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Report on

THE SECOND MEETING OF

THE WESTERN SECTION

OF THE

CANADA SOIL SURVEY COMMITTEE

Held at

Kelowna, British Columbia

February 15-17, 1972

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CANADA SOIL SURVEY COMMITTEE

SECOND MEETING OF THE WESTERN SECTION

KELOWNA, BRITISH COLUMBIA February 15-17, 1972

J.S. Clark, Acting Chairman

The Chairman called the meeting to order and welcomed the delegates to the meeting. He suggested that the deliberations and the discussions of this Western Section could be free-wheeling, informal and provocative as no binding decision could be reached before the next formal meeting. He pointed out that it would be most useful if the meeting could serve as a forum to develop a western point of view which could be carried to the next general meeting as has been done by the Eastern group in their earlier deliberations. The hope was expressed that although the discussion were to be formal that those attending the sessions would attempt to reach general consensus at the more controversial issues and that others would serve as useful preparation the next national meetings in 1973.

Several visitors were welcomed to the meetings. These were: W. Holland, E. Oswald, E. Hervoner and J. Senyk of the Canadian Forestry Service in B.C. and Alberta; A. van RysWyck, CDA, Kamloops.

Special arrangements for the meetings were outlined and explained by Mr. A. Dawson of the B.C. Survey who also welcomed the members of the committee on behalf of the B.C. Soil Survey and the City of Kelowna. Apples and fruit juices for the members were supplied through the courtesy of the B.C. Fruit Growers Association.

Report on the Classification of Landforms for Soil Surveys

D. F. Acton

Introduction

Attempts to develop a classification of landforms for use by soil surveys have been undertaken by members of the Canada Soil Survey Committee for several decades. At the national meetings held in Ottawa in 1970 it was recommended that a committee be established representing the National Committee of Forest Lands, Quaternary Geology Division of the Geological Survey of Canada and the Canada Soil Survey Committee to jointly develop a system which would have application to a number of disciplines in addition to soil science.

Although no formal organization was established, the Canada Soil Survey Committee was fortunate to obtain the co-operation of Dr. R. Fulton of the G.S.C. in preparing a classification scheme. This scheme outlined a system of classification of "regional" as well as "local" landforms. It is presented as Appendix I.

A second scheme, presented in Appendix II, was prepared by myself. It attempted to concentrate on the dominant well known local forms and as such was an incomplete system.

These two schemes were circulated for consideration of the members of the Canada Soil Survey Committee in western Canada, prior to the regional meetings. A third scheme developed by Given, Lewis and Lavkulich was submitted for consideration during the course of the meetings. It is presented in Appendix III.

Discussion of the Proposed Systems

D.F. Acton: Suggested that four questions must be satisfactorily answered for a proposed scheme to be acceptable. They were: 1. Is the system comprehensive (can all landforms known to you be placed in the scheme)? 2. Is the system complete (does it start at a broad level and continue to subdivide in such a manner that increasingly precise statements may be made about a landform at each category in the system)? 3. Is it clear what differentiae are used to separate classes within and between categories? 4. Are the differentiating criteria used consistently?

D.A. Rennie: Why is this group interested in landform classification? Why do we not also consider such factors as hydrology as part of the system?

G. Runka: In reply to the question by Rennie. Hydrology is one of the interpretations that can be carried out from a landform classification in conjunction with the primary climate and soil information. It is not necessarily something that you are going to indicate on a landform map, or it may not even be an input into your considerations in classification.

S. Pawluk: A favorable feature of Fulton's classification is that it contains both a local and regional separation that appears to be workable. The system proposed by Acton is a categorical separation on the basis of degree. This may require "in depth" training for all soil surveyors in both geomorphology and landscape dynamics, as well as a geomorphologist in Ottawa that can provide guidance in the use of the system. A final point is that a system, such as proposed by Acton, should be acceptable to other professions. Some form of cross referencing with other disciplines may be essential to realize the full benefit from such a detailed approach.

D.F. Acton: In reply to questions raised by S. Pawluk. Agreed. Training pedologists so they can effectively use a system such as this has been accomplished in Saskatchewan, but this has likely benefited from the strong geological orientation of these surveys, practically from their inception. Groups lacking personnel that do not have this geomorphological background must recognize a high priority on providing this training as there would appear to be serious limitations in soil surveys where pedologists do not fully appreciate the landform they are dealing with. With regard to interdisciplinarity, if agreement is reached on a scheme at these meetings it should be turned over to foresters, earth scientists, etc., for consideration and then followed by more detailed consideration by all concerned groups at the next meeting of the Canada Soil Survey Committee.

J. Dumanski: Fulton's scheme is designed for descriptive purposes whereas Acton's is designed for classification. I think there is a very strong need for some type of regional approach which could be worked into a system which is still essentially classification.

J. Ellis: I think that before we can make any major decision on a system to be adopted, a field trip by pedologists and others in the west would appear to be essential.

G. Beke: I am disturbed by the absence of a reference to vegetation in the land classification scheme being proposed.

D.F. Acton: In reply to question by Beke. I think first of all, and this is a mistake that many of us have made is that we do not distinguish landform from land or terrain. Landform is the composition and shape of the land. You can have the same landform under different climates and different types of vegetation. Land is broader than this and involves the climate and vegetation that is superimposed on that form. Now I agree wholeheartedly that we need land classification. This group is becoming increasingly aware of this; as I pointed out the Saskatchewan system provides the opportunity to get closer to land classification rather than strictly making a map of the soils. So what I can see is the vegetation and hydrology and other things being components of land and land classification but not of landform.

W. Pettapiece: Firstly, I am not clear what the exact connotation of "midlands" and "uplands" are in Fulton's scheme. Secondly, I had the chance to work with a scheme essentially the same as Fulton's and it worked very well for the type of mapping we were doing. It was comprehensive, as far as I was concerned. It could perhaps be made more complete by adding lower level categories such as those proposed in Acton's scheme. The use of different differentiae in different groups in Fulton's scheme did not appear to create any problem.

D.F. Acton: In reply to Pettapiece. I think local forms can be put into a regional context but we cannot classify from broad regional landforms down to local forms using Fulton's scheme.

J. Clark: I'd like to make a comment and it's going back a little bit. After the last national meeting several people asked me to keep in touch with Fyles of the geological survey to try and promote a participation by the geological survey in developing a land classification system. He can understand our need, he said they have two problems. One is they have priorities that put a lot of pressure on their geologists. Secondly, they have disagreement within their own group as well and they haven't come to any uniform understanding in these descriptions themselves. We discussed how we might go about this and Fyles suggested that if we think its important we ought to "take the bit in our own teeth" and go out and "stick our chin out" and come up with a classification system that we felt was necessary or suited our needs. They were quite willing to sit back and criticize this and help us develop it because they did not have the time to do it themselves.

R. Smith: I think we have two problems here. One is a taxonomic problem. What we haven't done though is address ourselves to the second problem and that is this business of the fourth category in your system, the elements of landform. For instance we don't have a common interpretation of what simple topography is as opposed to complex topography. I'd like to see more attention paid to this particular category. I think there is definite need for work with geomorphologists to develop a taxonomic system for landform. I think we ourselves have to be responsible though for the fourth category in any system, or those that you have proposed here. I was disappointed to not see more detail within this particular category. I think this is what we really need.

D.F. Acton: In reply to Smith. While we must be fully cognizant of the local landform elements it is difficult to concentrate on these until the higher categories in the system have been agreed on.

S. Pawluk: Just one more comment. You asked about a comparison between Acton's classification and Fulton's. Both Acton and Dumanski mention that Acton's classification is designed as a descriptive classification. I noticed in Fulton's he has in his separation a genetic category, compositional groupings, and these truly are genetic categories, and the terminology is genetic rather than descriptive. I see you use the same terminology than in a descriptive sense. Is this reconcilable? Is it possible to use terminology that has been developed in geomorphology as genetic terminology, is it possible then to define these same terms descriptively? I think, coming back to Pete's comments, the reason why the geologists never did come up with a classification, including the terminology, is that they could not agree on the genetics of the various landform units. I have been out in the field with them. They are willing to admit that some of these things have certain describable physiographic characteristics but the question is can you separate an esker from a crevasse filling descriptively? Can you separate the kame moraine which is 50% sorted and 50% unsorted from ground moraine? They can't because their terminology is genetic and this is the reason why they have never been able to agree in their work. They generally have to go out first and work out the glacial history of an area to determine how and what had happened in the past. The history of the area before they could classify. Now that we're thinking of a descriptive classification maybe it's best to think of coining new terminology or making darn certain that we can define these terms because you're going to have to sooner or later define them descriptively so that in fact there won't be any confusion in the use of this terminology.

D.F. Acton. In reply to Pawluk. I don't entirely agree that all usage of these terms by geomorphologists has been entirely genetic. Some authors use them as forms representing processes, others as forms representative of composition or structure. They are, in my thinking, terms many of us have some feeling for. We must aim at being completely descriptive, as you suggest, in using these terms.

(At this point, the system of Given _et al._ was also presented for discussion).

L. Lavkulich: The rationale that we tried to develop was the fact that we are dealing with a continuum in a sense that we have ice features, we have ice-water, water-ice, moving-water, standing water. The mode of origin is what the surficial geologists sometimes call their facies. This is what we were looking at. We're going to split this continuum because you know what they are, the various agencies. When you come to material I know people will argue what is till, we can use it as a genetic term or we can use it as some sort of economical material, i.e., boulders and cobbles. So what we have done is review the information that Acton and Fulton prepared. We also have used information, for example, Flint's book, 1971. We tried to define every one of the units, every one of the genetic terms, not only by genesis but also by description. The idea here is you will notice that basal till, ground moraines, those are all plains. When you come to ablation till, your moraines are going from plains and then moraines. We are trying to orient the scheme towards air photo interpretation and thus we're hoping that from conventional black and white air photography you should be able to recognize all of those, particularly the landform and repetitive landform pattern on the air photo.

J. Belsham: Are the separations in the Given _et al._ scheme between lacustrine and glacio-lacustrine and fluvial-glacial and glacial-fluvial important at this level?

G. Mills: In reference to the scheme of Given _et al._ Should the highest, broadest category be the one which depends more on morphological expression rather than material? Morphology is easily recognizable on all photos and as such should occur at a high category.

D.F. Acton: In reply to Mills. This is a very basic question. My only answer is that it would appear that materials lend themselves to a higher category than does form.

T. Lewis: We felt that the individual that Acton referred to earlier would be the repetitive landform pattern on broad scale mapping. At a more detailed level it would be some element of it, some slope position or particular aspect of that particular pattern. Similarly with the soil series you can break it down to finer subdivisions or else go the other way and generalize it to a higher category, here you can do the same thing, you can go really either way from this particular type of individuals. I think you have to agree on this individual which you are classifying. Another point that has come up a number of times is that what we see here on the board and on these other classifications is a hierarchial taxonomic system and there is a split when you come to looking at for instance Fulton's regional things. These are not landforms that have generalized any kind of categorical or taxonomical sense but these are kind of broad geographical or cartographic groupings similar to a soil association. The soil association doesn't appear in the soil classification hierarchy either. I think this is analogous to these physiographic regional kind of groupings that are largely genetic rather than taxonomic.

W. Holland: Can I have a review of your objectives here? Is this a system for mapping all of Canada so that you can use it for the geologists in the Northwest Territories or whatever usage you are going to have there? Are you going to have an influence for Forestry or are you trying to develop a system that is only aiding you in classifying soils?

D.F. Acton: The first objective is to develop a system to be used in mapping soil resources. This should also serve the needs for landform classification in forestry.

W. Holland: In reply to Acton. You refer to soil as opposed to land here.

D.F. Acton: In reply to Holland. Although I am thinking of our conventional soil surveys I also believe that anyone dealing with land classification could also use it.

J. Clark: Perhaps a decision ought to be made to accept the scheme proposed by Fulton. It is not at too great a variance with the other one proposed and perhaps they could be matched together.

J. Shields: I see no reason why the three proposals cannot be integrated.

D.F. Acton: We must proceed and put together a comprehensive and complete system in the proceedings that will be published from this meeting. I would attempt to do this based on the discussion that we have had this morning. I would circulate this for consideration by soil survey groups in Western Canada, and do what I possibly could to resolve any differences. I think Jim Ellis has made a good point earlier that I didn't comment on at that particular time but I think if at all possible in the summer to come if we could arrange for a small group to examine a cross-section of landforms to see how a more fully developed scheme would apply. Having published this in the proceedings of this particular meeting I think we must then ensure that it is drawn to the attention of groups outside of this one and we must ensure that these people will have access to our subsequent national meeting.

J. Clark: Are we capable of really doing anything effectively in a reasonable amount of time, or are you going to have to decide that this is an important enough aspect or program to devote fairly concentrated effort on the part of a smaller number of people, to at least lead the way? I think this is the geologist's feeling, somebody has got to put something out and then it gets picked away and straightened out as you go.

J. Shields: I think we have to realize that this is open ended from both ways, and it is also open ended to things that might need to be amended later, it is not necessarily going to be a crude initial attempt and from this aspect I hesitate to suggest a great number of people be involved in it. We have a nucleus of people here, now I don't say they are necessarily going to dictate exactly what goes into it.

D.F. Acton: I think perhaps if we can start with a regional approach where we can reach some agreement, and present it for examination nationally, we are apt to get further than stopping now on a regional approach and trying to expand it into national approach. I would be very strongly in favour of considering this a regional system at this stage.

J. Clark: I think your recommendations are to go ahead and prepare an interim regional report. Basically this is the crux of the recommendation and to keep this group active. Part of this activity is this possibility of forming a study group. You have come along with a fairly firm proposal here that you go with no more than three from the soils area and one from GSC and one from Forestry at this state because that's about all you can effectively communicate with.

J. Dumanski: I would like to make only one comment that concerns the working group when it gets off the ground and starts working. Let us not forget the new element in our pedological society and this is the data bank. We are leaving room in the data bank for a landform classification when and if it is developed and the big thing in this is that everybody calls the same thing by the same name.

S. Pawluk: Motion that these three proposals together with comments off the tape be sent to each of the provincial groups. Let them get together with their own contact, in forestry, in geology, so forth, discuss this once again and come back with recommendations to you and let the contact be made first of all at the local level.

L. Lavkulich: Seconded the motion by Pawluk.

This motion was amended by a second motion by A. Ballantyne that Acton takes the three proposals and out of these then synthesizes a system which he sends out for criticism and trial.

A show of hands indicated the majority favored the motion.

Appendix I

LANDFORM CLASSIFICATION

R. J. Fulton

This is an initial and incomplete proposal. Definitions will probably have to be modified and tightened, some categories may be dropped and others will undoubtedly be added. Also many terms such as hummocky, rolling, etc. will have to be defined in quantitative terms.

This landform classification is designed for use at scales of 1:250,000 and larger. Two levels of units are proposed:

1) a regional subdivision for segregating major landform units,

2) a local subdivision for identifying the components of the major units.

A. Regional Landform Subdivision

It is proposed that terms currently in use be retained for regional units but that an attempt be made to standardize usage and to define each in terms of objective criteria. This is a two part subdivision: the first part indicates the general nature of the area and the relationship to adjacent landform units; the second part is a modifying term which describes the general nature of relief and slopes of the major landform unit.

Major Unit Terms

Mountains - areas of high local relief (2,000 ft. per mile or greater).

Hills - areas of moderate local relief (300 to 2,000 ft. per mile).

Uplands - areas of variable local relief that are elevated above the general level of the surrounding country (local relief up to 2,000 ft. per mile).

Midlands - areas of moderate to low local relief that are adjacent to mountains or uplands but stand above adjacent valley floors or lowlands (local relief up to 500 ft. per mile).

Lowlands - areas of broad extent and moderate to low local relief that lie at or near the regional base level (local relief up to 500 ft. per mile).

Valleys - major linear depressions, including both the side slopes and the bottom.

Relief Modifier Terms

Mountainous - high relief and long steep slopes (relief of more than 2,000 ft. per mile and slopes mainly over 35% and more than 1.5 miles long).

Hilly - moderately high relief and moderately long, moderately steep slopes (relief 500 to 2,000 ft. in 1 mile and slopes generally between 20% and 35% and 0.5 miles to 1.5 miles long).

Rolling - moderately low relief and moderately long but moderately gentle slopes (relief 50 to 500 ft. per mile and slopes generally between 5% and 20% and 0.5 to 1.5 miles length).

