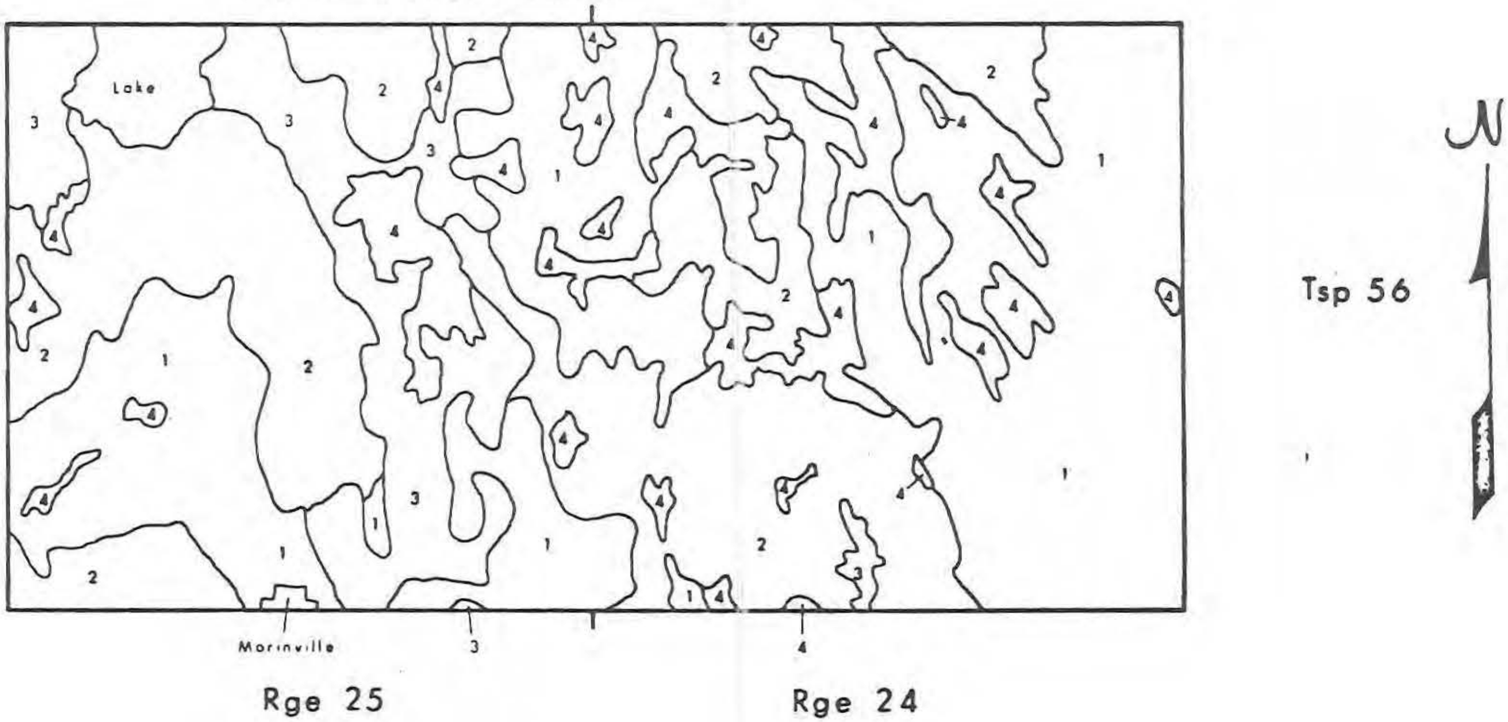
Source: Soil Survey of Edmonton Sheet

Soil Interpretation - Inherent Hydraulic Conductivity

Tsp 56, Rge 24, W 4 th Meridian

Tsp 56, Rge 25, W 4 th Meridian

Scale 2 miles = 1 inch



1	Moderately Permeable
2	Slowly Permeable
3	Very Slowly Permeable
4	Very Slowly Permeable (depressional)

Source: Soil Survey of Edmonton Sheet

DISCUSSION ON SOIL SURVEY REPORTS

D.B. Cann and C.R. Wood

The purpose of the discussion on this subject was to obtain a greater degree of uniformity in emphasis in soil survey reports in Canada. The following details were considered.

Technical or nontechnical reports--There was considerable discussion on the extent to which technical language should be used in a report. Some people expressed the opinion that two reports, a technical and a nontechnical one, should be written. Others thought that a report should be technical. It was pointed out that it would be difficult to get out two reports because of the time involved. There could be more elaboration and explanation in the reports to make them more useful to a wider range of readers. Some members said that an entirely new approach was needed, but gave no details. Many members felt that the reports should be written for research and technical personnel and well-informed farmers and that these people have no difficulty in interpreting the reports. It was concluded that the present reports are as adequate as can be made under present circumstances and that we should carry on in this manner for the present.

Style manual--It was recommended that the Style Manual for Biological Journals be used as a guide in writing soil survey reports. The members agreed to accept this recommendation.

Introduction to soil reports--There was some discussion on whether soil reports should have an introduction, a preface, or a foreword. After receiving an explanation of the meaning of these terms, it was agreed to use a preface or foreword in future reports.

Vegetation--There was considerable discussion on the manner in which vegetation is described in soil reports. It was recommended that the common and scientific name, together with the authority, should appear in a table in an appendix to a report. Common names may be used throughout the text. It was thought that, in some cases, complete scientific names might be difficult to obtain. In other cases, the identification by the local botanist would be acceptable.

Tables--There were various opinions as to where tables should appear in a report. It was the general opinion that some flexibility must be allowed, depending on the amount of data being used. It was suggested that when a large number of tables are used in a report, they could be gathered into a separate leaflet to be placed in a pocket of the report. No firm recommendations were made.

Series and soils--It was pointed out that these words were used interchangeably in some soil reports. The members felt that this was acceptable, but that one or the other should be used throughout a report.

Soil capability--There was general agreement that a discussion of soil capability should form a separate section of a report and should not be a part of a detailed soil description. A brief statement on capability included in the Use section of the soil description would be accepted.

Soil descriptions--In order to promote uniformity in describing soil profiles, the following format was proposed for describing soil horizons.

1. Color - moist or dry or both
2. Texture
3. Mottling - abundance, size, contrast
4. Structure - grade, class, kind
5. Consistence
6. Roots - abundance, size, distribution
7. Pores - abundance, size, distribution
8. Clay films - frequency, thickness, location
9. Concretions
10. Carbonates
11. Stones
12. Horizon boundaries - distinctness, topography
13. pH

Members agreed to follow this proposal.

Metric system--The use of the metric system in soil survey reports was discussed at some length. A number of members favored using the system for soil depths. A vote on the subject resulted in most members favoring the use of the English system.

PROGRESS - CANADA LAND INVENTORY

R. J. McCormack
Chief, Canada Land Inventory

I am pleased to have the opportunity to report to you on the progress of the Canada Land Inventory. The National Soil Survey Committee has been one of the principal groups responsible for the Inventory and your early and continuing support of the program has been very gratifying. I would also like to take this opportunity to publicly acknowledge the invaluable assistance you have provided and are continuing to provide.

To give you a complete background on progress, I will deal with three aspects of the program. These are:

1. Progress of all sectors at the two scales, that is, for publication and computer input.

2. Progress of the economic feasibility studies to parallel the physical capability mapping.

3. Land-use planning projects announced as a policy of ARDA in November 1967.

Mapping Progress - 1:250,000 Scale for Publication

On the index map of southern Canada is shown a tentative boundary within which capability mapping has been carried out in agriculture, forestry, wildlife, and recreation. Considerable progress has been made and it may be of interest to note that we will be distributing indices showing publication progress in each sector from time to time.

Agriculture: As of April 16, 1968, 87 manuscripts had been received. Of these, 26 have been published and are ready for distribution. An additional 27 are in the final stages of preparation.

Forestry: Fourteen manuscripts have been received and of these 5 are in the final stages of publication. One map has been experimentally printed.

Wildlife (Waterfowl): Fifty-six manuscripts have been received; none has been published nor is awaiting publication.

Wildlife (Ungulates): Eighteen manuscripts have been received and one has been prepared for publication on an experimental basis.

Recreation: Of the 17 manuscripts received for publication, one is in the final stage of preparation and has been experimentally printed.

In summary, 192 manuscripts are in the process of preparation for publication; of these, 26 have been published or are about to be and an additional 33 are in the final stages of preparation.

Mapping Progress - 1:50,000 Scale for Computer Input

The manuscripts, that is full map sheets, received and prepared or in the process of preparation for computer input are as follows:

Present Land Use	-	1,581
Agriculture	-	573
Forestry	-	161
Wildlife (Waterfowl)	-	869
Wildlife (Ungulates)	-	310
Boundary Maps	-	1,769
Total	-	5,263

Maps of sports-fish capability, which will be input at the 1:250,000 scale, have not yet been received in any significant number.

Forty-nine watershed maps at 1:250,000 have been compiled and 11 are in preparation.

Economic Feasibility Studies

As some of you know we are interested in studies to justify the economic feasibility of land use for a given purpose. These studies will, of necessity, be regional in nature, but are, we feel, an essential supplement to the physical capability studies to formulate land-use policies.

Studies in the economics of use for recreation and wildlife have been the subject of discussions with the Canadian Council of Resource Ministers. Forest land economic studies have been carried out in southern Ontario (J.R.M. Williams and D. V. Love, Economics of Plantation Forestry in Southern Ontario) and projects are being undertaken by the Forest Economics Research Institute of the Forestry Branch, Department of Forestry and Rural Development. In addition to the study, primarily of dairy farming, carried out by H. F. Noble in eastern Ontario, several studies are being carried out to support the comprehensive development plans being undertaken under the Fund for Rural Economic Development. As funds permit other studies will be started.