Hummocky - moderately low relief and moderately short but moderately steep slopes (relief 20 to 500 ft. in a mile and slopes 20% to 35% and 100 ft. to 0.5 miles in length).

Plain - low relief and gently slopes (relief 0 to 150 ft. per mile and slopes up to 5% where longer than 0.5 miles and up to 20% where slopes are shorter than 0.5 miles).

The slope and relief figures used have been chosen in a rather arbitrary manner and are subject to review. Effort will have to be made to see if the units are defined fit actual landform populations and the terms redefined to make the classification more useful.

Major unit terms and relief modifiers are to be combined so a landform would be referred to as a hilly upland, an upland plain, rolling midlands, a hummocky lowland, etc.

B. <u>Local Landform Subdivision</u>

The nature of the major landform units should be described in terms of nature and content of rock and unconsolidated material. These two components are subdivided on a basis of composition and geomorphic form. An attempt has been made to base this sibdivision on objective descriptive criteria only. Individual units are referred to in terms of these criteria rather than by the specific landform names that have been used in the past. This is done to make the system flexible and easier to apply universally, to illiminate the confusion which arises when different names are applied to landforms that in a descriptive sense are the same and to illiminate genetic bias from the mapping of landforms.

<u>Bedrock Component</u>

It is proposed that the criteria for subdividing the bedrock component of landforms be composition, rock structure and morphologic expression. The categories suggested for each are:

1. Composition

intrusive acid (granite etc.)
intrusive basic (gabbro etc.)
gneissic
schist
carbonate (limestone, dolomite)
evaporites
fine grained clastic
coarse grained clastic
volcanic acid (rhyolite etc.)
volcanic basis (basalt etc.)

2. Structure

flat lying
gently dipping
steeply dipping
folded
massive

3. Morphologic expression

   hilly
   rolling
   hummocky
   ridged
   plain

The bedrock landform component name would be obtained by combining these expressions, eg.: a hilly area of massive acid igneous rock, a plain underlain by gently dipping basic colcanics, a ridged area consisting of carbonate and fine grained clastic rocks.

<u>Unconsolidated Component</u>

Composition and morphologic expression are the main criteria used to subdivide the unconsolidated landform component. In this case the terms used for the broad compositional groupings are genetic terms. It is however felt that as the genetic terms used are broad and as the categories are defined by simple objective criteria, there should be little dispute over which grouping a landform component belongs in:

1. Compositional categories (genetic categories)

   Morainal - variable mixture of boulders, gravel, sand, silt, and clay deposited by glacier ice.
   Alluvial - sand, gravel, silt and minor coarser material deposited by flowing water.
   Lacustrine - silt, clay, sand and minor coarser material deposited in standing fresh water.
   Marine - sand, silt, clay and minor coarser material deposited in a marine environment.
   Colluvial - variable mixture of boulder to clay textured material deposited by various processes of mass-wasting.
   Organic - deposit predominantly of peat or other organic material.
   Eolian - sand and silt deposited by the wind.

2. Morphologic expressions

   plain - relatively flat, unconsolidated material generally thick enough to cover irregularities in underlying bedrock.
   rolling plain - undulating topography, unconsolidated material generally thick enough to mask irregularities in the underlying bedrock.
   hummocky - small but steep sided, hillocks and hollows, unconsolidated material generally thick enough to cover irregularities in underlying bedrock.
   ridged - small but steep sided linear hills and hollows, unconsolidated material generally thick enough to cover irregularities in underlying bedrock.

terraced - relatively flat surfaced feature terminated by an abrupt change in slope on one or more sides, unconsolidated material generally thick enough to mask irregularities in underlying bedrock.

fan - shaped like a fan with a noticeable slope towards the fan toe, unconsolidated material generally thick enough to cover irregularities in underlying bedrock.

veneer - thin cover of material of one genetic category on material of another category or of unconsolidated material on bedrock, material too thin to mask morphologic expression of underlying unit (6 ft?).

complex - a mixture of several morphologic units (nature generally must be explained in written text).

The name for the unconsolidated component is obtained by combining genetic category and morphologic expressions, e.g., morainal plain, alluvial fan, and terraced alluvial deposit.

Glaciation is a factor which complicates the classification and subdivision of most unconsolidated landform components. In this proposed classification glaciofluvial, glaciolacustrine and glaciomarine are not recognized as genetic categories distinct from alluvial, lacustrine and marine. However if positive evidence is available (either in morphologic expression or composition of the deposit) which indicates deposition adjacent to ice, glacio can be attached to the genetic category term. For example certain types of alluvial deposits will be referred to as glaciofluvial, certain types of lacustrine deposits as glaciolacustrine and certain marine deposits as glaciomarine.

3. Unconsolidated component texture

The genetic category term defines unconsolidated landform component texture in broad terms, i.e., morainal deposits consist largely of till, alluvial deposits are generally sand and gravel, and lacustrine deposits generally consist of silt and clay. In some instances, particularly where detailed information is available, it is possible to define deposit texture in more specific terms. The following textural modifiers are proposed for this purpose:

bouldery - abundance of material classed as boulder in size (>256 mm or > 10 in.).

gravelly - dominantly gravel and coarse sand sized material (1-256 mm or .4-10 in.).

sandy - dominantly granule and sand sized material (.4-05 mm).

silty - dominantly fine sand and silt sized (.25-.005 mm).

clayey - dominantly fine silt and clay in size (<.01 mm).

The textural modifier is merely added to the other two parts of the unconsolidated component term so that if a morainal plain is known to consist of a clay rich till, the landform component will be referred to as a clayey morainal plain, if an alluvial plain is known to consist dominantly of fine sand and silt, it will be referred to as a silty alluvial plain, etc.

Erosional Modification

Both bedrock and unconsolidated landform components can show the effects of or be currently undergoing erosional modification by one or more processes. The nature of this modification and whether or not the modifying process is currently active should be indicated in the component name. Some erosional modifying terms that might be used are:

- glaciated - eroded or molded by glacial ice (to be used where unconsolidated material has been overridden by a glacier but not covered by morainal deposits).
- washed - modification of a deposit or feature by the washing action of a body of standing water.
- eroded - modification of a deposit or feature by a through-flowing stream.
- gullied - modification of a deposit or feature by the cutting of channels and removal of material from along local drainage ways.
- soliflucted - modified by the slow flowage of water soaked material from higher to lower areas.
- congeliturbated - modified by heaving, churning or mixing due to frost action.
- mass-wasted - modified by the down slope movement of loose material.
- karst modification - modification by the subsurface solution of carbonates.
- avalanche modification - modification by the processes associated with frequent avalanche activity.
- thermokarst modification - modified by the melting of ground ice.
- piping modification - modified by the subsurface removal of particulate material.

A morainal plain that showed the effects of wave washing would be referred to as a washed morainal plain; a shale plain that was being dissected would be described as a plain underlain by fine clastic rocks subject to gullying, and silty alluvial deposits being modified by thermokarst processes would be referred to as a silty alluvial plain subject to thermokarst erosion.

Not all these terms may be useful and some will only be useful if they are narrowly defined. Mass-wasting, for example, covers a variety of processes by which materials are moved by gravity from one place to another. All areas that are not completely flat are subject to mass-wasting to some degree. In this classification it is suggested that the term be restricted to slopes of such a nature that material once loosened, will move freely away from its point of origin. An example would be a steep bare shale slope. Also some terms will be used to indicate slightly different types of modifications in different areas but only through use will the bugs be ironed out and the terms given regional significance.

Concluding Statement

This scheme is proposed largely as a method of mapping landforms. Hence the emphasis is placed on being able to describe the entire terrain objectively rather than providing names for minor features thought to be of great genetic significance. An attempt is made to eliminate names of genetic but not necessarily descriptive significance (such as end moraine, DeGeer moraine, outwash plain etc.) and to use single terms for groups of deposits which in a broad descriptive sense are the same (ridged moraine used to include, washboard moraine, rippled till, ribbed moraine etc.; hummocky till used for moraine plateau, prairie mound, humpies, disintegration moraine etc.).

As the proposed scheme uses the same morphologic descriptive terms for all compositional categories of unconsolidated landform components, and for all structural categories of the bedrock landform component, the two classifications can most easily be presented as Tables. The tabular classifications are presented as an appendix along with a suggested "short hand" system for designating the landform components on a map.

Shorthand system for referring to landform units

In showing landform units on maps and in interpreting air photographs, a short method of designating landform units is required. All landform units and all possible variations could be listed and each assigned a number but it would be necessary to continually refer to a Table when reading the maps or interpreting the air photographs. A system based on the use of letters or symbols, each of which stand for certain words or characteristics, is far more flexible and easier to use than a system that designates unique units by numbers.

Rock Component

Table I gives the form and structures used in subdividing the rock components of landforms. This part of the landform can be further defined by the use of superscripts indicating the following compositions.

Table I: Rock Components

Morphologic Expression		Massive ⊕	Flat lying +	Gently dipping γ	Steeply dipping Ƶ	Folded ∩
hilly	y	⊕ y	+ y	γ y	Ƶy	∩ y
rolling	m	⊕ m	+ m	γ m	Ƶm	∩ m
hummocky	h	⊕ h	+ h	γ h	Ƶh	∩ h
ridged	r	⊕ r	+ r	γ r	Ƶr	∩ r
plain	p	⊕ p	+ p	γ p	Ƶp	∩ p

intrusive acid	ia
intrusive basic	ib
volcanic acid	va
volcanic basic	vb
gneissic	g
schist	s
carbonate	l
evaporite	e
fine grained clastic	f
coarse grained clastic	c

Examples of designations of rock component of landform: a hilly area of granite would be designated as ia + y or massive acidic intrusive rock with a hilly landform expression, an area consisting of ridges of steeply dipping carbonate bedrock would be lZr and a plain developed on flat-lying shale would be f+p.

Unconsolidated Component

Examples of shorthand designations of unconsolidated landform components are given in Table II. Textural modifiers used are:

bouldery - b

gravelly - g

sandy - s

silty - $\not{s}$

clayey - c

If the texture is known a textural modifier is used as a superscript; e.g., ^{b}C - a veneer of colluvially derived boulders, $^{c}M_{p}$ - a plain of clay rich till, and $^{s}L^{G}_{h}$ - a hummocky area of glaciolacustrine silt. In this last example the G indicates that there was something about the deposit morphology or composition that indicated it was uniquely glacial in origin. Glaciofluvial (A^{G}), and glaciomarine (M^{G}) are designated in this same way. If the genetic process responsible for the landform is still active an uppercase A is used, e.g., M^{A}_{r} would be a modern marine beach, A^{A}_{p} would be a presently active floodplain. If there was a reason for emphasizing that a depositional surface was no longer undergoing active aggradation an uppercase I (for inactive) could be used, for example: A^{I}_{f} would designate a fan no longer subject to active deposition.

Erosional Modifier

If either the rock or unconsolidated component of a landform shows the effects of post-formation modification an erosional modifier is placed at the end of the component designation. Letters used to indicate the various types of erosional modification are:

G - glaciated	S - soliflucted	T - thermokarst
W - washed	C - congeliturbated	P - piping
E - eroded	M - mass-wasted	A - avalanche
V - gullied	K - karst	

The erosional modifier is separated from the rest of the component designator by a short dash. For example Mp-T would be a morainal plain modified by thermokarst processes, Ap-G would be a floodplain deposit that has been overridden by ice, f+m-V would be a rolling plain of shale that had been modified by gullying, and l p-K would be a plain underlain by gently dipping carbonates that have been modified by karst solution. An additional dimension can be added by designating whether or not the erosional process is presently active for example: Mp-T^A would be a morainal plain currently undergoing thermokarst modification, Lp-P^A would be a plain of silty lacustrine material subject to piping at the present time, and f+m-E^G would be a rolling plain underlain by flatlying shale that had been eroded by glacial meltwater, and Mp-W^G would be a morainal plain that had been washed (or bevelled) by a glacial lake.

Table: Unconsolidated Components

Morphologic Expression	Compositional Groupings (Genetic Categories) M - Morainal	A - Alluvial	L - Lacustrine	m - Marine	C - Colluvial	O - Organic	E - Eolian
p - plain	Mp-morainal plain	A_p^G- glaciofluvial plain Ap-alluvial plain	Lp-Lacustrine plain	m_p^G-glaciomarine plain p-marine plain		Op-organic plain	Ep-eolian plain -loessal plain
m - rolling	Mm-morainal rolling plain		Lm-Lacustrine rolling plain	mm-marine rolling plain			Em-eolian rolling plain
h - hummocky	Mh-hummocky moraine	A_h^G-hummocky glacio-fluvial	L_h^G-hummocky glacio-lacustrine	m_h^G- hummocky glaciomarine	Ch- hummocky colluvium	Oh-hummocky organic	
r - ridged	Mr-ridged moraine	A_r^G-ridged glaciofluvial	L_r^G-ridged glacio-lacustrine Lr lake beach	m_r^G- ridged glacio-marine r-marine beach	Cr-ridged colluvium	Or-ridged organic	Er-ridge eolian
t - terraced		A_t^G-glaciofluvial terrace At-alluvial terrace	Lt-terraced lacustrine	mt-terraced marine			
f - fan		A_f^G-glaciofluvial fan Af-alluvial fan			Cf-colluvial fan		
v - veneer	Mv-moraine veneer	Av-alluvial veneer	Lv-lacustrine veneer	m_v^G-glaciomarine veneer m_v-marine veneer		Ov-organic vaneer	Ev-eolian veneer -loessal veneer
x - complex	can be used in morphic modifier position with any genetic category i.e., Mx or Mhx but the nature of the complex must be explained in a written text.						

Appendix II

Classification of Landforms for Soil Surveys in Canada

D. F. Acton

I INTRODUCTION

The need for a landform classification system for Canadian soil surveys was recognized as early as 1945 (National Soil Survey Committee, 1945) and in 1948 (National Soil Survey Committee, 1948) a system of terminology for simple and complex topographic classes was presented. The recognition, by those involved in this development, that a more complete landform classification system would be desirable, was exemplified by the compilation of a list of all landform terminology used by soil surveys at that time (National Soil Survey Committee, 1948). A lack of co-operation by all of the participating soil survey groups appears to have hindered the accomplishment of this objective. Numerous subsequent attempts to develop a more complete landform classification would suggest that at least certain individuals, or groups, felt such an endeavor was of considerable importance. However, the lack of progress reported through the past two decades could be interpreted to signify that the need for a classification of Canadian landforms is not widely recognized.

Prior to the meeting of the Canada Soil Survey Committee in 1970, the national chairman expressed the hope that the Subcommittee on the Classification of Landforms could develop a scheme for trial purposes. In accordance with these wishes many subcommittee members presented classification systems and descriptions of landforms pertinent to their geographic areas. From these presentations, and other available literature, a comprehensive scheme was prepared for consideration at the national meetings. This scheme was basically descriptive, but required intuitive genetic judgements. Reaction to it varied from complete acceptance, acceptance in principle with detailed modification, unacceptable due to genetic implications, and unacceptable because earth scientists from other groups were not involved in its preparation. As a result, a recommendation was approved "that the chairman of the Canada Soil Survey Committee ensure that a working committee be established to press toward the development of a landform classification scheme for Canada". (Canada Soil Survey Committee, 1970).

It is understood that representations from members of the Canada Soil Survey Committee have been made to the Geological Survey of Canada to jointly develop a classification system. In that the latter group is presently unable to devote the attention that would be required to jointly develop a scheme, it was deemed advisable that members of the Canada Soil Survey Committee independently continue to work towards the development of a classification system with the Geological Survey willing to advise on and critically review any proposal which may be forthcoming.

The presentation to follow is an attempt to continue toward the development of a landform classification for use in soil surveys in Canada. It follows the same principles as those used in the scheme presented to the Canada Soil Survey Committee in 1970 but incorporates some changes, suggested by this group. It is the intention to seek the approval of this scheme at the Western Regional Meeting of the Canada Soil Survey Committee at Kelowna. Such a scheme, or any modified or alternate scheme approved at this regional meeting would be submitted for national consideration at the next meeting of the Canada Soil Survey Committee.

Before considering the proposed scheme, the objectives of a national scheme will be outlined, the specifications or requirements of an acceptable scheme will be considered, and various alternative systems will be reviewed.

What is A Landform?

No clear definition of landform has been found in the literature. Many of the early geomorphologists used the term synonymous with surface features only to have subsequent investigators redefine these features on the basis of structure rather than topography. As a consequence, we have terms such as plains and plateaus which were originally defined on the basis of form later redefined to include structure. Confusion has also arisen as a result of using the term landform to reflect the stage of development of a landform as well as the form itself. Still further, landform has been defined as a "topographic feature that can be recognized as a recurrent unit of the landscape by its shape and/or mode of origin" (Kowall and Runka, 1968). In this and other publications (Lacate, 1969) the lithology associated with the surface form also receives considerable attention. It is apparent that "we are thus faced with the problem of whether to retain the term 'landform' with its present all-embracing meaning, but with its illogical connotation, or to substitute some other term for the whole variety of features heretofore classified as landforms and restrict the term 'landform' to one particular group of features. It is the opinion of the writers that retention of the term 'landform' is advisable because of its established position in the literature. Confusion would undoubtedly attend any attempt to restrict its meaning. The term is therefore retained in its broadest sense and is defined as follows: A landform is any element of the landscape characterized by a distinctive surface expression, internal structure, or both, and sufficiently conspicuous to be included in a physiographic description" (Howard and Spock, 1940). In that it is sometimes difficult to recognize surface forms and internal structures without reference to the composition of the materials, the following definition will be used in the remainder of this text: A landform is any element of the landscape characterized by a distinctive surface expression, which may be associated with a definite internal structure and/or composition, and sufficiently conspicuous to be included in a physiographic description".

The definition proposed above is more restrictive than may be found in some literature of the earth sciences. For instance, in a landform classification for Ontario, prepared for the Canada Soil Survey Committee Meetings in 1970 (Gillespie, 1970), provision was also made for drainage, soils and stoniness. Such a usage more closely approximates the usage of the term "terrain" in the land classification literature of Great Britain (Beckett and Webster, 1969) and "land", in literature of a similar nature from Australia (Christian, 1952, 1957). Following these examples, it is suggested that the term "land" be used where a broad meaning is required and "landform" for a more restrictive term centring on the "form of the land", not the "land" *per se*.

Objectives of a National System of Landform Classification

"The purpose of any classification is so to organize our knowledge that the properties of objects may be remembered and their relationships may be understood more easily for a specific objective. The process involves formation of classes by grouping of objects on the basis of their common properties. In any system of classification, groups about which the greatest number, most precise, and most important statements can be made for the objective serve the purpose best. As the things important for one objective are seldom important for another, a single system will rarely serve two objectives equally well". (Cline, 1949).

It is apparent from the foregoing quotation that one of the first considerations in developing a classification scheme should be establishing the objectives of such a scheme. Perhaps it is the lack of a clear, single objective for a comprehensive and complete landform classification system for Canada that has hindered the progress in this direction by the Canada Soil Survey Committee and other groups. Considering this, it would appear that the objective of a landform classification system for use in soil surveys in Canada should be to provide a uniform basis for organizing, naming and defining landforms to facilitate the recognition, delineation, understanding, description and representation of soils in the content of the geomorphological environment in which they have formed.

The present trend in Canada from independent soil surveys to integrated, interdisciplinary natural resource surveys has focused sharply on the need for a "common ground" for the team members engaged in such surveys. "The fact that photo interpretation usually takes a central position in the survey work adds to the necessity of a geomorphological basis of the work because landforms are such conspicuous phenomena in the stereoscopic photo images. It is logical therefore that the other investigations related to integrated surveys root in landform classification" (Verstappen, 1966).

Specifications of a Satisfactory Landform Classification System

Recognizability and reproducibility have been considered to be important general attributes of a satisfactory terrain classification system (Beckett and Webster, 1965). They consider recognizability to be the ease which terrain units may be recognized, particularly in inaccessible or little known areas. It is loosely defined as the percentage of a terrain unit that can be recognized out of the total area it covers. From this it follows that the definition of terrain, or landform, units must not depend upon obscure attributes, but upon attributes that may directly or indirectly be inferred from air photographs and background information that is likely to be available. By reproducibility is meant the similarity in attributes of different occurrences of the same terrain unit. From this it follows that if any advantage is to result from the recognition of a terrain, or landform, type at a particular location it must be because all other occurrences of that terrain, or landform, unit are sufficiently similar that one can generalize about them, and infer the properties of an unknown from a known site.

It is apparent that reproducibility and recognizability are more or less in an inverse relationship. Reproducibility can be increased by subdividing terrain, or landform, units more finely, by introducing more and more attributes into the definition, and by narrowing the permitted range of each. However, the more conditions that are introduced into the definition of a unit, the more difficult it is to recognize the unit and consequently as reproducibility increases, recognizability is likely to decrease. It is essential, then, that a balance must be achieved in developing a landform classification system to enable maximum reproducibility with little or no sacrifice of recognizability.

Alternative Types of Landform Classification

There are four fundamental approaches to landform classification, namely morphometric, morphographic, morphogenetic and morphochronologic.

In the morphometric approach, "landscapes are grouped according to measurable characteristics. Slope, form of slope, length of slope, exposure, density of gullies, can all be measured and expressed in exact numerical values, and classified". (Goosen, 1966).

A technique of morphological mapping which depended on the recognition of facets of constant slope and elements of smoothly curved profile, delimited by boundaries observed in the field (Savigear, 1956) followed by the addition of a third parameter, contour curvature (Troeh, 1965), and a fourth catchment area, (Speight, 1968) provided the basis for a morphometric or parametric approach to landform description, classification and mapping. (Speight, 1968).

The preceding studies, and in particular the latter one, have demonstrated that the classification of land systems and land units on the basis of form can be put on an entirely numerical basis, so that the element of subjectivity does not extend beyond the initial definitions. On a given set of definitions, mapping may proceed in a self-consistent way that allows no ambiguity and permits the quantitative comparison of landscapes from place to place. It is also worthy of note that electronic data handling, which sets quantitative criteria at a premium and which allows the incorporation of a much greater range of defining attributes also tends to favor this approach.

The procedures utilized in mapping slope and other parameters in the preceding studies appears impractical in that they are laborious and also require considerably more topographic contour information than is generally available in most areas. It must be recognized, however, that the development of new sensors could not only enable a direct scanning of attributes which formerly had to be inferred from associated features but could also provide for easy recognition of various land components. Such sensors, coupled with automatic photogrammetric equipment capable of recording co-ordinates on the land surface for computer analysis may radically alter the matter of practicality in the very near future.

Notwithstanding the possibility that technological developments will eventually facilitate a morphometric approach to landform classification, it must still be considered that "such a classification of landscapes is highly artificial. It may separate at a high level landscapes, which genetically belong together". (Goosen, 1966).

Just as morphometric designates the measurement of shape, morphographic suggests depicting of shape. The morphographic approach is frequently encountered in physiographic sketches (Raicz, 1948; Fenneman, 1916). It is frequently used in conjunction with other fundamental approaches for rarely is a pictorial presentation of landforms suffice without some subordination through quantification provided by morphometric analysis or subjective interpretations through morphogenetics or morphochronology.

Attempts to arrive at distinctive landform units by repeated subdivision on the basis of causal environmental factors may be considered the morphogenetic approach to landform classification. One of the fundamental concepts of geomorphology is that "geomorphic processes leave their distinctive imprint upon landforms, and each geomorphic process develops its own characteristic assemblage of landforms". (Thornbury, 1965). The simple fact that individual geomorphic processes do produce distinctive land features makes possible a genetic classification of landforms.

Three theoretical arguments have been proposed in support of genetic landform schemes.

1. It is a logical breakdown, and similarities between widely separated areas should be predictable where the basic controls are similar.
2. It offers a rational hierarchy and should allow further investigation and subdivision within the one framework.
3. It has the promise of universality. (Mabbutt, 1968).

Objections to the genetic approach are numerous and frequently very strong. Those frequently cited are: the regions are large, internally complex and the boundaries are vague (Linton, 1951; Mabbutt, 1968). These criticisms are aimed primarily at the Physiographic Divisions of the United States

(Fenneman, 1916) as they state that consistent subdivision of the very broad subsections is not possible in that likely criteria for further subdivision were already used.

A morphochronological approach to a landform classification, where shape or form are considered in relation to time can hardly be considered to suffice as a complete landform classification scheme. It must be considered particularly restrictive in an area such as Canada where a sometimes considered accidental event, glaciation, has been responsible for the dominant surface forms of a large part of the country and geologic time has lacked the magnitude to impart major chronological differences to the glacial from.

Considering the limitations mentioned for each of the basic approaches to a landform classification, it is apparent that a single approach cannot likely be used throughout a system. A multiple approach must be considered involving two, or perhaps all, of the four basic approaches mentioned.

The landform classification to be presented can best be described as descriptive even though many of the units to be employed are suggestive of a genetic classification. Many of the terms used were originally descriptive (i.e. moraine, drumlin, esker) but have subsequently been used in a genetic sense in some literature. This is not to suggest, however, that genesis is not also an integral part of the system. It is indeed; but not necessarily as dominant a part of the approach taken as may be suggested by a cursory examination of the unit names. Just as the approach taken is not strongly morphogenetic neither is it rigidly morphometric. Exacting measurements of slope gradient, length, height, direction, etc. may be applied to the classification units as a mapping procedure but rarely is measurement used as a specific criterion.

The Population, Individuals, Classes, Categories

"The smallest natural body that can be defined as a thing complete in itself is an individual. All the individuals of a natural phenomenon, collectively, are a population". "A class is a group of individuals, or of other classes, similar in selected properties and distinguished from all other classes of the same population by differences in these properties". "A category in such a system is a series of classes, collectively, formed by differentiation within a population on the basis of a single set of criteria". (Cline, 1949).

The population to be considered at this time is not intended to include all known landforms in Canada. It includes only those that occur commonly in the inhabitated part of the country which are consequently better known to pedologists and other earth scientists. These are predominantly glacial landforms but also include non-glacial fluvial, lacustrine, marine, aeolian and colluvial forms. Forms associated with igneous extrusion and intrusion, tectonic activity, solution, periglacial and organic terrains are excluded. It should perhaps be noted that many of the excluded forms do not have soil, as generally defined, at the land surface.

The individual may generally be considered to be a recurring pattern of form, or assemblage of slopes, associated with a surficial deposit. It can be considered to be both morphologic and lithologic in nature. The emphasis in definition is on description but genetic inference is also present. This basic unit, to be termed "repetitive landform pattern", may be compared to the subgroup in systems of soil classification (Canada Soil Survey Committee, 1968; U.S.D.A., 1960), the land unit (Christian, 1952 and 1957) or repetitive land pattern (Beckett and Webster, 1965), or the land system (Lacate, 1969) in land or biophysical classifications, and to the catena (Milne, 1935) or the association (Ellis, 1931) in soil mapping.

An example of a repetitive landform pattern is a hummocky moraine. Such a unit consists of a unique assemblage of slopes and associated deposits occurring in such a repetitive fashion that a basically similar assemblage of slopes and deposits may be found in local association or in completely separate geographic areas.

The repetitive landform pattern (RLP) defined above, is composed of minor slopes, to be termed "landform elements". In addition, several repetitive landform patterns possessing certain common characteristics may be considered to form a "landform group". Still further, several landform groups may have one or several important properties in common enabling a grouping of such landforms to be considered at an even higher level of abstraction, to be termed the "landform great group". It is apparent, then, that at least four categories have been considered in this classification scheme. Several classes of landforms may be distinguished within any category. In each case, some differentiating characteristics are considered as the basis for distinguishing between classes. Accessory and accidental characteristics are also included in the descriptions to follow as these characteristics may be of considerable consequence in pattern recognition.

Further description of landform characteristics can be applied to the system at a lower level, beyond the system. Envisaged here are textural groups, relief classes, gradient classes, etc. Hence, a more complete landform description may be: coarse textured, moderate relief, gently rolling hummocky moraine.

An outline of the three upper categories of the system is presented in Table 1. The fourth and lowest category of the system envisaged at this time,

Table 1. An Outline of the Landform Classification

Category I	Category II	Category III	Possible Symbology
(Landform Great Group)	(Landform Group)	(Repetitive Landform Pattern)	
	Ground Moraine	Undissected Ground Moraine	G
		Dissected Ground Moraine	Gd
	Fluted Ground Moraine	Undissected Fluted Ground Moraine	Gf
		Dissected Fluted Ground Moraine	Gfd
Ground Moraine	Drumlined Ground Moraine	Undissected Drumlined Ground Moraine	G
		Dissected Drumlined Ground Moraine	G
	Bevelled Ground Moraine	Undissected Bevelled Ground Moraine	Gb
		Dissected Bevelled Ground Moraine	Gbd
	Bedrock Controlled Ground Moraine	Undissected Bedrock Controlled Ground Moraine	Gc
		Dissected Bedrock Controlled Ground Moraine	Gcd
	Hummocky Moraine	Undissected Hummocky Moraine	Mh
		Dissected Hummocky Moraine	Mhd
	Washboard Moraine	Undissected Washboard Moraine	Mw
Moraine		Dissected Washboard Moraine	Mwd
	Crevasse Fillings	Undissected Crevasse Fillings	Mr
		Dissected Crevasse Fillings	Mrd
	Bedrock Controlled Moraine	Undissected Bedrock Controlled Moraine	Mc
		Dissected Bedrock Controlled Moraine	Mcd
	Kame	Undissected Kame	Fk
		Dissected Kame	Fkd
	Esker	Undissected Esker	Fe
		Dissected Esker	Fed
Glacio-Fluvial Plain	Outwash Plain	Undissected Outwash Plain	Fp
		Dissected Outwash Plain	Fpd
	Pitted Outwash Plain	Undissected Pitted Outwash Plain	F
		Dissected Pitted Outwash Plain	L d

Table 1. (continued)

Category I	Category II	Category III	Possil Symbo
Glacio-Fluvial Plain (continued)	Glacial Valley	Dissected Glacial Valley	Fvc
	Valley Train (Terrace)	Undissected Valley Train (Terrace)	Ft
		Dissected Valley Train (Terrace)	Ftc
Glacio-Lacustrine Plain	Glacial Lake Plain	Undissected Glacial Lake Plain	Lp
		Dissected Glacial Lake Plain	Lpc
	Pitted Glacial Lake Plain	Undissected Pitted Glacial Lake Plain	L
		Dissected Pitted Glacial Lake Plain	L d
	Glacial Lake Shorelines	Undissected Glacial Lake Shorelines	Ls
		Dissected Glacial Lake Shorelines	Lsd
	Controlled Glacial Lake Plain	Undissected Controlled Glacial Lake Plain	Lc
		Dissected Controlled Glacial Lake Plain	Lcd
Aeolian Plain	Loess Plain	Undissected Loess Plain	Ep
		Dissected Loess Plain	Epd
	Sand Plain	Undissected Sand Plain	E
		Dissected Sand Plain	E d
	Dunes	Undissected Dunes	E
	Controlled Loess Plain	Undissected Controlled Loess Plain	Ec
		Dissected Controlled Loess Plain	Ecd
Alluvial Plain	Accretion Flood Plain	Undissected Accretion Flood Plain	Aa
		Dissected Accretion Flood Plain	Aad
	Leveed Flood Plain	Undissected Leveed Flood Plain	Al
		Dissected Leveed Flood Plain	Ald
	Braided Flood Plain	Undissected Braided Flood Plain	A
		Dissected Braided Flood Plain	A d
	Alluvial Fan	Undissected Alluvial Fan	A
		Dissected Alluvial Fan	A d

Table 1. (continued)

Category I	Category II	Category III	Possible Symbology
Alluvial Plain (continued)	Alluvial Terrace	Undissected Alluvial Terrace	At
		Dissected Alluvial Terrace	Atd
	Alluvial Delta	Undissected Alluvial Delta	A
		Dissected Alluvial Delta	A d
Colluvial Plain	Colluvial Fans	Undissected Colluvial Fans	
		Dissected Colluvial Fans	
	Steepland Colluvium	Undissected Steepland Colluvium	
		Dissected Steepland Colluvium	
	Colluvial Talus	Undissected Colluvial Talus	
		Dissected Colluvial Talus	
Lacustrine Plain	Lake Basin	Undissected Lake Basin	
		Dissected Lake Basin	
	Lake Shoreline	Undissected Lake Shoreline	
		Dissected Lake Shoreline	
Marine Plain	Marine Plain	Undissected Marine Plain	
		Dissected Marine Plain	
	Marine Beach	Undissected Marine Beach	
		Dissected Marine Beach	

"landform element" has not been defined or included in the present scheme. It is envisaged, however, that this category will enable a consideration of individual slopes within a repetitive landform pattern. Some of these "elements" appear in the description of the "RLP" and include such features as knolls, ridges, mid-slopes, depressions, scarps, etc. Until the upper three categories are approved, however, it appears unnecessary to go beyond a general consideration of any lower categories of the system.