Land-Use Planning

In November 1967, the Rural Development Branch announced a policy of financial and technical support to the provinces for pilot projects in land-use planning. By this means it is hoped to ensure full and proper use of the Canada Land Inventory data and, in addition, provide an assessment of the adequacy of the information for land-use planning.

To date, planning projects are being supported in Prince Edward Island, Nova Scotia, and British Columbia. Discussions have also been held with a number of other provinces.

The foregoing outlines very briefly the progress of the Canada Land Inventory program. It is obvious that we are making very good progress, but still have a considerable amount of work to do. Our only hope is that we continue to receive the same unqualified support and assistance from the National Soil Survey Committee that we have up to now.

REPORT OF THE SUBCOMMITTEE ON BIOPHYSICAL LAND CLASSIFICATION

M. Jurdant
Canada Department of Forestry and Rural Development

Population increase and economic growth demand maximum utilization of renewable resources. It is generally agreed that land cannot be properly utilized unless it is managed, a concept first developed by foresters. According to Huffel (1926), forest management is the sum of all the operations of harvesting products of the forest on a sustained-yield basis. The Society of American Foresters (1944) defines forest management as "the management of a given forest unit so that the annual or periodic yield of timber or other forest products can be maintained in perpetuity." It was, however, in 1960 at the Fifth World Forestry Congress that the concept of multiple use of renewable land resources was fully recognized on a world-wide basis.

In his keynote address at the first general session of that congress, McArdle (1960) stated that multiple use "requires conscious, coordinated management of the various renewable resources, each with the other, without impairment of the productivity of the land." Cliff (1960), in his description of the preparation of regional guides for multiple-use planning and coordination by the United States Forest Service, states "the first step is to gather quantitative and qualitative facts about each resource, its potentiality and the demands that are likely to be made upon it." In addition to knowledge of the production of the land, an evaluation of its productivity is essential to land management. Production here is defined as the actual amount of products in a given area (the crop itself), whereas productivity is the potential production, i.e. the maximum amount that the area could produce on a sustained-yield basis (the ability to produce crops).

Paralleling the growth of the Canadian economy and population is the increasing attention being given to the potentialities of land for multiple use. This is particularly true of forested lands for which the alternative uses are more likely to conflict. Agriculture, forestry, wildlife, water, and recreation are the five major uses that should be considered if land planning and management are to be practiced. These uses are derived from natural resources that have the following characteristics in common:

1) They are renewable. As a consequence, conservation practices are needed to keep up high production rates.

2) They all depend on both the physical and biological environment... or, in other words, they all depend upon the five independent variables of Jenny's equation: climate, parent material, relief, organisms, and time. As a consequence, the knowledge of the physical and biological environment is the necessary basis on

which to evaluate capabilities. The corollary is that any information already collected for evaluation of capability for any of these resources should be useful (although not necessarily sufficient) for evaluating capabilities for the other resources.

3) They are interdependent; any exploitation of one of these resources causes effects on one or several others, which can be beneficial, indifferent, or disadvantageous. Consequently, cooperation is needed among the various users of the land.

One major aim of the National Committee on Forest Land is to advise on the development of a national system of forest land and soils inventory.

The Subcommittee on Biophysical Land Classification was created and the objectives described as follows:

1) To examine and review systems of land classification developed and used at national and regional levels.

2) To present recommendations to the National Committee on Forest Land on a suitable physical land classification, of a reconnaissance nature, which will lend itself to interpretations for forestry, agriculture, recreation, wildlife, and hydrology.

At its 1967 meeting, the National Committee on Forest Land proposed the undertaking of a series of pilot projects in various parts of the country to develop and refine a biophysical land classification system.

In May 1967, the Subcommittee on Biophysical Land Classification met in Winnipeg to establish preliminary guidelines for these pilot projects.

Five pilot projects were then begun in British Columbia, Manitoba, Quebec, Nova Scotia, and Newfoundland.

This paper briefly summarizes the preliminary results of these studies, which are described at length in a Canada Land Inventory progress report (Canada Land Inventory, 1968).

Following are the differences between and the similarities of a biophysical land survey and a soil survey and the reasons for them.

1) Since the purpose of the survey is to assess the capability of the land for various uses, the units of the classification must be based on criteria that bear significance to these uses. Soil surveys were devised primarily for an agricultural purpose. The forestry purpose, for example, was generally overlooked, partly because of scanty information about which soil features are significantly related to tree growth and forest land management, and partly because of higher mapping costs in the forest than in the open, which precludes the same level of detail. One main feature of the landscape not systematically considered in soil surveys yet, which is most significant to forestry, recreation and wildlife, is vegetation in both its actual (structure and composition of

vegetation) and dynamic (succession) aspects. This led foresters to direct their attention to the forest land rather than to the forest or the soil. The forest land can be looked upon either as an assemblage of organisms in an environment of air, water, and soil or as a physical area supporting living organisms. In other words, the forest land constitutes an entire ecological system (or ecosystem) in which complex interrelationships exist between organisms and the various components of the physical environment.

Considering that neither vegetation nor soil can adequately express the ecosystem (or forest land) as a dynamic, functional entity, a group of Canadian participants in the Fifth World Forestry Congress made a series of proposals based on opinions expressed at the Ninth International Botanical Congress. Proposal 5 recommends "that the description and classification of ecosystem units be based on significant features of both forest and land, as neither forest vegetation nor physical environment alone can indicate unequivocally the nature of the ecosystem (Rowe et al 1960).

The chairman of thé Biophysical Land Classification Subcommittee, who recently reviewed the work in land inventory and mapping in Canada, proposed that a biophysical land classification should be centered around a concept of land unit he defined as "a combination of soil series and vegetation type which has a specific physiographic position on a defined landform" (Lacate 1966).

Modern Canadian forest land classifications are centered around the concept of ecosystem considered as an objective entity, that is, in the terms of Rowe (1962): "a perceivable unit of the landscape, homogenous both as to the form and structure of the land and as to the vegetation supported thereon." The fact that the ecosystem types are called a "Total Site Type" by Hills and Pierpoint (1960), a "Land Unit" by Lacate (1965, 1966), a "Forest Habitat Type" by Mueller-Dombois (1964), a "Forest Type" by Damman (1964), a "Forest Site" by Jameson (1963), or an "Ecological Type" by Jurdant (1964a, 1964b) is not important, provided the types are based on significant attributes of both vegetation and land (soil, relief, climate). All these classifications provide the background on which the pilot projects in biophysical land classification have been undertaken.

In summary, the purpose of the biophysical classification forces is to use criteria of both vegetation and land (including soil) in the determination of taxonomic units.

2) The biophysical land classification is to be applied in large, unsettled areas of forest and associated "wildlands". These areas are characterized by the following features:

a) They are large. The merchantable forest lands of Quebec alone cover an area of more than 250,000 square miles (5 times the size of New York State or 21 times the size of Belgium).

b) They are largely unsettled and not readily accessible.

c) They are covered with forest vegetation, either disturbed or natural.

d) They are areas on which little basic knowledge is available concerning soils, geology, geomorphology, climate, and ecology.

From these features it is concluded that if the survey of these areas is to be undertaken rapidly and at a reasonable cost, it must make a very large use of aerial photographs. In other words, criteria to define or identify the taxonomic units of classification must lend themselves to an interpretation on aerial photographs so that the mapping units can be accurately identified with a minimum of field checking. Features that can best be identified or inferred on aerial photographs are: broad vegetation groups, topography, depth of soil, stream drainage pattern, surface erosion features, soil texture, soil drainage, and type of bedrock. Neither the soil profile nor the vegetation type can be of any use at this stage. But, from these features, the landforms can be delineated relatively easily, and it is within this geomorphological framework that soil and vegetation can be classified with a maximum of efficiency.

In summary, the technique employed in biophysical land surveys (i.e. airphoto interpretation) to a large extent influences the kinds of units that are to be established. In addition to soil science, the classifiers must make great use of information derived from geomorphology and ecology. The ideal team would be composed of a soil scientist, a geomorphologist, and an ecologist or a phytosociologist.

3) It is often argued that three separate maps (geomorphology, soil, and vegetation) followed by superposition would lead to the same result (a posteriori integration) as an a priori integration. It appears, however, that such a superposition is very difficult, if not impossible, due to great difficulties in setting the most useful criteria in every discipline; it is also very expensive. The method was used in the Gaspé Peninsula by the B.A.E.Q., but the integration was not made.

4) The usefulness of existing soil surveys might be questioned. Preliminary results of two pilot projects undertaken in areas for which soil survey information was available indicate a close agreement between the biophysical units and patterns of soil survey mapping units.

The five pilot projects are described in detail in a Canada Land Inventory report (Canada Land Inventory, 1968). They have the following characteristics in common:

a) They all rely on the use of airphoto interpretation techniques combined with supporting field checks.

b) The basic mapping unit is a geomorphological segment of the landscape.

c) Each unit is described in terms of both soil and vegetation patterns.

d) The surveys are carried out by a team.

The detailed approach is not always the same in the various projects, but the completed results will lead to a common methodology and classification units, which will have the same meaning throughout the country. The existing differences are caused mainly by differences between the geographical areas themselves.

Although the level of generalization varies from project to project, there is agreement on the need for a unit that can be mapped at the scale of 1:125,000. The latter is called a "Geo-Unit" in British Columbia, a "Land Unit" in Manitoba, a "Landscape Unit" in Quebec, a "Land System" in Nova Scotia and a "Land Component" in Newfoundland. These units can be described in terms of relative percentage area of soils (at a level equivalent to that of the Series) and vegetation (at the level of vegetation type). Furthermore, they could be defined by the Australian concept of "Land system", i.e. "an area or group of areas throughout which there is a recurring pattern of topography, soils, and vegetation" (Christian 1952).

In conclusion, these pilot projects have shown:

1) The feasibility of undertaking biophysical surveys rapidly and at relatively low cost.

2) Although the units used in each individual project are not exactly similar, a common degree of generalization can be foreseen in the near future.

3) The team approach has proven to be very satisfactory, the ideal team being composed of a geomorphologist, a soil scientist, and a vegetation specialist.

4) Because the complexed units are also soil associations, good correlations with existing and more detailed soil surveys are desirable and possible. This is most beneficial since more knowledge will become available.

References

Canada Land Inventory, 1968. Biophysical land classification pilot projects. Progress report. Canada Dep. of Forestry and Rural Development, 306 p.

Christian, C.S., 1952. Regional land surveys. J. of the Australian Inst. of Agr. Sci. 18: 140-146.

Damman, A.W.H., 1964. Some forest types of Central Newfoundland and their relation to environmental factors. Forest Sci. Monogr., No. 8, 62 p.

Hills, G.A. and G. Pierpoint, 1960. Forest site evaluation in Ontario. Ontario Dep. of Lands and Forests. Research report No. 42.

Jameson, G.S., 1963. Relation of jack pine height-growth to site in the mixed wood forest section of Saskatchewan. Forest-Soil Relationships in North America. Oregon State Univ. Press, p. 299-316.

Jurdant, M., 1964a. Photo-interpretation and forest land classification. Woodlands Review. Pulp and Paper Magazine of Canada, Oct. 1964.

Jurdant, M., 1964b. Pédologie, phytosociologie et classification des terrains forestiers au Canada. 8è Congrès Int. de la Sci. du Sol, Bucarest, Vol. 5: 1103-1110.

Lacate, D.S., 1965. Forest land classification for the University of British Columbia research forest. Canada Dep. of Forestry. Pub. 1107, 24 p.

Lacate, D.S., 1966. Wildland inventory and mapping. Forestry Chronicle, 42: 184-194.

Mueller-Dombois, D., 1964. The forest habitat types of southeastern Manitoba and their application to forest management. Can. J. Bot. 42: 1417-1444.

Rowe, J.S., 1962. Soil, site and land classification. Forestry Chronicle, 38: 420-432.

Rowe, J.S., P.G. Haddock, G.A. Hills, V. Krajina, and A. Linteau, 1960. The ecosystem concept in forestry. Proceedings 5th World Forestry Congress, Vol. 1: 570-572.

RESOLUTIONS

N.S.S.C. Meeting

1968

1. Be it resolved that the National Soil Survey Committee express the sincere appreciation of its members to the Government of Alberta for the warm welcome and buffet dinner provided on Wednesday evening.

   Moved by T. W. Peters
   Seconded by C. A. Rowles
   Carried

2. Be it resolved that the National Soil Survey Committee express the sincere appreciation of its members to the University of Alberta and its Faculty of Agriculture for providing excellent facilities for the plenary sessions and subcommittee meetings.

   Moved by C. A. Rowles
   Seconded by R. A. Hedlin
   Carried

3. Be it resolved that the National Soil Survey Committee express the sincere appreciation of its members to Dr. Peter Somers for his excellent address at the banquet on Wednesday evening.

   Moved by W. Odynsky
   Seconded by R. E. Smith
   Carried

4. Be it resolved that the National Soil Survey Committee express the sincere appreciation of its members to the staffs of the Department of Soil Science, University of Alberta, and the Alberta Soil Survey for the excellent arrangements made for the 1968 meetings and for the warm welcome extended to the members.

   Moved by R. A. Hedlin
   Seconded by C. A. Rowles
   Carried

5. Whereas the value of a soil survey is in large measure dependent on the method used in reporting the data, and

   Whereas there are many categories of readers interested in soil survey data; for example, pedologists at home and abroad, research workers in other scientific disciplines, extension workers and farmers, as well as government and commercial personnel in the administrative and technical fields from a variety of disciplines, who are concerned in some measure with the surface mantle, and

Whereas one publication or method of reporting cannot meet the requirements of all these categories, and

Whereas there have been many changes in methods of communication over the past three or four decades, and

Whereas the basic format of soil survey reports has changed little over this period.

Therefore, be it resolved that the National Soil Survey Committee appoint a committee on soil survey reporting to make a broad study of this topic and among other things to (a) determine the specific needs and interests of the various groups who use soil survey data, and (b) recommend methods of reporting that would best meet these needs.

Moved by W. E. Bowser
Seconded by J.F.G. Millette
Carried

6. Be it resolved that the National Soil Survey Committee approve the principle of an orderly evolution of Canadian taxonomic and correlative horizon criteria towards the development of an International System of Soil Classification and Identification.

Moved by J. S. Clayton
Seconded by D. W. Hoffman
Carried

7. Be it resolved that the proceedings of the National Soil Survey Committee meetings be published simultaneously in English and French.

Moved by P. Lajoie
Seconded by R. E. Smith
Carried

NOTE: The mover suggested that necessary translation be done by the Service of Translation in Ottawa and that the French version be submitted to Quebec pedologists for verification.

8. Whereas the present system of preparing subcommittee reports through the exchange of correspondence with the chairman does not permit free exchange of ideas among participating members, thus accentuating the influence of the subcommittee chairman in the preparation of the report which seems to be related to a recurrent cycle of ideas, and

Whereas meetings of the N.S.S.C. seem to allow insufficient time for a complete and thorough discussion and preparation of reports submitted in plenary sessions thus leading to necessary post-meeting corrections independent of decisions reached in plenary sessions, and

Whereas the usefulness of some subcommittee reports and of some recommendations depends on decisions reached by other subcommittees, and

Whereas the required synchronization of report submission is difficult to achieve in one N.S.S.C. meeting.

Therefore, be it resolved that the members of subcommittees meet prior to general meetings and at any other time that is deemed necessary, to prepare reports to be presented in plenary sessions and/or to participate in workshop sessions, field trips, etc., aimed at elucidating problems lying within the terms of reference of the subcommittees.

Moved by J.F.G. Millette
Seconded by K.K. Langmaid
Carried

9. Whereas the National Soil Survey Committee is now developing a classification of land forms and is involved in making engineering interpretations of soil survey information, and

Whereas the National Soil Survey Committee has been involved in the preparation of Canada Land Inventory soil capability maps, the accurate interpretation of which will require continued close cooperation between users of this information and soil scientists.

Therefore, be it resolved that the National Soil Survey Committee encourage further development of close liaison with those who can contribute to the collection of meaningful and accurate information (e.g. geologists, geographers, and engineers) and with all groups using soils information.

Moved by R. Protz
Seconded by L. J. Chapman
Carried

10. Whereas it has been agreed to prepare a monograph on Soils of Canada, and

Whereas it is important that there be a strong editorial board to plan the preparation of this monograph, and

Whereas it is important that this editorial board be representative of Canadian soil scientists with respect to knowledge of different regions of Canada and fields of interest.

Therefore, be it resolved that individual soil scientists or groups of scientists be invited to submit suggestions for an editorial board to the Chairman of the National Soil Survey Committee together with reasons for the suggestions.

Moved by W. E. Bowser
Seconded by R. Baril
Carried

MEMBERS OF SUBCOMMITTEES

Chernozemic soils - J. S. Clayton.

Solonetzic soils - W. E. Bowser.

Luvisolic soils - P. C. Stobbe.

Podzolic soils - P. C. Stobbe.

Brunisolic soils - P. Lajoie.

Regosolic soils - L. Farstad.

Gleysolic soils - A. McKeague.

Organic soils - J. H. Day (Chairman), B. Bernier, A. Dubé, P. Heringa, W. Odynsky, R. E. Smith, R. St. Arnaud, R. E. Wicklund.

Soil Families - R. Baril (Chairman), D. B. Cann, J. G. Ellis, D. W. Hoffman, D. Lindsay, J. MacDougall, R. McCormack, G. Millette, G. Mills, R. Raymond, P. N. Sprout.

Soil Series and Types - D. B. Cann (Chairman), J. G. Ellis, L. Farstad, P. Heringa, D. W. Hoffman, P. Lajoie, J. MacDougall, A. Mailloux, G. Mills, T. Peters.

Soil Phases - D. W. Hoffman (Chairman), J. G. Ellis, P. Heringa, J. Hilchey, P. Lajoie, A. Mailloux, G. Mills, W. Odynsky, P. N. Sprout.

Soils under Forest - J. S. Rowe (Chairman), R. Baril, B. Bernier, D. B. Cann, D. Lindsay, R. McCormack, R. Protz, J. A. Shields, R. E. Smith.

International Soil Correlation - J. S. Clayton (Chairman), R. Baril, D. B. Cann, J. H. Day, D. W. Hoffman, P. Lajoie, G. Millette, S. Pawluk, R. St. Arnaud, M. A. Zwarich.

Land Forms - L. J. Chapman (Chairman), P. Lajoie, R. Marcoux, T. Peters, C. A. Rowles, H. B. Stonehouse, R. E. Wicklund, M. A. Zwarich.

Chemical and Physical Analyses of Soils - J. S. Clark (Chairman), R. A. Hedlin, W. K. Janzen, A. McKeague, G. Millette, R. Protz, C. A. Rowles, J. A. Toogood.