Description of the Landform Great Groups

1. Ground Moraine - glacial landforms of low to moderate relief, unless dissected when relief may be high, associated with deposits of lodgement glacial till. Such a till is relatively free of stones, the stones present are relatively small, rounded and striated, and the proportion of silt and clay is high compared to ablation till. In addition, these lodgement tills are very compact, generally crudely fissile, practically impermeable, and often only slightly oxidized and hence are likely gray in color. (Elson, 1961).

2. Moraine - glacial landforms of moderate to high relief associated with deposits of ablation glacial till. Such tills are recognized by abundant large stones that are angular and not striated, the proportion of sand and gravel is high and clay is present only in small amounts. The texture of these tills is loose and they oxidize rapidly to brown or yellowish-brown colors. (Elson, 1961).

3. Glacio-fluvial Plain - glacial landforms of low to high relief associated with glacial stream deposits. These stratified deposits have sharp and numerous horizontal and vertical variations in grain size, and have a wide range in grain sizes from boulders to fine silt.

4. Glacio-lacustrine Plain - glacial landforms of low to high relief associated with glacial lake deposits. These stratified deposits are characterized by a predominance of silt and clay size particles in the centre of the basin but may be high in pebbles and cobbles on the shoreline. Varving and lamination is common. Bedding may be normal or contorted.

5. Aeolian Plain - landforms of low to high relief associated with wind laid sediments. These deposits may be homogeneous, non-stratified, unindurated, predominantly silt with a rude vertical parting or may be crossbedded, laminated sands with abrupt changes from well to poor compaction.

6. Alluvial Plain - landforms of low to high relief associated with sediments laid down in river beds, flood plains,and fans at the base of mountain slopes.

7. Colluvial Plain - landforms of moderate to high relief associated with gravity deposition. These deposits are generally loose and incoherent deposits, found usually at the foot of a slope or cliff.

8. Lacustrine Plain - landforms of low relief associated with lake deposits. These stratified deposits are characterized by a predominance of silt and clay sized particles in the centre of the basin but may be high in pebbles and cobbles on the shoreline. Varving and lamination are common. Bedding is normal.

9. Marine Plain - landforms of low to moderate relief associated with deposition in a marine environment. These stratified deposits are usually well sorted, compact, lack varving.

Description of the Landform Groups

1. Ground Moraine

1.1 Ground Moraine - undulating plains with gently sloping swells, sags, and closed depressions, the whole having a local relief of no more than 20 to 30 feet. (Flint, 1955).

1.2 Fluted Ground Moraine - a field of narrow, straight to gently curved, parallel ridges and grooves. Ridges may be 3 to 20 feet above adjacent grooves. The grooves are up to 4 miles long and are 200 to 300 feet wide at the base. (Christiansen, 1960).

1.3 Drumlined Ground Moraine - a field of parallel, half-ellipsoidal to rounded hills which may be nearly one mile long, 1,200 to 1,800 feet wide, and 60 to 100 feet high. (Flint, 1955).

1.4 Bevelled Ground Moraine - a nearly level plain of low relief with only occasional mounds remaining above the general level. Cobble stones, pebbles, gravel and coarse sands, with beds of stones and boulders exposed in former channels form the surface cover overlying lodgement till beneath this eroded surface deposit.

1.5 Bedrock Controlled Ground Moraine - a plain characterized by gentle swells, sags, or closed depressions associated with a thin cover of lodgement till over a bedrock surface, the form of which is recognizable through the mantle of drift.

2. Moraine

2.1 Hummocky Moraine - areas of moderate to high relief consisting of a non-descript jumble of knolls and mounds of glacial debris separated by irregular depressions. The knolls do not align into ridges, and no dominant trends are discernible. (Gravenor and Kupsch, 1959).

2.2 Washboard Moraine - a sequence of sub-parallel, generally arcuate swells and swales. The ridges range from 5 to 40 feet in height. (Christiansen, 1960).

2.3 Crevasse Fillings - a field consisting of two sets of ridges intersecting at acute angles. The ridges are 5 to 10 feet high and are about 200 feet wide at the base. (Christiansen, 1960). The outstanding morphological characteristic of the typical crevasse filling is its straightness. (Kupsch, 1956). The material composing the crevasse fillings in most cases appears to be till, which at and near the surface is of a loose nature with an abundance of stones, suggestive of some washing by meltwater. It is believed to represent ablation till. (Kupsch, 1956).

2.4 Bedrock Controlled Moraine - a field of numerous rounded hills, or hummocks, and broad, gently dished basins associated with a thin cover of ablation till over a bedrock surface, the form of which is recognizable through the mantle of drift.

3. Glacio-fluvial Plain

3.1 Kame - assemblages of short, conical, often steep hills, built of stratified materials and interlocking and blending in the most diversified manner. (American Geological Institute, 1962).

3.2 Esker - a long, narrow ice-contact ridge commonly sinuous, and composed chiefly of stratified drift. They range in height from a few feet to 50 and even more than 100 feet, in breadth from a few tens to a few hundreds of feet, and in length from a fraction of a mile up to nearly 150 miles, if gaps are included. Sides are generally steep, crests are smooth or broadly hummocky. Kettles may pit the broader parts of some esker tops. (Flint, 1955).

3.3 Outwash Plain - a single fan, a row of coalescent fans, or a vast mass of outwash. The surface form may frequently contain a braided stream pattern, small kettles, or terraces. (Flint, 1955).

3.4 Pitted Outwash Plain - a nearly level plain with sags, swells, and unsymmetric irregularities in the surface.

3.5 Glacial Valleys - deep valleys with rough broken slopes, and steep head-cut tributary gullies. Most glacial drainage valleys are now occupied by small streams or may even lack an active stream. A flood plain, entrenched river channel with levees, oxbows, meanders, former sandbars, poorly drained flats and terraces may frequently be encountered, on a small scale, in the valley bottom. Small talus slopes and alluvial fans may mark the valley sides. If the valley is a spillway, older terraces may occur near the top of the valley walls. (National Soil Survey Committee, 1948).

3.6 Valley Train (Terrace) - a long narrow body of outwash confined within a valley and often terraced. Remnants of braided streams and occasional small pits may mark an otherwise level surface which may have a steep slope down-valley.

4. Glacio-lacustrine Plain

4.1 Glacial Lake Plain - typically a nearly level glacio-lacustrine plain with a very gentle regional slope towards the centre of the basin. The deposits are usually very fine sandy, silty or clayey; the finer deposits located in the more central part of the basin and the coarser near the margins. Bedding is normal, horizontal (noncontorted).

4.2 Pitted Glacial Lake Plain - generally a rolling glacio-lacustrine plain consisting of assemblages of broad rounded hills (sometimes with flat tops) and bowl-shaped depressions. As such, it has many features in common with a hummocky moraine. The deposits consist of very fine sands, silts and clays. Contortion of bedding is frequently encountered.

4.3 Glacial Lake Shorelines - a glacio-lacustrine plain consisting of a single or series of gravelly to pebbly and stony beaches, former wave-cut cliffs and low, nearly flat areas occurring between successive beaches. (National Soil Survey Committee, 1948).

4.4 Controlled Glacial Lake Plain - undulating glacio-lacustrine plains where much of the surface form is a reflection of an underlying till plain, bedrock surface or other form. Most typically an assemblage of low, smooth knolls or ridges of thin lacustrine material, or a till knob or ridge, with thicker lacustrine materials on the side slopes and in the depressions.

5. Aeolian Plain

5.1 Loess Plain - nearly level, featureless aeolian plain comprised of wind transported very fine sands, silts and clays.

5.2 Sand Plains - nearly level, featureless aeolian plains comprised primarily of sands too coarse to be transported by wind.

5.3 Dunes - aeolian plains of moderate to high relief comprised of longitudinal, parabolic or U-shaped, and crescent shaped features which may be as much as several hundred feet high. Composed of well sorted sand.

5.4 Controlled Loess Plain - undulating or rolling loess plains where much of the surface form is a reflection of the underlying structure of a till plain, bedrock or other form. Such forms are frequently characterized by a smooth, rounded knoll or ridge, smooth undulating or rolling slope and a slight depression.

6. Alluvial Plain

6.1 Accretion Flood Plain - nearly level to undulating ridge and swale alluvial plain situated in areas adjacent to an active stream and level to depressional topography located between these ridged areas and the uplands. (Runka and Kowall, 1969).

6.2 Leveed Flood Plain - an alluvial plain which typically has a slight ridge adjacent to the depositing stream with a broad level plain between it and the upland. (Runka and Kowall, 1969).

6.3 Braided Flood Plain - an alluvial plain which typically comprises several divided and interlaced channels resembling the strands of a braid. Local slopes vary from 0-7% and may have a steep regional gradient down-stream. (Runka and Kowall, 1969).

6.4 Alluvial Fan - level to steeply sloping (0-50% slopes) alluvial plain comprised of water sorted materials deposited in a fan-like shape where a stream runs out onto a level plain or meets a slower stream. Coarser materials are located at the fan apex and finer materials on the fan apron. Surface is often marked by variegated current scars, abandoned and presently occupied channels. (Runka and Kowall, 1969).

6.5 Alluvial Terrace - an alluvial plain consisting of relatively level (0-5%) remnants of former flood plains, terraced in sequence above the present flood plain. The surface may be marked by current scars and abandoned channels. (Runka and Kowall, 1969).

6.6 Alluvial Delta - an alluvial plain consisting of a relatively level (0-5% slopes) triangular shaped form at the mouth of a stream as it enters into a lake or ocean. May have numerous presently occupied or abandoned channels which appear as an integrated drainage pattern. (Runka and Kowall, 1969).

7. Colluvial Plain

7.1 Colluvial Fans - very steeply sloping (50%+ slopes) colluvial plains with a cone-like shape extending from a steep ravine onto the plain below. The deposit is comprised of a heterogeneous mixture of coarser and finer materials from fan apex to apron. Surface is occasionally marked by variegated current scars, abandoned and presently occupied channels. (Runka and Kowall, 1969).

7.2 Steepland Colluvium - steeply sloping colluvial plains (30+% slopes) comprising features such as land slides, slumps and mudflows located on valley sides, hilly and mountainous terrain. (Runka and Kowall, 1969).

7.3 Colluvial Talus - colluvial plains characterized by very steeply sloping (50%+ slopes) sometimes cone-shaped form consisting of fallen, disintegrated detrital material which has formed a slope at the base of a steeper slope or rock cliff. The distribution of materials on the landform is variable but most often the larger fragments are located on the talus apron while finer materials are located near the apex. (Runka and Kowall, 1969).

8. Lacustrine Plain

8.1 Lake Basin - nearly level lacustrine plain with a very gentle regional slope towards the centre of the basin. The deposits are usually very fine sandy, silty or clayey; the finer deposits located in the more central part of the basin and the coarser near the margins. Varving and lamination are common. Bedding is normal.

8.2 Lake Shoreline - a lacustrine plain consisting of a single or series of gravelly to pebbly and stony beaches, former wave-cut cliffs and low, nearly flat areas occurring between successive beaches. (National Soil Survey Committee, 1948).

9. Marine Plain

9.1 Marine Plain - level to irregular (0-30% slopes) marine plains consisting of an interspersion of undissected level plains only slightly elevated above present water surfaces and undulating glacio-marine materials at higher elevations near the edge of the marine plains. Deposits are water sorted, often compacted and stratified materials associated with a marine environment of deposition. (Runka and Kowall, 1969).

9.2 Marine Beach - level to irregular (0-30% slopes) marine plains comprised of wave washed and sorted materials, occupying areas adjacent to former or present seas. The forms consist of long, narrow, smoothly curving to straight ridges with generally smooth surfaces. When in groups they are more or less parallel, and if associated with a still present, but removed water body, they tend to parallel its present shoreline. (Runka and Kowall, 1969).

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Appendix III

LANDFORM CLASSIFICATION SYSTEM

W.J.B. Given, T. Lewis and L.M. Lavkulich

This system of classifying landforms is a hierarchial system beginning at the broad level, identifying the mode or origin, subdividing on the basis of material, landform and Repetitive Landform Pattern (RLP)(Acton, 1972). This system is a composite of several proposed landform classifications (see reference list).

An attempt has been made to meet these requirements: 1. at all levels of the classification, the units are recognizable on conventional air photographs. 2. The classification system is applicable over the usual range of mapping scales. 3. The system is open-ended especially at the lowest level.

At a small scale (1:250,000), "Materials" and "landform" can be used and where possible the "Repetitive Landform Pattern" (RLP) may be delineated. At larger scales (1:50,000), the map units will increasingly be the RLP's. The RLP's themselves may be of differing scales, e.g. at one level, one might map an accretion floodplain using the appropriate symbol (Fa), whereas at a larger scale, lateral accretions (Fla) and vertical accretions (Fva) may be delineated.

Complexing of "landforms" and "RLP's" is provided for in the usual manner, e.g. drumlinized till plain and hummocky morainal plain (Td^6 + ah^4).

Shallow Lithologic differences (less than 2 meters thick) may be indicated on the map by a slash, e.g. Eolian over Till plain (E/Tp) or fluted Till plain over granitic rock. Tf/Ria.

Wherever possible, textural modifiers can be used by preceding the RLP by the appropriate symbol, e.g. silty lake plain ($ Lp).

Modifications of the RLP can also be used, e.g. peat plateau influenced by Thermokarst. Oop-T or Piping lake terrace Lt-P.

Patterned Ground features where they can be readily identified can also be described in a manner similar to Modifications of the RLP, e.g. sorted circles features on a till plain. Tp-Cs

More information is required on these patterned ground features to be meaningfully placed into the classification system.

The following attempts to indicate the rationale used in developing the classification and the definition of terms.

Mode of Origin

1. Glacial Ice (Ice and ice > water)
2. Water (Water and water > ice)
3. Wind
4. Gravity
5. Polygenetic(Gravity, water and ice)
6. Organic

Material

1. Glacial Ice

1.1 Basal Till (T))

Till deposited at the base of a glacier. No size sorting or stratification is involved but stones tend to lodge with their axis paralleling the direction of flow. Crushing and abrasion of particles is intense and the till is compact and may acquire fissile structure as it is built up. These compact tills are practically impermeable and often only slightly oxidized and hence gray in color. (Flint, 1971)

1.2 Ablation Till (A)

Till deposited from drift in transport upon or within the terminal area of a shrinking glacier. The resulting till is loose, non-compact and non fissile and its clasts are less strongly abraided than those in lodgement till. During the process of melting, fines are selectively washed away. (Flint, 1971)

2. Water

2.1 Lacustrine (L)

Blanket of stratified silt, clay and sand of various degrees of thickness and continuity deposited in a standing body of water. (Fulton, 1967)

2.2 Glacio-lacustrine (Lg)

Blanket of stratified silt and clay with inclusions of ice-rafted coarse fragments and/or till. Varving and lamination is common. Bedding may be normal or contorted due to melting of incorporated ice. (Acton, 1972).

2.3 Marine (M)

Predominantly silts and clays deposited in a marine environment. These deposits are well sorted, stratified, compact and lack varving. (Acton, 1972)

2.4 Glacio-marine (Mg)

Materials were deposited by glacial activity in a marine environment, i.e. stones and part of the fine material transported and deposited by melting ice and the remainder of the fine material carried by meltwater and seawater. Generally materials are of a compact nature and blocky rather than fissile. (Flint, 1971)

2.5 Alluvium (F)

Materials consist of sediments laid down by running water of modern rivers and streams under flow regime conditions similar to those of the present time. Deposits consist of well sorted, well stratified materials generally gravelly to silty textured.