Climate in Relation to Soil Classification and Interpretation - W. E. Bowser (Chairman), L. J. Chapman, L. Farstad, J. Hilchey, G. Robertson, J. A. Shields, S. Pawluk, R. St. Arnaud, M. A. Zwarich.

Crop Yield Assessments - A. O. Ridley (Chairman), J. H. Day, L. Farstad, L. Henry, K. Langmaid, G. Millette, S. Pawluk, R. Protz.

Engineering Applications and Interpretations of Soil Surveys - S. Pawluk (Chairman), R. Baril, E. Dejong, L. Farstad, R. A. Hedlin, J. MacDougall, E. Penner, R. Protz, L. Tardif.

Canada Land Inventory - R. McCormack.

Biophysical Land Classification - M. Jurdant.

Soil Reports - D. B. Cann and C. R. Wood.

Soil Terms - J. H. Day.

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P. C. Stobbe	Research Branch, C.D.A.
C. R. Wood	Research Branch, C.D.A.

TERMINOLOGY FOR DESCRIBING SOILS*

Many terms are used to describe soils and their environment. In order to draw this material into one document, the various groups of terms are presented in two broad categories: those which characterize the land or a pedon, and those which characterize the soil horizons.

APPENDIX 1

LAND SURFACE TERMINOLOGY

Land Forms and Topographic Classes

The following topographic classes and symbols were adopted for use in 1963 and confirmed in 1968:

Simple Topography		Complex Topography		Slope
	Single slopes (regular surface)		Multiple slopes (irregular surface)	%
A	depressional to level	a	nearly level	0 to 0.5
B	very gently sloping	b	gently undulating	0.5+ to 2
C	gently sloping	c	undulating	2+ to 5
D	moderately sloping	d	gently rolling	5+ to 9
E	strongly sloping	e	moderately rolling	9+ to 15
F	steeply sloping	f	strongly rolling	15+ to 30
G	very steeply sloping	g	hilly	30+ to 60
H	extremely sloping	h	very hilly	over 60

Water Erosion

The water-erosion classes as defined in the U. S. Dep. Agr. Soil Survey Manual were adopted. The four classes are designated on the map as W1, W2, W3, and W4. The classes are defined as follows:

W1 (Slightly eroded land): The soil has a few rills or places with thin A horizons that give evidence of accelerated erosion, but not to an extent to alter greatly the thickness and character of the A horizon. Except for soils having very thin A horizons (less than 8 inches), the surface soil (Ap) consists entirely of A horizon throughout nearly all of the delineated area. Up to about 25% of the original A horizon, or original plowed layer in soils with thin A horizons, may have been removed from most of the area. In most soils, areas with this class of erosion are not significantly different in use capabilities and management requirements from the uneroded soil. In a few soils having very shallow sola over a nonconforming layer, or in a few having a shallow A horizon over a claypan or hardpan, a significant difference may exist.

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*Compiled by J. H. Day

W2 (Moderately eroded land): The soil has been eroded to the extent that ordinary tillage implements reach through the remaining A horizon, or well below the depth of the original plowed layer in soils with a thin A horizon. Generally, the plow layer consists of a mixture of the original A horizons and underlying horizons. Mapped areas of eroded soil usually have patches in which the plow layer consists wholly of the original A horizon and others in which it consists wholly of underlying horizons. Shallow gullies may be present. Approximately 25 to 75% of the original A horizon or surface soil may have been lost from most of the area.

W3 (Severely eroded land): The soil has been eroded to the extent that all or practically all of the original surface soil, or A horizon, has been removed. The plow layer consists essentially of materials from the B or other underlying horizons. Patches in which the plow layer is a mixture of the original A horizon and the B horizon or other underlying horizons may be included within mapped areas. Shallow gullies, or a few deep ones, are common on some soil types. More than about 75% of the original surface soil, or A horizon, and commonly part or all of the B horizon or other underlying horizons, have been lost from most of the area.

W4 (Gullied land): The land has been eroded until it has an intricate pattern of moderately deep or deep gullies. Soil profiles have been destroyed except in small areas between gullies. Such land is not useful for crops in its present condition. Reclamation for crop production or for improved pasture is difficult, but may be practicable if the other characteristics of the soil are favorable and erosion can be controlled.

Gully erosion--The following classes of gully erosion have been adopted for use.

E1) These are shallow occasional gullies that may be crossed by mechanized implements and that are more than 100 feet apart.

E2) These are shallow frequent gullies that may be crossed by mechanized implements, but are less than 100 feet apart.

E3) These are deep occasional gullies that cannot be crossed by mechanized implements. A change of land use is indicated.

E4) These are deep frequent gullies that cannot be crossed by mechanized implements. A change of land use is indicated.

The following special symbol is used for the accumulation of water-eroded materials.

+ Recent accumulations less than 12 inches thick resulting from accelerated erosion, and not including normal floodplain deposits.

1+2+ Thickness of accumulations in feet.

Wind Erosion

The wind-erosion classes as defined in the U. S. Dep. Agr. Soil Survey

Manual were adopted in 1963. The classes are designated on the map as D1, D2, and D3. The classes are defined as follows:

D1 (Wind-eroded [or blown] land): Wind has removed from the soil a sufficient amount of the A horizon that ordinary tillage will bring up and mix the B horizon or other lower lying horizons with surface soil in the plow layer. Rarely is this condition uniform throughout a mappable area, however. Usually the plow layer consists mainly of the original A horizon in some patches, whereas in others the original A horizon is removed. Generally, about 25 to 75% of the original A horizon (or surface soil in soils with thin A horizons) may have been removed.

D2 (Severely wind-eroded [or blown] land): Wind has removed all of the A horizon and part of the B or other lower lying horizon. The plow layer consists mainly of the original horizons below the A (or below the original plowed layer in soils with thin A horizons), although some patches having much of the original A horizon remain in the area. An occasional blow-out area may be included.

D3 (Blown-out land): The wind has removed most of the soil profile and the land is classified as a miscellaneous land type. Use of the land for ordinary agriculture is not feasible without extensive reclamation. Blow-out holes are numerous and deeply carved into the lower soil or parent material. Areas between blowouts are deeply buried by soil material from the blowouts.

The following special symbols were adopted for use in wind-eroded areas.

Blow-pit removal. The number indicates the depth in feet.

Recent dune or dunelike accumulations. The number indicates the height in feet.


Hummocky area of mixed removal and accumulation.

Stoniness, Rockiness, and Coarse Fragments

The classes of stoniness, rockiness, and coarse fragments defined below were adopted in 1955. The agricultural significance and the description of the classes of stoniness and rockiness should be determined by each regional organization.

The classes of stoniness are defined as follows:

Stones 1 (Slightly stony land): There are some stones, but they offer only slight to no hindrance to cultivation.

Stones 2 (Moderately stony land): There are enough stones to cause some interference with cultivation.

Stones 3 (Very stony land): There are enough stones to constitute a serious handicap to cultivation and some clearing is required.

Stones 4 (Exceedingly stony land): There are enough stones to prevent cultivation until considerable clearing is done.

Stones 5 (Excessively stony land): This land is too stony to permit any cultivation (boulder or stone pavement).

The classes of rockiness are defined as follows:

Rocky 1 (Slightly rocky land): Sufficient bedrock exposures to interfere with tillage but not to make intertilled crops impracticable. Depending upon how the pattern affects tillage, rock exposures are roughly 100 to 300 feet apart and cover about 2 to 10% of the surface.

Rocky 2 (Moderately rocky land): Sufficient bedrock exposures to make tillage of intertilled crops impracticable, but soil can be worked for hay crops or improved pasture if other soil characteristics are favorable. Rock exposures are roughly 30 to 100 feet apart and cover about 10 to 25% of the surface, depending upon the pattern.

Rocky 3 (Very rocky land): Sufficient rock outcrop to make all use of machinery impracticable, except for light machinery where other soil characteristics are especially favorable for improved pasture. The land may have some use for wild pasture or forests, depending on the other soil characteristics. Rock exposures, or patches of soil too thin over rock for use, are roughly 10 to 30 feet apart and cover about 25 to 50% of the surface, depending on the pattern.

Rocky 4 (Exceedingly rocky land): Sufficient rock outcrop (or very thin soil over rock) to make all use of machinery impracticable. The land may have some value for poor pasture or for forestry. Rock outcrops are about 10 feet or less apart and cover some 50 to 90% of the area.

Rocky 5 (Excessively rocky land): Land on which over 90% of the surface is exposed bedrock (rock outcrop).

As a guideline it is suggested that land with more than 50% bedrock exposed is a Rockland - soil series complex.

The names, sizes, shapes, and kinds of fragments are designated as follows:

Shape and kind of fragments	Size and name of fragments		
	Up to 3 inches in diameter	3 to 10 inches in diameter	10 + inches in diameter
Rounded and subrounded fragments (all kinds of rock)	Gravelly[1]	Cobbly	Stony (or bouldery)[2]
Irregularly shaped angular fragments			
Chert	Cherty	Coarse cherty	Stony
Other than chert	Angular gravelly	Angular cobbly[3]	Stony
	Up to 6 inches in length	6 to 15 inches in length	15 + inches in length
Thin flat fragments			
Thin flat sandstone, limestone, and schist	Channery	Flaggy	Stony
Slate	Slaty	Flaggy	Stony
Shale	Shaly	Flaggy	Stony

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[1] The individual classes are not always differentiating characteristics of mapping units.

[2] Bouldery is sometimes used where stones are larger than 24 inches.

[3] Formerly called "stony".

APPENDIX 2

SOIL DRAINAGE CLASSES (N.S.S.C. 1963)

The 1955 report of the Subcommittee on Soil Drainage Terminology attempted to describe drainage classes on the basis of soil morphological features that were presumed to indicate the moisture status of the soil. On application of these criteria it became apparent that soils of similar morphological features did not necessarily have similar moisture regimes.

Accordingly, the present Subcommittee on Soil Drainage has defined the soil drainage classes in terms of (i) actual moisture content in excess of field moisture capacity, and (ii) the extent of the period during which such excess water is present in the plant-root zone.

It is recognized that permeability, level of groundwater, and seepage are factors affecting moisture status. However, because these are not easily observed or measured in the field, they cannot be used generally as criteria of moisture status.

It is further recognized that soil profile morphology, e.g. mottling, normally, but not always, reflects soil moisture status. Hence, it is recommended that although soil morphology may be a valuable field indication of moisture status, it should not be the overriding criterion. For example, a soil may exhibit the morphology of a poorly drained soil, but recent changes (either natural or artificial) may have established the moisture status as defined for imperfectly drained soils. Such a soil should be classified as imperfectly drained regardless of its morphology. Some soils that we consider to be well drained are mottled within their sola during the early spring and unmottled throughout most of the year. Other well-drained soils are permanently mottled in their sola due to the nature and the distribution of minerals within them. Soil drainage classes cannot be based solely on the presence or absence of mottling. Topographic position and vegetation as well as soil morphology are useful field criteria for assessing soil moisture status.

The recommended definitions of the soil drainage classes are underlined. As a guide to surveyors, additional comments under each class indicate some of the pertinent morphological features that commonly, but not necessarily, are found in soils having the particular moisture status. The word "significant" as used in the definitions is to be considered in relation to plant growth.

1. <u>Rapidly drained--The soil moisture content seldom exceeds field capacity in any horizon except immediately after water additions.</u>

Soils are free of any evidence of gleying throughout the profile. Rapidly drained soils are commonly soils of coarse texture or soils on steep slopes.

2. <u>Well drained--The soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year.</u>

Soils are usually free of mottling in the upper 3 feet, but may be mottled below a depth of 3 feet. B horizons, if present, are reddish, brownish, or yellowish.

3. Moderately well drained--The soil moisture in excess of field capacity remains for a small but significant period of the year.

Soils are commonly mottled in the lower B and C horizons or below a depth of 2 feet. The Ae horizon, if present, may be faintly mottled in fine-textured soils or in medium-textured soils that have a slowly permeable layer below the solum. In grassland soils the B and C horizons may be only faintly mottled and the A horizon may be relatively thick and dark.

4. Imperfectly drained--The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year.

Soils are commonly mottled in the B and C horizons; the Ae horizon, if present, may or may not be mottled. The matrix generally has a lower chroma than in the well-drained soil on similar parent material.

5. Poorly drained--The soil moisture in excess of field capacity remains in all horizons for a large part of the year.

The soils are usually very strongly gleyed. Except in high-chroma parent materials the B, if present, and upper C horizons usually have matrix colors of low chroma. Faint mottling may occur throughout.

6. Very poorly drained--Free water remains at or within 12 inches of the surface most of the year.

The soils are usually very strongly gleyed. Subsurface horizons usually are of low chroma and yellowish to bluish hues. Mottling may be present but at depth in the profile. Very poorly drained soils usually have a mucky or peaty surface horizon.

Note: In some instances it may be desirable to indicate whether the moisture status is a result of high groundwater level, low permeability, seepage, or telluric water. If so, an appropriate notation can be made following the drainage class designation, for example D4TW (telluric water), D6GW (groundwater), and D5P (permeability).

APPENDIX 3

SOIL PROFILE TERMINOLOGY

Individual horizons are described in terms of dry or moist color, texture, mottles (dry or moist color), structure, consistence (dry, moist, or wet), roots and pores, additional features, reaction, lower boundary, and thickness range. These features should be described for each horizon in the order listed to facilitate comparisons among horizons and among series. All of these may not need to be recorded for every horizon, but most of them will. The features should be described insofar as possible in standard terminology.

Color

Color descriptions should include Munsell notations with few exceptions. The few exceptions are fine mottles, some of which are too small for exact matching with the standards. These are, therefore, more correctly described by color names alone.

For individual horizons, color may be given for moist conditions, dry conditions, and preferably for both conditions. Moisture conditions are to be indicated for the individual color identification or for the whole profile, as already specified.

If there are differences between the color of the soil material in place and of the crushed mass or between ped faces and interiors, these should be recorded in the description of a horizon. The first color given should be the dominant one, that which marks the matrix or major mass of the specimen. Changes in color when the mass is crushed or the color of ped coats as contrasted to the color of ped interiors should follow. The positions of individual colors should be identified unless the context makes this obvious.

Most horizons have a dominant color, which changes in value and less commonly in hue and chroma with a change in moisture conditions. The colors of both moist and dry conditions should be specified if both are known. When both are given, they should be identified in the individual horizon descriptions. The color of the usual moisture condition is given first.

Texture

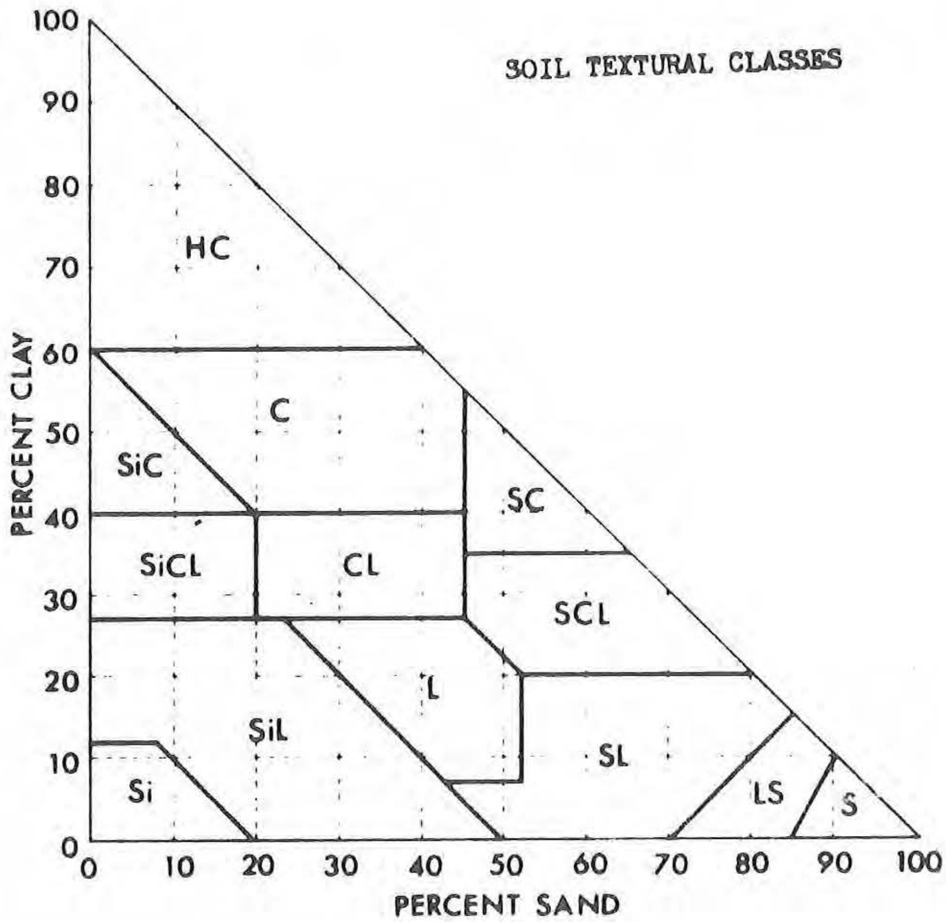
The textural classes are defined wholly in terms of size distribution of the primary particles, sand (2.0 to 0.05 mm), silt (0.05 to 0.002 mm), and clay (less than 0.002 mm). The textural classes are shown in the diagram.

Sands, loamy sands, and sandy loams may be further separated on the basis of the proportion of coarse, medium, fine, and very fine sand in the class.

The gravelly class names are added to the textural class names according to the following rule (U. S. Dep. Agr. Soil Survey Manual):

% Gravel by volume	
<20	- use textural class name only
20-50	- gravelly and texture
50-90	- very gravelly and texture
>90 in surface 8 inches	- cobble land type

The textural class name may be further modified by the addition of words that describe the kind and amount of stones in the horizon, for example stony loam and flaggy loam. See the section on stoniness.



Mottles

Mottling in soils is described by noting (i) the color of the matrix and the color or colors of the principal mottles, and (ii) the pattern of the mottling. It is usually sufficient to use the standard Munsell color names rather than the Munsell notation, because the precise color measurement of the color of the mottles is rarely significant. In fact, descriptions of soil horizons containing several Munsell notations are difficult to read rapidly.

The pattern and size of mottles is conveniently described by three sets of notations: abundance, size, and contrast (as defined in the U. S. Dep. Agr. Soil Survey Manual).

Abundance

Few--Mottles occupy less than 2% of the exposed surface.
Common--Mottles occupy 2 to 20% of the exposed surface.
Many--Mottles occupy more than 20% of the exposed surface.

Size

Fine--Less than 5 mm in width or diameter.
Medium--5 to 15 mm.
Coarse--More than 15 mm.

Contrast

Faint--The hue and chroma of the matrix and mottles are similar.
Distinct--The mottles are more than 2.5 units of hue (e.g. 10YR matrix, 7.5YR mottles), or more than 1 unit of value or chroma, different from the matrix.
Prominent--The matrix and mottles vary by 5 units of hue (10YR matrix, 5Y mottles) and by three or more units of value or chroma.