2.6 Glacio-fluvial (outwash) (G)

Materials consist of sediments laid down by running water of post glacial, pro-glacial rivers and streams under flow regime conditions of considerably higher flows than present rivers. Deposits consist of well sorted, well stratified materials generally, sands and gravels. (Flint, 1971)

2.7 Fluvio-glacial (Gf) (Ice Contact Stratified Drift)

Materials consist of sediments layed down by running waters in contact with decaying glacial ice. These deposits have sharp and numerous horizontal and vertical variations in stratification. The strata may be moderately to well sorted. Slumping resulting from ice melting destroys a part or all of the stratification. Textures range from gravels to sands with local deposits of either lacustrine silts and clays, basal or ablation till. (Flint, 1971)

3. Wind

3.1 Eolian (E)

Wind laid materials may be homogeneous, well sorted, non-stratified, loose, predominantly silts with a rude vertical parting or cross-bedded, laminated sands with abrupt changes from well to poor compaction. (Acton, 1972)

4. Gravity

4.1 Colluvium (C)

These materials are generally loose and incoherent drifts, found usually at the foot of a slope or bedrock exposure. The materials are non-stratified, non sorted of textures ranging from boulders to clay. (Acton, 1972)

5. Polygenetic

5.1 Steepland Drift (S)

Material is generally a mixture of lodgement and ablation till often modified by colloyial activity. Colluvium may be added and incorporated; downslope movement and soil creep occur and minor reworking by slope wash periodically takes place as these materials are locally derived in areas of high relief. The texture of the material is variable, ranging from coarse to fine textures with varying amounts and sizes of coarse fragments. Generally these materials are fairly loose, stony and overly either lodgement till or bedrock at depth.

5.2 Cordilleran Drift (D)

Materials generally consist of residual and colluvial materials at higher elevations that may have been overridden by glacial ice. Modification consists of two parts: (1) erosion - plucking and abrasion. (2) reworking of original materials and deposition of erratics. Materials are commonly shallow over bedrock with textures ranging from coarse to fine, primarily depending on the nature of the underlying bedrock.

6. Organic

6.1 Ombrotrophic (Oo)

The ombrotrophic materials are dependent on precipitation for water and nutrients because their surface configuration is convex which prevents inflow from mineral soils. The organic material is dominantly peaty or fibric in nature which may overly moderately decomposed organic materials at depth. The water table is often close to the surface but there is little standing water. Characteristically, these materials are very acid and have low fertility. (Tarnocai, 1970)

6.2 Minerotrophic (Om)

These organic materials are moderately decomposed and develop under minerotrophic conditions, i.e. nutrient rich, minerotrophic waters from mineral soils. These materials are found in areas of high water tables at or near the surface through out the year. These organic materials are higher in both nutrients and pH than ombrotrophic materials. (Tarnocai, 1970)

6.3 Transitional (Ot)

These organic materials receive some nutrient rich waters from mineral soils and consist of either moderately decomposed transitional materials throughout or poorly decomposed ombrotrophic materials over moderately decomposed minerotrophic materials. The water table is generally below the surface of these organic materials. (Tarnocai, 1970)

Landforms

1. Glacial   1.1   Basal Till (T)

1.1.1   Ground Moraine (T)

- glacial landforms of low to moderate relief associated with basal till; usually undulating plains marked by gently sloping swells, sags and depressions (closed or not) and with local relief less than 6 m. (Flint, 1971)

1.2 Ablation Till (A)

1.2.1 Moraine (A)

- glacial landforms of moderate to high relief associated with deposits of ablation till. (Acton, 1972)

1.2.2 End Moraine (Ae)

- a ridge like accumulation of drift built along any part of the margin of an active glacier. (Flint, 1971)

2. Water 2.1 Lacustrine (L)

2.1.1 Lacustrine basin (L)

- landforms of low relief associated with lake deposits. These stratified deposits are characterized by a predominance of fine particles (fine sand, silt and clay) in the center of the basin but may be high in pebbles and cobbles near the shoreline. (Acton, 1972)

2.2 Glacio-lacustrine (Lg)

2.2.1 Glacio-lacustrine basin (Lg)

- landforms of low to high relief associated with glacial lake deposits. Surface features may be undulating or hummocky due to incorporated material as the ice melted. (Acton, 1972)

2.3 Marine (M)

2.3.1 Marine basin (M)

- landforms of low to moderate relief associated with deposition in a marine environment. (Acton, 1972)

2.4 Glacio-marine (Mg)

2.4.1 Glacio-marine basin (Mg)

- landforms of moderate relief associated with deposition by blacial activity in a Marine environment.

2.5 Alluvium (F)

2.5.1 Alluvial plain (F)

- landforms of low to moderate relief associated with sediments laid down in river beds and floodplains. (Acton, 1972)

2.6 Glacio-fluvial (G)

2.6.1 Glavio-fluvial plain (G)

- glacial landforms of low to high relief associated with glacial stream deposits. (Acton, 1972)

2.7 Fluvio-glacial (Gf)

2.7.1 Fluvio-glacial ridges (Gf)

- glacial landforms of moderate to high relief associated with englacial streams.

3. <u>Wind</u>

3.1 Eolian (E)

3.1.1 Eolian plains (E)

- landforms of low to high relief associated with wind laid deposits. (Acton, 1972)

5.2 Cordilleran Drift (D)

5.2.1 Glaciated Valleys (D)

- landforms of moderate to high relief with in mountain systems caused by glacial modification.

6. <u>Organic</u>

6.1 Ombrotrophic (Oo)

6.1.1 Raised Bog (Oo)

- has either an elevated, convex central area,much higher than the margin, or a surface generally flat, higher than the margin. The elevated surface is due to either sphagnum peat accumulation and/or upheaval by permafrost. (Tarnocai, 1970)

6.2 Minerotrophic (Om)

6.2 Fen (Om)

- landform of flat to very low relief associated with areas of moderately decomposed organic materials (sedges, willow, Bog birch, etc.) formed under conditions of very poor drainage. (Tarnocai, 1970)

6.3 Transitional (Ot)

6.3.1 Transitional Bog (Ot)

- organic landforms of depressions to moderate slopes associated with moderately decomposing organic materials under conditions of poor drainage. (Tarnocai, 1970)

Repetitive Landform Pattern (RLP)

1.1.1 Ground Moraine (T)

1.1.1.1 Till plain (Tp)

- undulating plains with gently sloping swells, sags, and depressions (open and closed) and having low local relief (20-30 feet). (Acton, 1972)

1.1.1.2 Fluted till plain (Tf)

- a field of narrow, straight to gently curved, parallel ridges and grooves. Ridges may be 3 to 20 feet above adjacent grooves. The grooves may be up to 4 miles long and 200 to 300 feet wide at the base. (Acton, 1972)

1.1.1.3 Drumlinized till plain (Td)

- a field of parallel, half-ellipsoidal to rounded hills which may be one mile long, 1,200 to 1,800 feet wide and 60 to 100 feet high. (Acton, 1972)

1.1.1.4 Drumlin (Td)

- a singular elongated smooth streamlined hill.

1.1.1.5 Bevelled till plain (Tb)

- a nearly level plain of low relief with only occasional mounds remaining above the general level. Cobble stones, pebbles, gravel and coarse sands, with beds of stones and boulders exposed in former channels form the surface cover overlying lodgement till beneath this eroded surface deposit. (Acton, 1972)

1.2.1 Moraine (A)

1.2.1.1 Hummocky morainal plain (Ah)

- areas of moderate to high relief consisting of a non-descript jumble of knools and mounds of glacial debris separated by irregular depressions. The knools do not align into ridges, and no dominant trends are discernible. (Acton, 1972)

1.2.1.2 Washboard morainal plain (Aw)

- a sequence of sub-parallel, generally arcuate swells and swales. The ridges range from 5 to 40 feet in height. (Acton, 1972)

1.2.2 End Moraine

1.2.2.1 Lateral Moraine (Ael)

- an end moraine built along the lateral margin of any glacier lobe occupying a valley. (Flint, 1971)

1.2.2.2 Medial (Interlobate) Moraine (Aem)

- an end moraine built along the junction of two adjacent glacier lobes. (Flint, 1971)

1.2.2.3 Terminal Moraine (Aet)

- an end moraine built along the downstream or terminal margin of a glacier lobe occupying a valley. (Flint, 1971)

1.2.2.4 Recessional Moraine (Aer)

- a series of sub-parallel ridges marking the retreat of a glacier.

2.1.1 Lacustrine Basin (L)

2.1.1.1 Lake plain (Lp)

- nearly level lacustrine plain with a very gentle regional slope towards the center of the basin. Finer textures in the central portion of the basin and coarser near the margin. (Acton, 1972)

2.1.1.2 Lake beach (Lb)

- consists of a single or series of gravelly to pebbly and stony beaches, former wave-cut cliffs and low, nearly flat areas occurring between successive beaches. (Acton, 1972)

2.1.1.3 Lake terraces (Lt)

- Erosional remnants of a lacustrine plain.

2.2.1 Glacio-lacustrine basin (Lg)

2.2.1.1 Glacial lake plain (Lgp)

- a nearly level glacio-lacustrine plain with a very gentle regional slope towards the center of the basin. Bedding normal. (Acton, 1972)

2.2.1.2 Pitted Glacial Lake Plain (Lgk)

- a rolling plain consisting of assemblages of broad rounded hills (sometimes with flat tops) and bowl-shaped depressions. Contortion of bedding frequently encountered. (Acton, 1972)

2.2.1.3 Glacial Lake beach (strand lines) (Lgb)

- a glacio-lacustrine plain consisting of a single or series of gravelly to pebbly and stony beaches, former wave-cut cliffs and low, nearly flat areas occurring between successive beaches. (Acton, 1972)

2.2.1.4 Glacial lake terraces (Lgt)

- erosional remnants of a glacial lake plain resulting in a terrace.

2.3.1 Marine basin (M)

2.3.1.1 Marine plain (Mp)

- level to irregular (0-30%) slopes) marine plains consisting of an interspersion of undissected level plains only slightly elevated above present water surfaces. (Acton, 1972)

2.3.1.2 Marine beach (Mb)

- level to irregular (0-30%) marine plains comprised of wave washed and sorted materials, occupying areas adjacent to former or present seas. The forms consist of long, narrow, smoothly curving to straight ridges with generally smooth surfaces. (Acton, 1972)

2.3.1.3 Marine terraces (Mt)

- level to irregular linear landforms adjacent to existing shoreline.

2.4.1 Glacio-marine basin (Mg)

2.4.1.1 Glacio marine plain (Mgp)

- landforms of moderate relief associated with deposition of material in a marine environment under the influence of shelf ice.

2.4.1.2 Rolling Glacio-marine plain (Mgr)

- landforms of moderate to high relief associated with deposition of material in a marine environment under the influence of shelf ice.

2.5.1 Alluvial plain (F)

2.5.1.1 Accretion Floodplain (Fa)

- nearly level to undulating ridge and swale alluvial plain situated in areas adjacent to an active stream and level to depressional topography located between these ridged areas and the uplands.

2.5.1.2 Leveed Flood Plain (Fl)

- an alluvial plain which typically has a slight ridge adjacent to the depositing stream with a broad level plain between it and the upland.

2.5.1.3 Braided Flood Plain (Fb)

- an alluvial plain which typically comprises several divided and interlaced channels resembling the strands of a braid. Local slopes vary from 0-7% and may have a steep regional gradient down-stream.

2.5.1.4 Alluvial Terrace (Ft)

- an alluvial plain consisting of relatively level (0-5%) remnants of former flood plains, terraced in sequence above the present flood plain. The surface may be marked by current scars and abandoned channels.

2.5.1.5 Alluvial Delta (Fd)

- an alluvial plain consisting of a relatively level (0-5% slopes) triangular shaped form at the mouth of a stream as it enters into a lake or ocean. May have numerous presently occupied or abandoned channels which appear as an integrated drainage pattern. (Acton, 1972)

2.5.1.6 Fluvial Fan (Ff)

- level to steeply sloping (0-50% slopes) alluvial plain comprised of water sorted materials deposited in a fan-like shape where a stream runs out onto a level plain or meets a slower stream. Coarser materials are located at the fan apex and finer materials on the fan apron. Surface is often marked by variegated current scars, abandoned and presently occupied channels.

2.5.1.7 Lateral Accretions (Fla)

- characteristic ridge and swale topography (0-7% slopes) immediately adjacent to the present stream channel. (Runka and Kowall, 1969)

2.5.1.8 Vertical Accretions (Fva)

- level to depressional topography (0-2% slopes) and located in back swamps and abandoned channels between the uplands and the lateral accretions. (Runka and Kowall, 1969)

2.6.1 Glacio-Fluvial Plain (G)

2.6.1.1 Outwash plain (Gp)

- a row of coalescent fans, or a vast mass of outwash. The surface form may frequently contain a braided stream pattern, small kettles, or terraces.

2.6.1.2 Pitted Outwash Plain (Gk)

- a nearly level plain with sags, swells, and unsymmetric irregularities in the surface. (Acton, 1972)

2.6.1.3 Valley Train (Terrace) (Gv)

- a long narrow body of outwash confined within a valley and often terraced. Remnants of braided streams and occasional small pits may mark an otherwise level surface which may have a steep slope down-valley. (Acton, 1972)

2.6.1.4 Delta (Gd)

- relatively level (0-5% slopes), occasionally pitted, loose, water sorted, stratified materials which end abruptly in a fairly steep face. Visible current scars and abandoned channels may occur. (Ranka and Kowall, 1969)

2.6.1.5 Fan (Ff)

- moderately to steeply sloping, water sorted materials in a fan-like shape deposited at the sharp decrease in gradient of a proglacial stream.

2.6.1.6 Valley train terrace (Gt)

- a long narrow terrace of outwash deposited within a valley.

2.7.1 Fluvio-glacial ridges (Gf)

2.7.1.1 Kame (Gfm)

- assemblages of short, conical, often steep hills, built of stratified materials and interlocking and blending in the most diversified manner. (Acton, 1972)

2.7.1.2 Kame terrace (Gft)

- terraces of poorly water sorted materials which are ice-contact features associated with or adjacent to valley walls.

2.7.1.3 Esker (Gfe)

- a long, narrow ice-contact ridge commonly sinuous, and composed chiefly of stratified drift. They range in height from a few feet to 50 and even more than 100 feet, in breadth from a few tens to a few hundreds of feet, and in length from a fraction of a mile up to nearly 150 miles, if gaps are included. Sides are generally steep, crests are smooth or broadly hummocky. Kettles may pit the broader parts of some esker tops. (Acton, 1972)

2.7.1.4 Crevasse fillings (Gfc)

- a field consisting of two sets of ridges intersecting at acute angles. The ridges are 5 to 10 feet high and are about 200 feet wide at the base. (Christiansen, 1960). The outstanding morphological characteristic of the typical crevasse filling is its straightness. (Kupsch, 1956). The material composing the crevasse fillings in most cases appears to be till, [illegible] and near the surface is of a loose nature with [illegible], suggestive of some washing by [illegible].

It is believed to represent ablation till. (Acton, 1972).

2.7.1.5 Fan (Gff)

- water-sorted materials deposited in a fan-like shape - often a series of coalescing fans.

2.7.1.6 Rill complex (Gfr)

- intimate associations of small hummocks and ridges of gravel and sand, lag concentrations of boulders, small patches of silt and clay, and abandoned stream channels thought to have been cut by ice-marginal streams. (Fulton, 1967)

2.7.1.7 Kettle (Gfk)

- depression most often steep-sided (0.60% slopes) caused by melting ice.

3.1.1 Eolian plain (E)

3.1.1.1 Loess plain (Ep)

- nearly level, featureless aeolian plain comprised of wind transported fine sands, silts and clays. (Acton, 1972)

3.1.1.2 Dunes (Ed)

- plains of moderate to high relief comprised longitudinal, parabolic (u shaped) or crescent shaped features composed of well sorted sand. These may be up to several hundred feet high. (Acton, 1972)

3.1.1.3 Ablated plain (Ea)

- nearly level, featureless plains comprised primarily of sands and coarser materials too coarse to be transported by wind.

4.1 Colluvium (C)

4.1.1 Mantle (Cm)

- steeply sloping deposits of materials through land slides, slumps, mudflows, etc. on valley sides, hilly and mountainous terrain. (Runka and Kowall, 1969)

4.1.2 Fan (Cf)

- very steeply sloping deposits of material in a cone-like shape as it emerges from a steep ravine on to the plain beneath. Heterogeneous mixture of coarser and finer materials from apex to apron. (Runka and Kowall, 1969)

4.1.3 Talus (Ct)

- very steeply sloping deposits at the foot of a steeper slope or cliff with usually the larger fragments located at the apron and finer materials at the apex. (Runka and Kowall, 1969)

5.2.1 Glaciated Valleys (D)

5.2.1.1 Aretes (Da)

- acute and rugged ridges formed along the crest of a mountain range, ridges between two mountains and mountain spurs that separate two cirques (erosion caused by plucking, quarrying and [illegible] cause the cirque to cut into the walls behind them causing a sharp ridge). (Spencer, 1962)

5.2.1.2 Horns (Dh)

- a sharp peak caused by glacial erosion. (Spencer, 1962)

5.2.1.3 Cols (Dl)

- a pass formed where two cirques converge, cutting into the same wall and thus lowering the wall below the level of the remainder of the summit area. (Spencer, 1962)

5.2.1.4 Cirque (Dc)

- an amphitheater shape formed at the head of a glacier by glacial quarrying or plucking as the glacier moves down the valley. (Spencer, 1962)

5.2.1.5 Fiord (Df)

- a u-shaped valley partially filled with sea water caused by glaciers flowing from mountains into the sea. (Spencer, 1962)

5.2.1.6 Glacial Valleys (Dv)

- deep valleys (u shaped) with rough broken slopes, and steep head-cut tributary gulleys. These are often many small scale features found along the valley bottom - flood plain, terraces, etc. (Acton, 1972)

5.2.1.7 Hanging Valley (Dh)

- small valleys high up the sides of a major valley caused by small tributary glaciers meeting the major glacier. These small tributary glaciers do not cut their valleys as deeply as the major glacier and hence are left hanging up on the sides of the major glacier. (Spencer, 1962)

5.2.1.8 Rock Glacier (Dr)

- a lobe-shaped accumulation of angular boulder rubble originating at the toe of a cliff (cirque headwall, etc.) and marked by concentric lobes or wrinkles, as well as crevasses and pits, suggesting flow. (Flint, 1971)

5.2.1.9 Glacier (Dg)

- a body of ice and firm consisting of recrystallized snow and refrozen melt water, lying wholly or mostly on land and showing evidence of present or former flow. (Flint, 1971)

6.1.1 Raised Bog (Oo)

6.1.1.1 Pulsa (Ood)

- mounds of peat with a frozen peat and/or mineral core which occurs on waterlogged, treeless or sparsely wooded fens. Height is generally 1-3 meters and width varying up to 10's of meters. (Tarnocai, 1970)

6.1.1.2 Peat Mound (Oom)

- treeless mounds in the continuous Permafrost zone; generally 1-3 meters in diameter and 30-50 cm in height. These occur in water-saturated fens. (Tarnocai, 1970)

6.1.1.3 Peat Plateau (Oop)

- relatively flat lying raised peat deposits associated with permafrost. Their height is dominantly due to upheaval due to ice lens formation. Often these peat plateau have hummocky surfaces and may have collapse scars associated with them. (Tarnocai, 1970)

6.1.1.4 Peat Bog (Oob)

- raised, convex shaped peat landform due to the accumulation of poorly decomposed peat materials. These bogs are ombrotrophic in nature and not caused by upheaval by ice. (Tarnocai, 1970)

6.2.1 Fen (Om)

6.2.1.1 Unpatterned fen (Omu)

- fen occupies extensive flat, low-lying areas that show insignificant differences in the level of the peat surface. The water table is usually at or close to the surface. (Tarnocai, 1970)

6.2.1.2 String fen (Oms)

- long strips of peatland running downslope toward their outlet. These are more or less parallel low ridges, separated by water saturated hollows (flarks) oriented across the slope, at right angles to water movement. (Tarnocai, 1970)

6.2.1.3 Reticulate Fen (Omr)

- similar to the string fen but the parallel ridges are interlocked and form a net-like pattern. (Tarnocai, 1970)

6.2.1.4 Floating Fen (Omf)

- occupies areas over a shallow water surface. The fen vegetation forms a floating or quaking mat encroaching on a water surface. (Tarnocai, 1970)

6.2.1.5 Collapse Scar (Omc)

- circular fens developing as a result of melting of permafrost. The collapsed fen part of the peatland has a high water table and the collapsing edge forms a steep bank with leaning and dead trees being very characteristic. (Tarnocai, 1970)

6.2.1.6 Pond Fen (Omp)

- unpatterned fen characterized by abundant shallow ponds. (Rowe, 1971)

6.2.1.7 Minerotrophic Palsa (Omm)

- low peatlands on periodically flooded areas, having layed peat and alluvium. (Tarnocai, 1970)

6.3.1 (Transitional) (Ot)

6.3.1.1 Flat Bog (Off)

- low relief bog influenced by nutrient rich waters but bog conditions are produced as a result of peat accumulation. (Tarnocai, 1970)

6.3.1.2 Bowl bog (Otw)

- depressional bog with a concave peat surface receiving nutrient-rich water which, because of peat conditions, is reached by plant roots only near the margins of the bog. (Tarnocai, 1970).

6.3.1.3 Peat Polygon (Otp)

- perennially frozen peatland with shallow polygonal cracks at the surface, occuring in the continuous permafrost zone. (Tarnocai, 1970)

6.3.1.4 Blanket Bog (Otb)

- peat covers the uplands, slopes, and depressions alike in the landscape. Some parts of the bog are influenced by nutrient rich groundwaters. (Tarnocai, 1970).

6.3.1.5 Slope Bog (Ots)

- gently to steeply sloping organic landforms consisting of moderately decomposed organic materials formed under conditions of poor drainage. (Tarnocai, 1970)

Additional Information

Textural modifier (Fulton, 1972)

Unconsolidated component texture

The genetic category term defines unconsolidated landform component texture in broad terms, i.e., morainal deposits consist largely of till, alluvial deposits are generally sand and gravel, and lacustrine deposits generally consist of silt and clay. In some instances, particularly where detailed information is available, it is possible to define deposit texture in more specific terms. The following textural modifiers are proposed for this purpose:

bouldery - abundance of material classed as boulder in size (>256 mm or > 10 in.) b

gravelly - dominantly gravel and coarse sand sized material (1-256 mm or .4-10 in.) g

sandy - dominantly granule and sand sized material (.4-05 mm) s

silty - dominantly fine sand and silt sized (.25-.005 mm) clayey - dominantly fine silt and clay in size

(<.01 mm) C

(Fulton, 1972)

Modifications of the RLP

(Fulton, 1972)

Washed - W - modification of a deposit or feature by the washing action of a body of standing water.

Eroded - E - modification of a deposit or feature by a through flowing stream

Gullied - V - modification of a deposit or feature by the cutting of channels and removal of materials from along local drainage ways.

Channelled - W - a deeply incised flat bottomed channel appearing oversized for the present stream which occupies it (meltwater channels)

Mass-wasted - M - modified by the downslope movement of loose material.

Karst - K - modification by the subsurface solution of carbionates

Thermokarst - T - modified by the melting of ground ice

Piping - P - modified by subsurface removal of particulate material

Avalance - A - modification by the processes associated with frequent avalanche activity

Solifluctent - S - modified by the slow flowage of water soaked material from higher to lower areas.

Congeliturbated - C - modified by heaving, churning or mixing due to frost action

Permafrost - F - modification of a deposit due to the existance of temperatures below 0°C for periods greater than 2 years.

Patterned ground features

(Spencer, 1962)

Circles - Cs - sorted - normally a border of coarser stones around an area of finer material. (0.8 to 3m in diameter). The stones in the border appear to get larger in size and thickness of the border increase. Found in polar and high mountain areas.

Cu - unsorted - occur in environments where no frost occurs.

Nets - Ns - sorted - pattern is less circular but not yet polygonal. Permafrost is not necessary but these features are common in sub-artic and alpine areas. Earth hummocks of unsorted material comes in this category. (1-2 m in diameter).

Polygons - Ps - sorted - usually a tetragonal, rectangular or 5-6 sides polygonal form, usually occuring in areas of permafrost or seasonal frosts and can occur in organic deposits or alluvial deposits.

Steps - Ts - sorted - bordered by embankments of stones larger than the rest of the material on rather steep slopes. The steps sometimes form parallel with the slope contours but at times they can be in lobate form. (solifluction pattern).

- unsorted - vegetation changes show the position of the features. The riser of the step is well vegetated and the tread in base.

Stripes - Ss - sorted - elongated down the slopes and consist of alternating stripes of coarser and finer stones. Coarser material collects in the furrow and finer material forms a slight ridge.

Bedrock Component

It is proposed that the criteria for subdividing the bedrock component of landforms be composition, rock structure and morphologic expression. The categories suggested for each are:

1. Composition

intrusive	intrusive acidic (granite, etc.)	Ria
	intrusive basic (gabbro, etc.)	Rib
metamorphic	gneissic	Rmg
	schist	Rms
sedimentary	carbonate (limestone, dolomite	Rsl
	evaporites	Rse
	fine grained clastic	Rsh
	coarse grained clastic	Rss

extrusive	(volcanic) acid (rhyolite, etc.)	Rea
extrusive	(volcanic) basic (basalt, etc.)	Reb

2. Structure

flat lying	+
gently dipping	y
steeply dipping	ƶ
folded	∩
massive	⊕

3. Morphologic expression

hilly	y
rolling	l
hummocky	h
ridged	r
plain	p

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Proposed Landform Classification

Department of Soil Science
The University of British Columbia

Mode of Origin	Material	Landform	Repetitive Landform Pattern	
1. Glacial Ice (Ice and Ice > Water)	1.1 Basal till T	1.1.1 Ground Moraine T	1.1.1.1 Till plain	Tp
			1.1.1.2 Fluted Till Plain	Tf
			1.1.1.3 Drumlinized Till Plain	Td
			1.1.1.4 Drumlin	Td
			1.1.1.5 Bevelled Till Plain	Tb
	1.2 Ablation Till A	1.2.1 Moraine A	1.2.1.1 Hummocky Morainal Plain	Ah
			1.2.1.2 Washboard Morainal Plain	Aw
		1.2.2 End Moraine Ae	1.2.2.1 Lateral Moraine	Ael
			1.2.2.2 Medial Moraine	Aem
			1.2.2.3 Terminal Moraine	Aet
			1.2.2.4 Recessional Moraine	Aer
2. Water (Water and Water > Ice)	2.1 Lacustrine L	2.1.1 Lacustrine Basin L	2.1.1.1 Lake Plain	Lp
			2.1.1.2 Lake Beach	Lb
			2.1.1.3 Lake Terraces	Lt
	2.2 Glacio-lacustrine Lg	2.2.1 Glacio-lacustrine basin Lg	2.2.1.1 Glacial Lake Plain	Lgp
			2.2.1.2 Pitted Glacial Lake Plain	Lgk
			2.2.1.3 Glacial Lake Beach (strand line)	Lgb
			2.2.1.4 Glacial Lake Terraces	Lgt

Mode of Origin	Material	Landform	Repetitive Landform Pattern	
2. Water (cont.)	2.3 Marine M	2.3.1 Marine basin M	2.3.1.1 Marine Plain	Mp
			2.3.1.2 Marine Beach	Mb
			2.3.1.3 Marine Terraces	Mt
	2.4 Glacio-Marine Mg	2.4.1 Glacio-Marine Basin Mg	2.4.1.1 Glacial Marine Plain	Mgp
			2.4.1.2 Rolling Glacial Marine Plain	Mgr
	2.5 Alluvium F	2.5.1 Alluvial Plain F	2.5.1.1 Accretion Floodplain	Fa
			2.5.1.2 Leveed Floodplain	Fl
			2.5.1.3 Braided Floodplain	Fb
			2.5.1.4 Alluvial Terrace	Ft
			2.5.1.5 Alluvial Delta	Fd
			2.5.1.6 Alluvial Fan	Ff
			2.5.1.7 Lateral Accretion	Fla
			2.5.1.8 Vertical Accretion	Fva
	2.6 Glacio-Fluvial G	2.6.1 Glacio-Fluvial Plain G	2.6.1.1 Outwash Plain	Gp
			2.6.1.2 Pitted Outwash Plain (Kettled)	Gk
			2.6.1.3 Valley Train	Gv
			2.6.1.4 Delta	Gd
			2.6.1.5 Fan	Gf
			2.6.1.6 Valley Train Terrace	Gt
	2.7 Fluvio-Glacial Gf	2.7.1 Fluvio-Glacial Ridges Fg	2.7.1.1 Kame	Gfm
			2.7.1.2 Kame Terrace	Gft
			2.7.1.3 Esker	Gfe
			2.7.1.4 Crevasse Filling	Gfc
			2.7.1.5 Fan	Gff
			2.7.1.6 Rill Complex	Gfr
			2.7.1.7 Kettle	Gfk

Mode of Origin	Material	Landform	Repetitive Landform Pattern	
3. Wind	3.1 Eolian E	3.1.1 Eolian Plain E	3.1.1.1 Loeso Plain	Ep
			3.1.1.2 Dunes	Ed
			3.1.1.3 Ablated Plain (blown out plain)	Ea
4. Gravity	4.1 Colluvium C		4.1.1.1 Mantle	Cm
			4.1.1.2 Fan	Cf
			4.1.1.3 Talus	Ct
5. Polygenetic (Gravity, Water and Ice)	5.1 Steepland Drift S			
	5.2 Cordilleran Drift D	5.2.1 Glaciated Valley D	5.2.1.1 Aretes	Da
			5.2.1.2 Horns	Dh
			5.2.1.3 Cols	Dl
			5.2.1.4 Cirques	Dc
			5.2.1.5 Fiords	Df
			5.2.1.6 Glacial Valley	Dv
			5.2.1.7 Hanging Valley	Dh
			5.2.1.8 Rock Glacier	Dr
			5.2.1.9 Glacier	Dg
6. Organic	6.1 Ombrotophic Oo	6.1.1 Raised Bog Oo	6.1.1.1 Palsa	Ood
			6.1.1.2 Peat Mound	Oom
			6.1.1.3 Peat Plateau	Oop
			6.1.1.4 Peat Bog (domed bog ombrotrophic Bog)	Oob
	6.2 Minerotropic Om	6.2.1 Fen Om	6.2.1.1 Unpatterned Fen	Omu
			6.2.1.2 String Fen	Oms
			6.2.1.3 Reticulate Fen	Omr
			6.2.1.4 Floating Fen	Omf
			6.2.1.5 Collapse Scar	Omc
			6.2.1.6 Pond Fen	Omp
			6.2.1.7 Minerotrophic Palsa	Omm

Mode of Origin	Material	Landform	Repetitive Landform Pattern	
6. Organic (cont.)	6.3 Transitional Ot	6.3.1 Bog Ot	6.3.1.1 Flat Bog	Otf
			6.3.1.2 Bowl Bog	Otw
			6.3.1.3 Peat Polygon	Otp
			6.3.1.4 Blanket Bog	Otb
			6.3.1.5 Slope Bog	Ots

	Type		Structure		Morphologic Expression	
Bedrock R	Intrusive Acidic	Ria	Flat Lying	+	Hilly	y
	Intrusive Basic	Rib	Gently Dripping	y	Rolling	r
	Gneissic	Rmg	Steeply Dipping	z	Hummocky	h
	Schistic	Rms	Massive	⊕	Ridged	r
	Carbonatic	Rsl	Folded		Plain	p
	Evaporitic	Rse				
	Fine Drained Clastic	Rsh				
	Coarse Drained Clastic	Rss				
	Extrusive (Volcanic) Acidic	Rea				
	Extrusive (Volcanic) Basic	Reb				

Textural Modifier

bouldery	-	b
gravelly	-	g
sandy	-	s
silty	-	s
clayey	-	c

Modifications of the RLP

Washed	W
Eroded	E
Gullied	V
Channelled	W
Mass Wasted	M
Karst	K
Thermokarst	T
Piping	P
Avalance	A
Solifluted	S
Congeliturbated	C
Permafrost	F

Patterned Ground Features

Circles - sorted	Cs
- unsorted	Cu
Nets - sorted	Ns
- unsorted	Nu
Polygons - sorted	Ps
- unsorted	Pu
Steps - sorted	Ts
- unsorted	Tu
Stripes - sorted	Ss
- unsorted	Su

Report on the Classification of Podzolic Soils

P. N. Sprout

The report on the above subject is presented in two parts. First, a resumé of the soil tour which took place in Western Canada in September. This is followed by proposals for modifications to the classification of Podzolic and Brunisolic soils.