The sequence of terms is abundance, size, contrast, and color, for example, "few, fine, and faint yellowish brown mottles."

Structure

The terminology for soil structure was adopted in 1963.

Soil structure refers to the aggregation of the primary soil particles into compound particles or clusters of primary particles, which are separated from adjoining aggregates by surfaces of weakness. The exteriors of some aggregates have thin, often dark-colored surface films that may serve to keep the aggregates apart. Other aggregates have surfaces and interiors of like color, and the forces holding the aggregates together appear to be wholly internal.

An individual natural soil aggregate is called a ped and should not be confused with (i) a clod, formed as a result of some disturbance, such as plowing or digging, that molds the soil to a transient mass that changes with alternating wetting and drying, (ii) a fragment, formed by a rupture of a soil mass across natural surfaces of weakness, or (iii) a concretion, formed by local concentrations of compounds that irreversibly cement the soil grains together.

The classification of structure involves consideration of (i) the shape and arrangement, (ii) the size, and (iii) the distinctness of the visible aggregates or peds. The terminology of structure consists of separate sets of terms designating each of these categories, which by combination form the names of the structure. Shape and arrangement of peds is designated as type of soil structure, which in turn is subdivided into kinds on the basis of the character of the faces and edges of the aggregates. The size of the peds is of consideration under the class of soil structure, whereas the degree of distinctness is expressed in the grades.

The table indicates four principal types of structure: (i) structureless, in which there is no observable aggregation or no definite orderly arrangement of natural lines of weakness; (ii) blocklike, in which the soil particles are arranged around a point and bounded by flat or rounded surfaces; (iii) platelike, in which the soil particles are arranged around a horizontal plane and generally bounded by relatively flat horizontal surfaces; and (iv) prismlike, in which the soil particles are arranged around a vertical axis and bounded by relatively flat vertical surfaces. Most of these types are subdivided into kinds or subtypes. Thus, under structureless, the single grain kind consists of an incoherent mass of individual particles whereas amorphous (massive) consists of a coherent mass showing no evidence of any distinct arrangement along natural lines of weakness. The blocklike type includes three kinds: the angular blocky, whose faces are rectangular and flattened, bounded by planes intersecting at relatively sharp angles; the subangular blocky, whose faces are subrectangular, or consist of mixed rounded; and the granular that are spheroidal, characterized by rounded vertices. Each type of structure includes peds that vary in shape, and detailed soil descriptions may require supplemental statements about the shape of the individual peds.

The classes recognized are indicated by their name and their size limits. The size limits vary with the shape and arrangement. The oblique dimension is inferred for the blocklike type, the vertical dimension for the platelike, and the horizontal dimension for the prismlike type.

Grade of structure is the degree of distinctness of aggregation. It expresses the differential between cohesion within the aggregates and adhesion between aggregates and is determined mainly by noting the durability of the aggregates and the proportions of aggregated and unaggregated material when the aggregates are displaced or gently crushed. Grade of structure varies with the moistening of the soil and should be described at the most important soil moisture content of the soil horizon. The principal description of the structure of a soil horizon should refer to its normal moisture content, although attention should be called to any striking contrasts in structure under other moisture conditions to which the soil is subject. If grade is designated at an unstated moisture content, it is assumed that the soil is nearly dry or slightly moist, which is commonly that part of the range in soil moisture in which soil structure is most strongly expressed. Terms for grade of structure are as follows:

Weak

Weak is the grade of structure characterized by weakly formed peds that are barely observable in place.

Moderate

Moderate is the grade of structure characterized by moderately well-formed peds that are moderately evident in place. Soil material of this grade, when disturbed, breaks down into a mixture of many distinct entire peds, some broken peds, and little unaggregated material.

Strong

Strong is the grade of structure characterized by strongly formed peds that are quite evident in undisplaced soil. They adhere to one another and withstand displacement and separation when the soil is disturbed. When displaced, soil material of this grade consists very largely of entire peds and includes few broken peds and little unaggregated material.

The sequence followed in combining the terms to characterize the structure is (i) grade (distinctness), (ii) class (size), and (iii) kind (shape). Thus the designation for the soil structure in which the peds are loosely packed and roundish, dominantly below 2 mm in diameter, and quite distinct is strong fine granular. The designation of structure by grade, class, and kind can be modified with any other appropriate terms wherever necessary to describe other characteristics of the peds.

Many soil horizons have compound structure consisting of one or more sets of smaller peds held together as larger peds. Such compound structures may be described as follows: compound moderate very coarse prismatic and moderate medium granular. Soil that has one structural form when in place may assume some other form when disturbed. When removed, the larger peds may fall into smaller peds, such as large prisms into medium blocks.

In the parent material of soils, the material with structural shapes may be designated as pseudo-blocky, pseudo-platy, etc.

Reference to geological terms in the description of parent materials should apply to accepted terminology. Many of the terms used in stratigraphy have different definitions. Generally the arrangement of sediments in layers is referred to as stratification. If these layers are not parallel to the dip of the formation they may be referred to as cross-stratified.

A stratum is a layer with certain unifying characteristics, properties, or attributes that distinguish it from adjacent layers. However, bedding and lamination connote a thickness of the strata. A bed is a unit layer in a stratified sequence that is visually or physically more or less distinctly separable from other layers above and below and is 1 cm or more in thickness. A lamina is a unit layer of thickness less than 1 cm. When thickness is implied, reference to cross-stratification will involve consideration of cross-bedding or cross-lamination.

Types and Classes of Soil Structure

Type	Kind	Class	Size mm
1. Structureless - no observable aggregation or no definite orderly arrangement around natural lines of weakness.	A. Single grain structure - loose, incoherent mass of individual particles as in sands.		
	B. Amorphous (massive) structure - a coherent mass showing no evidence of any distinct arrangement of soil particles.		
2. Blocklike - soil particles are arranged around a point and bounded by flat or rounded surfaces.	A. Blocky (angular blocky) - faces rectangular and flattened, vertices sharply angular.	Fine blocky Medium blocky Coarse blocky Very coarse blocky	<10 10-20 20-50 >50
	B. Subangular blocky - faces subrectangular, vertices mostly oblique, or subrounded.	Fine subangular blocky Medium subangular blocky Coarse subangular blocky Very coarse subangular blocky	<10 10-20 20-50 >50
	C. Granular - spheroidal - characterized by rounded vertices.	Fine granular Medium granular Coarse granular	<2 2-5 5-10
3. Platelike - soil particles are arranged around a horizontal plane and generally bounded by relatively flat horizontal surfaces.	A. Platy structure - horizontal planes more or less developed.	Fine platy Medium platy Coarse platy	<2 2-5 5
4. Prismlike - soil particles are arranged around a vertical axis and bounded by relatively flat vertical surfaces.	A. Prismatic structure - vertical faces well defined, and edges are sharp.	Fine prismatic Medium prismatic Coarse prismatic Very coarse prismatic	<20 20-50 50-100 >100
	B. Columnar structure - vertical edges near top of columns are not sharp. (Columns may be flat-topped, round-topped, or irregular.)	Fine columnar Medium columnar Coarse columnar Very coarse columnar	<20 20-50 50-100 >100