The intent of the resume is to point out problem areas as indicated by persons in the West, and to substantiate these contentions with descriptive and analytical data. Therefore the various viewpoints and suggestions are presented without modification. The order of the resume is that in which the soils were viewed - Saskatchewan first, followed by Alberta and then British Columbia.

1. Outline of Soils Visited On Podzolic Tour in Saskatchewan

During the September tour in Saskatchewan, essentially four different soil profiles were encountered. Three of these are soils developed in very sandy materials and are considered as "Podzolic" soils or weak expressions of "Podzolic" soils. These are the soils which have "Podzolic" morphology but which lack Bf horizons as defined and consequently some have tentatively been referred to as Brunisols. These are the soils with which the tour was mainly concerned. The fourth soil is generally developed in glacial till or a thin sandy glacio-fluvial material overlying glacial till. These latter soils are generally classified as Luvisolic soils but do present some problems in classification, as will be explained later.

In general terms the four types of profiles examined are:

A. Soils with strong "Podzolic" morphology but which lack Bf horizons as defined in the S.S.C.C. These soils have the following general morphological characteristics:

i) A well developed Ae horizon characterized by light gray colors (values 6 or higher) and is generally 4" or more in thickness.

ii) The Ae horizon is underlain by a distinct B horizon which has a hue of 10YR or redder (dry) and a chroma of 4 or more (dry).

iii) There is a sharp boundary between the Ae and B horizons. The B horizon, with the color criteria mentioned in ii, is then easily discernible below the Ae horizon and above either a Bm or C horizon.

Analysis

Profile No. P12.1 - Orthic Humo-Ferric Podzol

Table 1

Horizon	Depth (inches)	Oxalate Ext Fe	Oxalate Ext Al	Dithionite Ext Fe	Dithionite Ext Al	Pyrophosphate Ext Fe	Pyrophosphate Ext Al	Total Fe	pH in NaF*	Oxalate Δ(Fe + Al)
Ae	0-4	0.03	0.03	0.15	0.05	-	-	0.29	-	-
Bf1	4-8	0.32	0.30	0.60	0.27	.07	.06	0.99	10.1	.32
Bf2	8-12	0.17	0.26	0.47	0.20	.02	.11	1.00	10.3	.13
C1	12-17	0.12	0.18	0.39	0.13	-	-	0.93	-	-
C2	17-26	0.08	0.13	0.34	0.10	-	-	0.91	-	-
C3	26-31	0.07	0.07	0.08	0.06	-	-	0.20	-	-

* after one hour

Table 2

Horizon	Depth (inches)	pH	Cond	H_2O soluble ions in ppm Cl	Ca	Mg	Na	K	Sat'n %	$CaCO_3$ Equiv.	O.C.	N
Ae	0-4	4.5	0.13	8	1	9	4	9	36	-	0.57	0.03
Bf1	4-8	5.4	0.03	3	0	4	6	4	28	-	0.52	0.03
Bf2	8-12	5.9	0.03	2	0	2	4	2	24	-	0.22	0.02
C1	12-17	6.2	0.03	1	0	1	3	2	24	-	-	-
C2	17-26	5.8	0.03	2	0	1	35	2	22	-	-	-
C3	26-31	-	-	-	-	-	-	-	-	0.17	-	-

Table 3

Horizon	Depth (inches)	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Total Sand	Silt	Total Clay	<0.2 µ Clay	Texture
Ae	0-4	4.2	8.4	14.4	37.5	19.6	84.4	14.5	1.2	-	LS
Bf1	4-8	0.3	1.3	3.5	43.5	34.3	83.0	14.1	3.0	-	LS
Bf2	8-12	6.4	11.7	13.9	31.2	17.3	80.4	16.2	3.5	-	LS
C1	12-17	10.3	14.5	14.5	26.7	14.3	80.3	15.5	4.2	3.0	LS
C2	17-26	4.5	8.3	11.4	34.6	20.1	79.1	15.9	5.1	2.9	LS
C3	26-31	5.3	8.5	-	-	-	82.9	-	-	-	-

Table 4

Horizon	Depth (inches)	C.E.C. meq/100 gms	Exchangeable Cations meq/100 gms Ca	Mg	Na	K	Base Sat'n	micro gram per gram NO_3	P	K
Ae	0-4	3.0	.08	.12	.03	.07	10%	0	2.5	11
Bf1	4-8	4.7	.06	.15	.04	.07	7%	0	4	10
Bf2	8-12	2.9	.10	.10	.04	.05	10%	0	3	7.5
C1	12-17	2.2	.06	.10	.03	.05	11%	0	3	7
C2	17-26	2.2	.16	.08	.04	.04	15%	0	2.5	6
C3	26-31	2.0	-	-	-	-	-	-	-	-

The B horizon of these profiles, while very distinct colorwise, do not contain sufficient extractable iron and aluminum to meet the present chemical criteria for a Bf horizon. This is due to the fact that the parent material is likely very low in iron-bearing minerals. However, it is felt these soils should be retained in the Podzolic Order, possibly as a separate Great Group.

An example of this profile in Saskatchewan is Site 3a and the chemical and physical data for this profile is presented. Other examples of this type of profile are Saskatchewan Sites 3b, 3c, 5b, 6a, 7, 14a, 15 and 19. (For details of these and other sites, refer to the Guidebook For a Field Tour of Sandy Forested Soils in Northern Saskatchewan).

B. Soils with weak "Podzolic" morphology. These soils have the following general morphological characteristics:

i) A weak to moderately well developed Ae horizon (less than 4" thick and with values usually less than 6) underlain by a weakly discernible low chroma B horizon, or a very weakly discernible B horizon, or a C horizon.

ii) The boundary between the Ae and B or C horizon is not sharp and the B horizon, where present, is generally yellower than 10YR and with a chroma of less than 4.

These soils have tentatively been classified as Degraded Brunisols. However, we would like to see the removal of distinct eluvial horizons from the Brunisolic Order. Therefore, we would like to see these soils classified elsewhere such as Podzo Regosols as they once were or as a sub-group in a new Great Group in the Podzolic Order.

An example of these soils in Saskatchewan is Site 12, and the chemical and physical data for Profile P2.1 from this site is enclosed. Other examples are Sites 4b, 9, 10b, 13a, 13b, 14b, 16b, 17, 18.

Analysis

Profile No. P2.1 - Degraded Eutric Brunisol

Table 1

Horizon	Depth (inches)	Oxalate Ext Fe	Oxalate Ext Al	Dithionite Ext Fe	Dithionite Ext Al	Pyrophosphate Ext Fe	Pyrophosphate Ext Al	Total Fe	pH in NaF*	Oxalate △(Fe + Al)
Ae	0-4	0.08	0.02	0.15	0.04	-	-	0.45	-	-
Bfj1-1	4-12	0.17	0.10	0.34	0.13	.04	.08	0.31	9.7	-.05
Bfj1-2	12-18	0.09	0.03	0.26	0.05	.02	.00	0.70	8.8	-.10
Bfj1-3	18-24	0.15	0.03	0.33	0.05	.02	.00	0.77	8.7	-.04
Bfj2	24-36	0.15	0.03	0.35	0.04	.02	.00	0.77	8.7	-.04
Cg	36-48	0.19	0.03	0.36	0.05	-	-	0.97	-	-

* after one hour

Table 2

Horizon	Depth (inches)	pH	Cond	H_2O soluble ions in ppm Cl	Ca	Mg	Na	K	Sat'n %	$CaCO_3$ Equiv	O.C.	N
Ae	0-4	5.7	0.05	4	3	5	2	2	30	-	0.23	0.02
Bfj1-1	4-12	6.4	0.05	2	1	4	2	5	21	-	0.11	0.01
Bfj1-2	12-18	5.7	0.02	2	1	2	3	6	21	-	0.07	0.01
Bfj1-3	18-24	6.4	0.02	1	1	2	3	5	27	-	0.04	0.01
Bfj2	24-36	5.7	0.02	1	1	3	2	3	28	-	0.03	-
Cg	36-48	7.0	0.09	2	4	7	5	3	29	0.00	-	-

Table 3

Horizon	Depth (inches)	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Total Sand	Silt	Total Clay	<0.2 µ Clay	Texture
Ae	0-4	3.2	10.2	20.1	43.0	8.6	85.1	13.2	1.7	-	S-LS
Bfj1-1	4-12	2.7	9.5	20.1	36.6	9.6	78.7	17.4	3.9	2.4	LS
Bfj1-2	12-18	3.8	11.0	26.1	33.5	4.8	79.2	17.6	3.2	2.2	LS
Bfj1-3	18-24	0.1	0.8	9.7	75.1	9.2	94.9	1.8	3.4	2.4	S
Bfj2	24-36	0.0	0.3	9.2	78.9	7.9	96.3	1.1	2.6	1.8	S
Cg	36-48	0.0	0.0	0.4	50.1	37.2	87.8	6.8	5.4	4.4	S

Table 4

Horizon	Depth (inches)	C.E.C. meq/100 gms	Exchangeable Cations meq/100 gms				Base	micro gram per gram NO_3	P	K
Ae	0-4	3.0	1.28	.38	.14	.08	63%	0	14.5	11.5
Bfj1-1	4-12	2.6	.64	.25	.11	.15	44%	0	10.5	20
Bfj1-2	12-18	2.0	.74	.23	.09	.16	61%	0	6.5	22.5
Bfj1-3	18-24	2.1	.94	.28	.07	.12	67%	0	3.5	19
Bfj2	24-36	1.7	.90	.22	.06	.11	76%	0	3.5	13.5
Cg	36-48	4.3	3.70	1.00	.08	.17	115%	0	6	18

Analysis

Profile No. P4.1 - Orthic Eutric Brunisol

Table 1

Horizon	Depth (inches)	Oxalate Ext Fe	Oxalate Ext Al	Dithionite Ext Fe	Dithionite Ext Al	Pyrophosphate Ext Fe	Pyrophosphate Ext Al	Total Fe	pH in NaF*	Oxalate Δ(Fe + Al)
AeB	0-2	0.19	0.08	0.31	0.12	-	-	0.57	9.1	-
Bm1	2-9	0.18	0.19	0.35	0.14	.02	.01	0.93	9.8	.15
Bm2	9-13	0.10	0.13	0.26	0.09	.01	.01	0.76	9.4	.01
C1	13-21	0.13	0.09	0.30	0.06	-	-	0.86	-	-
C2	21-30	0.11	0.08	0.20	0.03	-	-	0.50	-	-

* after one hour

Table 2

Horizon	Depth (inches)	pH	Cond	H_2O soluble ions in ppm Cl	Ca	Mg	Na	K	Sat'n %	$CaCO_3$ Equiv	O.C.	N
AeB	0-2	5.8	0.09	3	5	6	1	4	33	-	0.78	0.03
Bm1	2-9	5.9	0.02	2	3	3	3	1	26	-	0.22	0.02
Bm2	9-13	6.0	0.02	1	1	1	3	1	25	-	0.09	0.01
C1	13-21	6.5	0.02	1	1	1	2	1	27	-	-	-
C2	21-30	6.3	0.02	4	1	1	5	3	26	0.00	-	-

Table 3

Horizon	Depth (inches)	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Total Sand	Silt	Total Clay	<0.2 μ Clay	Texture
AeB	0-2	5.0	19.8	29.6	35.7	2.7	91.3	5.8	3.0	0.6	S
Bm1	2-9	3.0	17.6	30.1	39.7	3.5	92.5	5.2	2.4	0.2	S
Bm2	9-13	4.6	26.9	34.2	28.4	1.6	94.8	3.2	2.0	0.4	S
C1	13-21	1.3	16.9	39.1	40.3	1.2	99.0	-	1.1	-	S
C2	21-30	3.4	10.0	21.8	58.4	3.6	98.4	0.70	1.0	0.0	S

Table 4

Horizon	Depth (inches)	C.E.C. meq/100 gms	Exchangeable Cations meq/100 gms Ca	Mg	Na	K	Base Sat'n	micro gram per gram NO_3	P	K
AeB	0-2	4.1	.98	.17	.06	.08	31%	0	3.5	14.5
Bm1	2-9	2.7	42	.08	.05	.04	22%	0	10	10
Bm2	9-13	1.5	2	.05	.07	.04	18%	0	8.5	8
C1	13-21	0.9	.24	.03	.06	.04	42%	0	3.5	7
C2	21-30	0.9	.60	.05	.06	.05	84%	0	2.5	12

C. Soils which at best have only very weak horizon differentiation. These soils are characterized by a very weak or no Ae horizon underlain by a very weak color B horizon or a C horizon.

These soils have tentatively been classified as Orthic Brunisols. However, if the Podzo Regosol were re-introduced they could be included in this sub-group or some perhaps could be included with soils described under B in a new Podzolic Great Group, possibly as a separate sub-group. If an Ae horizon is absent and a B horizon is very weak or absent these soils could probably be classified as Orthic Regosols.

An example of these soils in Saskatchewan is Site 10a, and the chemical and physical data for Profile No. P4.1 from this site follows. Other examples are Sites 4a and possibly Site 9.

D. Luvisolic soils in which the development of a more chromic horizon has occurred in the original Ae of an Orthic Gray Wooded soil. That is, the horizon sequence is either L-H, Ae1, Bm, Ae2, Bt, C or L-H, Ae, Bm, Bt, C

These soils have been classified as Brunisolic Gray Wooded. However, they do not fit the description as presently set out in the S.S.C.C. The present description states "The upper Ae1 is brown, with chromas of 3 or more, and usually grades to a light colored lower Ae2". The soils in question here have an upper Ae1 which is light gray or light brownish gray in color with a chroma of not more than 2. These soils more correctly fit the description of the Bisequa Gray Wooded sub-group, except they lack Bf horizons as defined. Perhaps what is required is a new sub-group for these soils or rewriting of the Brunisolic Gray Wooded sub-group to include them.

An example of these soils in Saskatchewan is Site 11, and the chemical and physical data for Profile No. P3.1 from this site follows. Other examples are Site2 and possibly Site 5a.