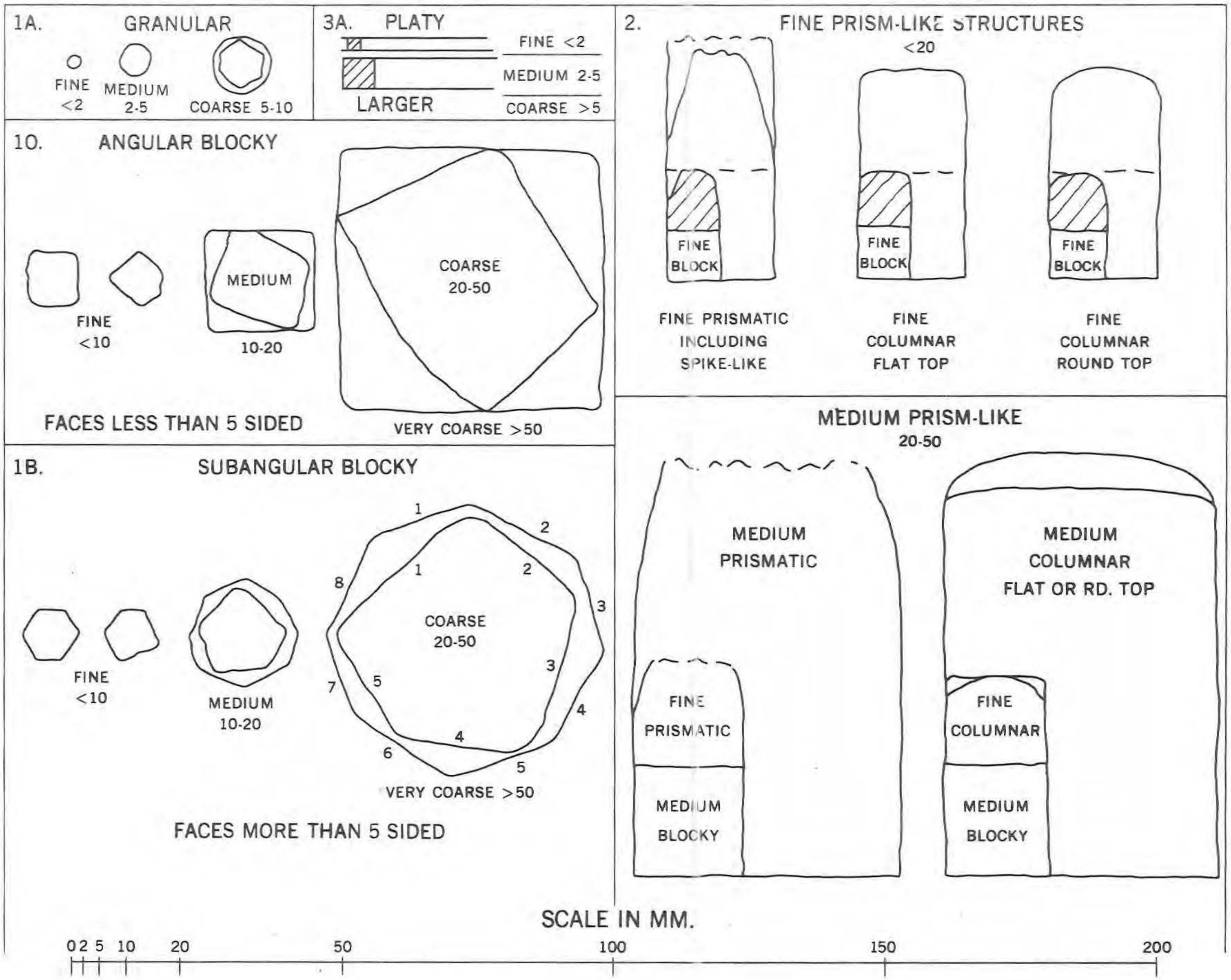


Fig. 33 Types, kinds and classes of soil structure

SRI

Consistence

The terminology for soil consistence was adopted in 1963.

Soil consistence comprises the attributes of soil materials that are expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation and rupture. Every soil material has consistence irrespective of whether the mass is large or small, in a natural condition or greatly disturbed, aggregated or structureless, or moist or dry. Although consistence and structure are interrelated, structure deals with the shape, size, and definition of natural aggregates that result from variations in the forces of attraction within a soil mass, whereas consistence deals with the strength and nature of the forces themselves.

The terminology for consistence includes separate terms for description at three standard moisture contents (dry, moist, and wet). If moisture conditions are not stated in using any consistence term, the moisture condition is that under which the particular term is defined. Thus friable used without a statement of the moisture content indicates friable when moist; hard used alone means hard when dry, and plastic means plastic when wet. If a term is used to describe consistence at some moisture content other than the standard condition under which the term is defined, a statement of the moisture condition is essential. Usually it is desirable to describe consistence at all three standard moisture conditions.

Although evaluation of consistence involves some disturbance, unless otherwise stated descriptions of consistence customarily refer to that of soil from undisturbed horizons. In addition, descriptions of consistence under moist or dry conditions carry an implication that disturbance causes little modification of consistence or that the original consistence can be almost restored by pressing the material together. Where such an implication is misleading, as in compacted layers, the consistence both before and after disturbance may require separate descriptions. Furthermore, compound consistences occur as in a loose mass of hard granules. In a detailed description of soils having compound structure, the consistence of the mass as a whole and of it parts should be stated.

The terms used in soil descriptions for consistence follow.

Consistence when Wet

Consistence when wet is determined at moisture levels at or slightly above field capacity.

Stickiness is the quality of adhesion to other objects. For field evaluation of stickiness, soil material is pressed between the thumb and finger and its adherence is noted. Degrees of stickiness are described as follows:

0. <u>Nonsticky</u>--After the release of pressure, practically no soil material adheres to the thumb and finger.

1. <u>Slightly sticky</u>--After pressure is applied, the soil material

adheres to both the thumb and finger, but comes off one or the other rather cleanly. The soil is not appreciably stretched when the digits are separated.

2. Sticky--After pressure is applied, the soil material adheres strongly to both the thumb and forefinger and tends to stretch somewhat and pull apart rather than pulling free from either digit.

3. Very sticky--After pressure is applied, the soil material adheres strongly to both the thumb and forefinger and is decidedly stretched when they are separated.

Plasticity is the ability to change shape continuously under the influence of an applied stress and to retain the impressed shape on removal of the stress. For field determination of plasticity, roll the soil material between the thumb and finger and observe whether or not a wire or thin rod of soil can be formed. If helpful to the reader of particular descriptions, state the range of moisture content within which plasticity continues, for example plastic when slightly moist or wetter, plastic when moderately moist or wetter, and plastic only when wet, or plastic with a wide, medium, or narrow range of moisture content. Express the degree of resistance to deformation at or slightly above field capacity as follows:

0. Nonplastic--No wire is formable.

1. Slightly plastic--Wire is formable, but the soil mass is easily deformable.

2. Plastic--Wire is formable and moderate pressure is required for the deformation of the soil mass.

3. Very plastic--Wire is formable and much pressure is required for the deformation of the soil mass.

Consistence when Moist

Consistence when moist is determined at a moisture content approximately midway between air-dry and field capacity. At this moisture content most soil materials exhibit a form of consistence characterized by (i) tendency to break into smaller masses rather than into powder, (ii) some deformation prior to rupture, (iii) absence of brittleness, and (iv) ability of the material after disturbance to cohere again when pressed together. The resistance decreases with moisture content, and the accuracy of field descriptions of this consistence is limited by the accuracy of estimating moisture content. To evaluate this consistence, select and attempt to crush in the hand a mass that appears slightly moist.

0. Loose--Noncoherent.

1. Very friable--The soil material is crushed under very gentle pressure, but coheres when pressed together.

2. Friable--The soil material crushes easily under gentle to moderate

pressure between the thumb and forefinger and coheres when pressed together.

3. Firm--The soil material crushes under moderate pressure between the thumb and forefinger, but resistance is distinctly noticeable.

4. Very firm--The soil material crushes under strong pressure, and is barely crushable between the thumb and forefinger.

(The term "compact" denotes a combination of firm consistence and a close packing or arrangement of particles and should be used only in this sense. It can be given degrees by the use of "very" and "extremely".)

Consistence when Dry

The consistence of soil materials when dry is characterized by rigidity, brittleness, maximum resistance to pressure, more or less tendency to crush to a powder or to fragments with rather sharp edges, and inability of crushed material to cohere again when pressed together. To evaluate, select an air-dry mass and break it in the hand.

0. Loose--Noncoherent.

1. Soft--The soil mass is weakly coherent and fragile, and breaks to a powder or individual grains under very slight pressure.

2. Slightly hard--The soil mass is weakly resistant to pressure, and easily broken between the thumb and forefinger.

3. Hard--The soil mass is moderately resistant to pressure; it can be broken in the hands without difficulty, but is rarely breakable between the thumb and forefinger.

4. Very hard--The soil mass is very resistant to pressure; it can be broken in the hands only with difficulty, and is not breakable between thumb and forefinger.

5. Extremely hard--The soil mass is extremely resistant to pressure and cannot be broken in the hands.

Cementation

Cementation of soil materials refers to a brittle hard consistence caused by some cementing substance other than clay minerals, such as calcium carbonate, silica, or oxides, or salts of iron and aluminum. Typically, the cementation is altered little, if any, by moistening; the hardness and brittleness persist in the wet condition. Semi-reversible cements, which generally resist moistening but soften under prolonged wetting, occur in some soils and give rise to soil layers having a cementation that is pronounced when dry but very weak when wet. Some layers cemented with calcium carbonate soften somewhat with wetting. Unless stated to the contrary, descriptions of cementation imply that the condition is altered little, if any, by wetting. If the cementation is greatly altered by moistening, it should be so stated. Cementation may be either continuous or discontinuous within a given horizon.

1. Weakly cemented--The cemented mass is brittle and hard, but can be broken in the hands.

2. Strongly cemented--The cemented mass is brittle and harder than can be broken in the hands, but is easily broken with a hammer.

3. Indurated--The mass is very strongly cemented and brittle, and does not soften under prolonged wetting. It is so hard that a sharp blow with a hammer is required to break it. The hammer generally rings as a result of the blow.

Soil consistence should be described at all three moisture states (dry, moist, and wet), the first given being that most frequently observed, but one should be sure that the moisture state first referred to is the same for color, structure, and consistence.

Roots and Pores

The terminology for roots and pores is borrowed (J. E. McClelland, unpublished data). The abundance, size, orientation, and distribution within peds for both roots and pores are similar. In addition, to fully describe pores, continuity classes and morphology must be recorded. The classes are as follows:

Abundance Classes:

Roots	Pores	Number per unit* area of surface
very few	very few	less than one
few	few	one tc three
plentiful	common	four to fourteen
abundant	many	more than 14

*Unit is a square inch for fine, very fine, and micro roots and pores, a square yard for medium and coarse roots and pores.

Diameter Classes:

micro - less than 0.075 mm
very fine - 0.075 to 1 mm
fine - 1 to 2 mm
medium - 2 to 5 mm
coarse - more than 5 mm

Continuity Classes: (for tubular pores)

continuous - individual pores extend throughout the horizon
discontinuous - individual pores extend only part way through the horizon

Orientation Classes: (for roots and tubular pores)

vertical - orientation mainly vertical
horizontal - orientation mainly horizontal
oblique - orientation mainly oblique
random - orientation in all directions

Distribution Classes: (within horizons)

inped - most roots and pores are within peds
exped - most roots and pores follow ped interfaces

Morphology Classes: (for individual pores)

simple - tubular pores not branched
dendritic - tubular pores branched open, pores are open at least at the upper end or at one horizontal end
closed - both ends of the pores are sealed from access to air and water by organic or organic mineral particles or clay flows

Types of pores:

vesicular - roughly spherical or ellipsoidal in shape, not appreciably elongated in any direction
interstitial - irregular in shape with faces that are curved inward; formed by curved or angular faces of adjacent mineral grains or peds, or both
tubular - more or less cylindrical in shape, elongated in one direction

Additional Features

Additional features are listed under this heading because not all of them are characteristics of every horizon. Additional features include such things as clay films, concretions, carbonates, salts, pebbles, and stones. No mention of such features in the description of a horizon indicates their absence. If these features are described, the kinds and numbers of concretions, stones, and pebbles; the thickness, extent and position of clay films; and the relative amounts and distribution pattern of carbonates, salts, etc., should be indicated.

Clay Films

Clay films are described by recording their frequency of occurrence, thickness, and locations. The following thickness and frequency classes are taken from the U. S. Dep. Agr. Work-Planning Conference, Chicago, 1963.

A complete description of clay films should include their frequency, thickness, and location with respect to other morphological features. Other properties of clay films, such as color and continuity (whether existing as patches or a continuous network), may need to be described to adequately characterize the morphology of some soils. Standard classes for the description of frequency and thickness of clay films follow.

Frequency Classes--The objective is to indicate the estimated percentage of the natural soil surfaces that are coated with clay films. The description may refer to the total surface of ped faces, or the total surface of tubular or interstitial pores, or to the combined surfaces of peds and pores in the soil material. The description of frequency of clay films is not intended to reflect total volume of clay films but simply percentage of ped faces or pore surfaces, or both, that are coated.

Class	Percent of surface covered	Remarks
Few	Present on less than 2% of surface	Patches of clay film are identifiable, but their frequency is so low that the significance of their presence may be nil or doubtful. The class includes occasional small patches of clay film not regularly associated with other morphological features.
Common	2 to 20	Patches of clay film regularly associated with other morphological features. Most of the surfaces of peds or pores, or both, are not coated with clay film.
Many	20 to 80	Clay films regularly associated with other morphological features. May occur as discrete patches or as a continuous network.
Continuous	More than 80	Most or all ped or pore surfaces, or both, are covered with clay films. Patches of natural surfaces may be free of clay films, but the films are essentially continuous.

Thickness Classes--Thickness of clay films often varies appreciably within distances of a few millimeters. In such cases an estimate of the average thickness should be used. If appreciable variations in thickness occur over distances of a centimeter or more or are related to other morphological features, and the variations are judged to be significant to description of the morphology, the variation should be described.

Very thin	<0.005 mm	Visible only when viewed normal to surface; hand lens needed for identification; not visible in cross section with a 10X hand lens; if present, very fine sand grains protrude through the film and are readily apparent.

Thin	0.005 to 0.05 mm	Hand lens usually needed for identification; visible in cross section with 10X lens but not to unaided eye; if present, very fine sand grains are enveloped by the film or their outlines are indistinct; fine sand grains protrude through the film or are only thinly coated and are readily apparent.
Moderately thick	0.05 to 0.5 mm	Visible in cross section to unaided eye; fine sand grains are enveloped by the film or their outlines are indistinct; film surfaces are relatively smooth.
Thick	0.5 to 1.0 mm	Clay films and their broken edges are readily visible without magnification; film surfaces are smooth; sand grains are enveloped by the film or their outlines are indistinct.
Very thick	$>$1.0 mm	

Conventions--The convention for describing frequency, thickness, and location of clay films is illustrated in the following examples:

a) common thin clay films on ped faces

b) continuous moderately thick clay films in common medium tubular pores

c) common moderately thick clay films on ped and pore surfaces

d) continuous moderately thick clay films on vertical prism faces and common thin clay films on blocky peds (compound structure of coarse prisms and medium blocky peds)

The thickness and frequency classes seem most useful for description of films on ped and tubular pore surfaces. They may also be useful for description of films of clay that occur in interstitial pore space in coarse or moderately coarse textured soils as illustrated in the following examples:

a) continuous thin clay films in interstitial pores as coatings on grains and as bridges between grains

b) common thin clay films in interstitial pores as bridges between grains but rarely coating grains

Concretions

Concretions are hardened local concentrations of certain chemical compounds that form indurated grains or nodules of various shapes, sizes, and colors. They are commonly formed from iron and manganese oxides. The size, shape, color, and location of the concretions should be described.

Carbonates

The presence of free carbonates in the soil and parent material may be tested for with 10% HCl. The relative effervescence is as follows:

very weakly effervescent	- a few bubbles
weakly effervescent	- bubbles readily observed
moderately effervescent	- bubbles form a low foam
strongly effervescent	- bubbles form a thick foam

The calcareous grades are:

weakly calcareous	1-5% as $CaCO_3$ equivalent
moderately calcareous	6-15% as $CaCO_3$ equivalent
strongly calcareous	16-25% as $CaCO_3$ equivalent
very strongly calcareous	26-40% as $CaCO_3$ equivalent
extremely calcareous	$>$40% as $CaCO_3$ equivalent

The size of carbonate accumulation is described as for mottles:

fine	- $<$5 mm in diameter or width
medium	- 5 to 15 mm in diameter or width
coarse	- $>$15 mm in diameter or width

The shape and degree of segregation of the lime accumulation is described in plain words.

Salts

The presence of salts in the soil and parent material should be described. The salts may occur as crystals or veins, or as surface crusts of salt crystals. Inhibited crop growth and the presence of salt-tolerant plants are indications of salts in the soil.

The salinity grades suggested are as follows (U. S. Dep. Agr. Soil Survey Manual):

Weakly saline--These soils are slightly affected by salt or alkali. The growth of sensitive crops is inhibited, but that of salt-tolerant crops may not be. The salt content is 0.15 to 0.35% and the conductivity 4 to 8 mmhos/cm.

Moderately saline--These soils are moderately affected by salt or alkali. Crop growth is inhibited and no crop does well. The salt content is 0.35 to 0.65% and the conductivity 8 to 15 mmhos/cm.

Strongly saline--These soils are strongly affected by salt or alkali. Only a few kinds of plants survive. The salt content is greater than 0.65% and the conductivity is greater than 15 mmhos/cm.

Stones and Pebbles

Describe the stones and pebbles in terms of their abundance, size, type, shape, and orientation. Describe the size and shape using the terms listed in Appendix 1 under "Stoniness, Rockiness, and Coarse Fragments". Report the abundance as percentage by area of the surface exposed.

Reaction Classes

The reaction classes and terminology adopted in 1965 are as follows:

	pH		pH
Extremely acid	4.5	Neutral	6.6-7.3
Very strongly acid	4.6-5.0	Mildly alkaline	7.4-7.8
Strongly acid	5.1-5.5	Moderately alkaline	7.9-8.4
Medium acid	5.6-6.0	Strongly alkaline	8.5-9.0
Slightly acid	6.1-6.5	Very strongly alkaline	9.0

Give the reaction in the descriptive terms. Where pH data are available they may be given in parentheses following the reaction terms.

Horizon Boundaries

The lower boundary of each horizon is described by indicating its distinctness and form as suggested in the U. S. Dep. Agr. Soil Survey Manual.

Distinctness

abrupt	- less than 1 inch wide
clear	- 1 to 2.5 inches wide
gradual	- 2.5 to 5 inches wide
diffuse	- more than 5 inches wide

Form

smooth	- nearly a plane
wavy	- pockets are wider than deep
irregular	- pockets are deeper than wide
broken	- parts of the horizon are unconnected with other parts

For example: clear smooth boundary, clear irregular boundary

Thickness Range

The thickness range is stated in plain language. Strictly speaking, thickness range is part of the range in characteristics for the series. It should be included in parentheses after each horizon description in the typifying pedon because it can be stated so much more briefly in this section.

A sample description of a profile follows; the depth may be shown in inches or centimeters but not both.

Horizon	Depth inches	cm	
L-H	3-0	8-0	Black (10YR 2/1 m), dark grayish brown (10YR 4/1 d) semidecomposed organic matter; fibrous, many fine and medium roots; abrupt, smooth boundary; 2 to 4 inches thick; pH 3.8.
Ae	0-4	0-10	Gray (5YR 6/1 m), light-gray (5YR 7/1 d) sandy loam; single grain; loose, friable; few, fine and medium roots; few, fine, vesicular pores; clear, wavy boundary with some fine tongues into underlying horizon; 2 to 5 inches thick; pH 4.3.
Bfhgj	4-12	10-30	Reddish-brown (5YR 4/4 m, 5/4 d) sandy loam; common, medium, distinct, strong-brown (7.5YR 5/6) mottles; amorphous; friable; few, fine and very fine roots; few, medium, and fine pores; some gravel; clear, smooth boundary; 6 to 10 inches thick; pH 4.7.
Bfg	12-24	30-61	Reddish-brown (5YR 4/3 m, 5/3 d) sandy loam; many, medium to coarse, prominent strong-brown (7.5YR 5/6) mottles; amorphous; firm, few stones; clear, smooth boundary; 8 to 15 inches thick; pH 4.9.
C	24+	61+	Reddish-brown (2.5YR 4/4 m, 5/4 d) sandy loam; amorphous; firm, slightly plastic; some stones; pH 4.8.

Additional Considerations

a) The committee recommends that for the present the measurement of depth or of thickness be given in English units followed by metric units.

b) The committee recommends the use of the glossary of soil terms prepared by the Canadian Society of Soil Science.

c) Give the location of soil profiles in latitude and longitude to the nearest one-tenth minute in areas covered by maps of 1:50,000 scale, or to the nearest minute in areas covered only by maps of 1:250,000 scale.