Table 1

Horizon	Depth (inches)	Oxalate Ext Fe	Oxalate Ext Al	Dithionite Ext Fe	Dithionite Ext Al	Pyrophosphate Ext Fe	Pyrophosphate Ext Al	Total Fe	pH in NaF*	Oxalate Δ(Fe + Al)
Ae	0-4	0.06	0.03	0.17	0.05	-	-	0.45	-	-
Bf	4-7.5	0.27	0.10	0.47	0.13	.10	.00	1.07	9.2	.23
Bm1	7.5-11	0.21	0.05	0.45	0.09	.03	.00	1.12	9.0	.12
Bm2	11-15	0.09	0.04	0.35	0.06	.02	.00	1.07	8.7	-.01
Ae'	15-18	0.08	0.03	0.30	0.03	.01	.00	1.04	-	-
Bt1	18-26	0.16	0.05	0.71	0.09	.01	.00	1.99	8.8	.07
Bt2	26-35	0.18	0.06	0.69	0.09	.02	.01	2.16	8.8	.10
B-C	35-42	0.16	0.01	0.47	0.05	.01	.01	1.21	9.1	-
Cca	42-50.5	0.12	0.02	0.47	0.05	-	-	1.36	-	-
Ck1	50.5-60.5	0.13	0.01	0.44	0.04	-	-	1.26	-	-
Ck2	60.5-70.5	0.13	0.02	0.45	0.04	-	-	1.26	-	-
Ck3	70.5-80.5	0.13	0.01	0.45	0.04	-	-	1.29	-	-

* after one hour

Table 2

Horizon	Depth (inches)	pH	Cond	H_2O soluble ions in ppm Cl	Ca	Mg	Na	K	Sat'n %	$CaCO_3$ Equiv	O.C.	N
Ae	0-4	5.6	0.17	11	8	10	3	8	25	-	0.46	0.04
Bf	4-7.5	6.1	0.12	4	4	7	2	10	22	-	0.33	0.02
Bm1	7.5-11	6.4	0.09	2	4	5	2	10	23	-	0.03	-
Bm2	11-15	6.2	0.09	3	5	3	3	10	24	-	0.10	-
Ae'	15-18	6.1	0.09	4	4	5	3	9	24	-	0.11	0.01
Bt1	18-26	6.3	0.14	4	6	11	5	9	24	-	0.18	0.02
Bt2	26-35	6.7	0.17	3	8	13	6	7	26	-	0.18	0.02
B-C	35-42	7.9	0.26	3	34	21	6	7	18	0.17	0.41	0.01
Cca	42-50.5	7.9	0.50	60	58	34	9	9	20	6.66	-	-
Ck1	50.5-60.5	8.0	0.26	3	32	20	6	7	24	5.16	-	-
Ck2	60.5-70.5	8.0	0.26	4	33	25	7	7	20	5.25	-	-
Ck3	70.5-80.5	7.9	0.28	4	34	27	7	8	19	5.58	-	-

Table 3

Horizon	Depth (inches)	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Total Sand	Silt	Total Clay	<0.2 μ Clay	Texture
Ae	0-4	5.7	11.6	15.0	24.7	17.0	72.6	24.6	2.8	1.6	LS
Bf	4-7.5	5.8	7.1	13.1	26.5	18.1	70.6	24.8	4.6	3.1	SL
Bm1	7.5-11	4.6	5.3	12.4	32.3	18.6	73.1	22.5	4.3	2.7	LS-SL
Bm2	11-15	7.8	9.0	10.1	22.3	21.7	69.2	27.0	3.9	1.6	SL
Ae'	15-18	3.6	9.3	11.3	25.3	16.6	65.0	31.2	3.8	0.8	SL
Bt1	18-26	4.7	7.6	8.2	17.9	16.5	55.0	29.8	15.2	7.1	SL
Bt2	26-35	3.5	7.1	7.9	17.2	14.9	50.6	31.3	18.1	8.0	L
B-C	35-42	8.3	12.7	0.1	25.7	23.3	68.3	22.8	8.9	3.3	SL
Cca	42-50.5	5.4	9.7	9.9	19.9	15.6	60.1	29.5	10.4	3.2	SL
Ck1	50.5-60.5	5.5	9.2	10.5	21.1	17.1	63.1	27.7	9.3	2.5	SL
Ck2	60.5-70.5	3.9	9.1	10.6	22.3	17.4	62.9	27.3	9.8	2.8	SL
Ck3	70.5-80.5	5.2	12.6	10.7	22.4	14.7	64.1	26.4	9.5	4.1	SL

Table 4

Horizon	Depth (inches)	C.E.C. meq/100 gms	Exchangeable Cations meq/100 gms Ca	Mg	Na	K	Base Sat'n	micro gram per gram NO_3	P	K
Ae	0-4	3.4	1.26	.18	.05	.17	49%	0	11.5	22
Bf	4-7.5	4.9	1.28	.17	.06	.24	36%	0	16	35
Bm1	7.5-11	3.2	1.60	.20	.10	.21	66%	0	5.5	32.5
Bm2	11-15	2.4	1.24	.13	.07	.16	67%	0	1.5	30
Ae'	15-18	2.0	1.82	.18	.06	.13	110%	0	1	27.5
Bt1	18-26	8.1	5.88	1.12	.14	.31	92%	0	2.5	49
Bt2	26-35	10.3	7.88	1.95	.12	.38	100%	0	2.5	52
B-C	35-42	4.1	6.18	1.60	.08	.18	196%	0	0.5	25
Cca	42-50.5	4.9	25.58	1.53	.09	.18	559%	0	0.5	28
Ck1	50.5-60.5	4.2	13.18	1.58	.10	.18	358%	0	0.5	26
Ck2	60.5-70.5	4.6	16.80	1.45	.10	.18	403%	0	0.5	22.5
Ck3	70.5-80.5	4.7	18.64	1.37	.07	.16	431%	0	0.5	23

2. Outline of Soils Visited on Podzolic Tour in Alberta

Purpose of the tour in Alberta was to review in the field certain soil profiles (often sandy) that morphologically appeared to be Podzols but chemically (Δ Fe+Al) usually did not meet the chemical criteria. Often similar profiles, but a few tens of feet apart, showed a fairly wide range in chemical properties so that their classification was difficult to determine.

A total of 11 sites were visited, but for this report only 4 are summarized - a Humo Ferric Podzol on alluvial sand (Hornbeck), a "Ferric Podzol" on aeolian sand (Heart), and 2 Bisequa Gray Luvisols on till (Wildhay and Mercoal). The "Ferric" Podzol is a new Great Group suggested to take care of some of the sandy soils of the Great Plains region. The profile summaries are as follows: For more detiled descriptions and other pertinent information refer to the guidebook "Soils with Podzolic Horizons in the Hinton-Edson area, Alberta".

A. Site No. 10. - NE22-53-26-W5

This site represents "Podzol" soils that are developed on alluvial sands on the Alberta Plateau-Benchlands. Modal soil reaction in this area varies about pH 5.5 - 6.0.

Soil Series:	Hornbeck
Soil Association:	Blackmud (BKM 5)
Parent Material:	Alluvial sand
Elevation:	3900 ft.
Tentative Classification:	Orthic Humo-Ferric Podzol

Characterization Analyses

Hor	Depth	Color	pH	%N	%O.C.	C/N	$CaCO_3$ Eq. %	Exch. H	NH_4AC C.E.C. (me/100g) Na	K	Ca	Mg	Det.
L-H	1-0		5.6	-	-	-	-	8.5	0.2	0.1	17.8	2.1	14.3
Ae	1-6	10YR7/2m	5.5	0.03	0.79	26	-	1.7	0.0	0.0	1.2	0.3	3.1
Bf	6-11	7.5YR5/8m	6.0	0.02	0.29	19	-	1.8	0.0	0.1	1.3	0.7	4.3
BC	11-17	7.5YR6/6m	6.2	0.01	0.19	24	-	0.6	0.0	0.0	4.1	0.9	3.4
Ck	17+	10YR4/1m	7.3	-	-	-	12.26	-	-	-	-	-	1.2

	Sand	Silt	Clay <2.0u	<0.2u
L-H	-	-	-	-
Ae	75	22	3	0
Bf	78	15	7	2
BC	86	6	8	3
Ck	90	7	3	0

Iron and Aluminum Analyses

Hor	Pyrophosphate Fe	Pyrophosphate Al	Oxalate Fe	Oxalate Al	Dithionite Fe	Dithionite Al	Total Fe	Total Al
L-H	0.05	0.10	0.18	0.07	0.37	0.13	0.65	3.9
Ae	0.04	0.16	0.09	0.01	0.35	0.05	0.54	4.4
Bf	0.23	0.37	0.62	0.41	1.06	0.34	1.61	5.0
BC	0.16	0.35	0.38	0.17	0.87	0.15	1.24	3.8
Ck	0.03	0.05	0.14	0.05	0.32	0.10	0.68	2.8

B. Soil Association: Heart (HRT 1)
Parent Material: Aeolian sand
Elevation: 3000 ft.
Tentative Classification: Degraded Eutric Brunisol
Proposed Classification: "Ferric" Podzol

Characterization Analyses

Hor.	Depth	Color	pH	%N	%O.C.	C.N	Exch. H	NH_4AC C.E.C. (me/100g) Na	K	Ca	Mg	Det.
L-H	2-0	10YR3/3m	4.7	-	-	-	33.3	0.3	1.5	30.9	11.4	61.6
Ae	0-1	10YR6/2d	5.7	0.06	0.85	14	3.3	0.0	0.2	5.4	2.2	8.7
Bm	1-3	7.5YR5/4m	6.0	0.04	1.06	27	3.3	0.0	0.2	4.6	2.5	9.5
BC	3-22	10YR5/6m	5.9	-	-	-	1.1	0.0	0.1	5.9	3.1	7.9
C	22+	2.5Y5/4m	6.2	-	-	-	0.7	0.0	0.1	4.6	3.5	6.8

Hor	Sand	Silt	Clay <2.0u	Clay <0.2u
L-H	-	-	-	-
Ae	74	19	7	2
Bm	80	14	6	3
BC	86	7	7	3
C	92	2	6	2

Iron and Aluminum Analyses

Hor	Pyrophosphate Fe	Pyrophosphate Al	Oxalate Fe	Oxalate Al	Dithionite Fe	Dithionite Al	Total Fe	Total Al
L-H	0.03	0.06	-	-	0.14	0.15	0.39	1.5
Ae	0.19	0.33	0.24	0.08	0.49	0.18	1.07	6.2
Bm	0.32	0.52	0.43	0.30	0.73	0.38	1.79	6.8
BC	0.32	0.26	0.20	-	0.67	0.19	1.76	6.5
C	0.27	0.33	0.16	0.04	0.51	0.18	1.68	6.5

C. Site No. 9. NW14-54-24-W5

This site represents a Bisequa profile that is developed on Marlboro till (Cordilleran origin) on the Alberta Plateau-Benchlands.

Soil Series:	Wildhay
Soil Association:	Marlboro (MLB 6)
Parent Material:	Marlboro till (Cordilleran)
Elevation:	4200 ft.
Tentative Classification:	Bisequa Gray Luvisol

Characterization Analyses

Hor.	Depth	Color	pH	%N	%O.C.	C.N.	Exch. H	NH_4AC C.E.C. (me/100g) Na	K	Ca	Mg	Det.
L-H	0-0		4.8	-	-	-	36.0	0.1	3.7	37.0	-	70.3
Ae_1	0-2	10YR6/1m	5.2	0.05	0.84	17	3.7	0.0	0.2	4.5	0.8	9.1
Bf	2-3	10YR4/4m	5.5	0.07	1.03	15	4.4	0.0	0.3	6.4	1.2	13.7
Ae_3	3-6	10YR5/4m	5.7	0.06	0.91	15	3.5	0.1	0.2	6.2	1.0	12.4
Bt	6-10	10YR5/4m	5.8	0.06	0.60	10	2.1	0.0	0.3	10.4	2.6	15.9
BC	10+	10YR5/3m	5.3	-	-	-	2.8	0.1	0.4	14.1	4.1	22.8

Hor	Sand	Silt	Clay < 2.0u	< 0.20u
L-H	-	-	-	-
Ae_1	40	53	7	4
Bf	29	57	14	6
Ae_3	33	55	12	6
Bt	56	12	32	17
BC	21	63	16	15

Iron and Aluminum Analyses

Hor	Pyrophosphate Fe	Al	Oxalate Fe	Al	Dithionite Fe	Al	Total Fe	Al
L-H	0.08	0.18	-	-	0.36	0.21	0.62	3.1
Ae_1	0.13	0.26	0.13	0.06	0.39	0.13	0.93	6.0
Bf	0.67	0.68	0.94	0.37	1.74	0.45	3.07	6.8
Ae_3	0.56	0.63	0.67	0.33	1.58	0.40	2.83	7.7
Bt	0.76	1.23	0.34	0.23	1.46	0.34	3.34	10.2
BC	0.39	0.58	0.20	0.15	0.92	0.18	2.96	8.8

D. Soil Series: Mercoal
Soil Association: Robb (RBB 2)
Parent Material: Predominantly till - some colluvium
Elevation: 4200 ft.
Tentative Classification: Bisequa Gray Luvisol

Characterization Analyses

Hor.	Depth	Color	pH	%N	%O.C.	C.N.	Exch. H	NH_4AC C.E.C. (me/100g) Na	K	Ca	Mg	Det.
L-H	2-0		5.2	-	-	-	25.3	0.1	1.8	27.2	11.2	60.0
Ae_1	0-2	10YR7/1d	5.5	0.08	1.10	14	5.4	0.2	0.4	3.2	2.1	11.3
Bf^1	2-4	10YR5/8m	5.8	0.15	2.62	17	7.6	0.1	0.4	3.0	0.9	26.8
Ae_3	4-7	2.5Y6/4m	5.7	0.05	0.40	8	4.9	0.1	0.4	2.7	0.6	12.5
Bt^3	7-16	2.5Y5/6m	5.0	0.03	0.39	13	4.8	0.2	0.3	10.4	4.2	22.9
BC	16-24	2.5Y5/4m	5.1	-	-	-	4.1	0.2	0.2	13.4	3.9	24.6
IIC	24+	2.5Y4/4m	5.5	-	-	-	2.5	0.1	0.2	12.6	4.2	20.3

Hor.	Sand	Silt	Clay <2.0u	<0.20u
L-H	-	-	-	-
Ae_1	12	74	14	4
Bf^1	5	81	14	2
Ae_3	30	54	16	3
Bt^3	36	36	28	14
BC	43	32	25	12
IIC	56	30	14	7

Iron and Aluminum Analyses

Hor.	Pyrophosphate Fe	Al	Oxalate Fe	Al	Dithionite Fe	Al	Total Fe	Al
L-H	0.16	0.37	-	-	0.49	0.27	0.80	1.80
Ae_1	0.10	0.44	0.06	0.15	0.15	0.26	0.96	5.83
Bf^1	0.43	0.88	1.42	3.34	1.95	1.77	3.56	11.20
Ae_3	0.24	0.55	0.28	0.58	1.00	0.58	2.83	8.80
Bt^3	0.66	0.95	0.39	0.34	1.46	0.38	3.35	7.90
BC	0.42	0.62	0.26	0.28	1.32	0.34	3.32	10.00
IIC	0.23	0.38	-	-	0.86	0.23	3.03	8.30

C. Outline of Soils Visited on Podzolic Tour in British Columbia

The general approach of using the properties of the B horizons to classify Brunisolic and Podzolic soils appears to fit the British Columbia situation reasonably well. In most cases the taxonomic differentiations reflect pertinent climatic and vegetative breaks. However, problems have occurred using the Oxalate procedure in determining the presence of a Bf horizon. This procedure is influenced by external factors not related to podzolization and is particularly misleading in the Southern Interior, an area which has been subjected to several volcanic ash falls.

The first portion of the tour was primarily designed to illustrate the influence of volcanic ash. It went from Cranbrook to Christina Lake, and covered the southern part of the Interior "Wet Belt" and adjoining drier areas. Precipitation is generally in the order of 20 to 35".

The following two soils are not considered to be in a Podzol zone. They contain a considerable amount of volcanic ash in the upper horizons, which is influencing the Fe and Al analyses by oxalate.

GLENLILY

Location: Near Yahk in the Moyie River Valley
Precipitation: 19" approx.
Elevation: 3000 ft.
Parent Material: Valley train outwash
Classification: Dystric Brunisol

Hor.	Depth	Texture	Color	pH H_2O	pH $CaCl_2$	Oxalate Fe	Oxalate Al	Pyrophosphate Fe	Pyrophosphate Al
LH	1-0			5.5	5.2				
Bm1	0-6	sl	7.5YR4/4m	6.1	5.5	0.83	2.84	0.09	0.39
Bm2	6-14	sl	7.5YR5/4m	6.2	5.6	0.52	1.62	0.03	0.20
CB	14-24	gls	10YR5/4m	5.8	5.5				
C	24-40	gs	10YR5/3m	5.8	5.5	0.23	0.15	0.03	0.06

LOVOLE

Location	Near Creston
Precipitation	19"+
Elevation	1800'
Parent Material	Glacio-lacustrine
Classification	Bisequa Gray Luvisol

Hor.	Depth	Texture	Color	pH H_2O	pH $CaCl_2$	Oxalate Fe	Oxalate Al	Pyrophosphate Fe	Pyrophosphate Al
LH	½ -0			6.4					
Bf1	0 -6	l-sil	10YR6/4m	6.5	5.87	0.85	1.10	0.27	0.35
Bf2	6-12	l-sil	10YR6/4m	6.3	5.4	0.80	1.22	0.24	0.39
Ae	12-14	sil	10YR7/3m	6.2		0.41	0.16	0.15	0.12
AB	14-17	cl	10YR5/4m	6.1					
Bt1	17-24	cl-c	10YR4/4m	6.2					
Bt2	24-30	cl-c	10YR4/3m	6.4					
BC	30-39	cl-c	2.5Y4.5/3m	6.5					
CB	39-45	sil	2.5Y4/2m	7.6					
Ck	45+	sicl	2.5Y5/4m	8.0					

The sum of Fe + Al by the Oxalate procedure indicates both as having Bf horizons; using Pyrophosphate and a level of .65% as suggested by McKeague (1967), they will not make Bf horizons, a situation which we favour.

Soils containing volcanic ash have a good source of material which tends to weather rapidly and develop unique properties. They have a higher content of active amorphous material than is normal for their environment, and they have low bulk densities.

Because of these and other unique features, it is suggested that a subgroup is required to identify soils containing ash. This would not apply to Podzol soils which already are indicative of containing active amorphous materials.

With the weathering of volcanic glass, considerable silica is released, and in areas where the soil is reasonably dry, this can be washed down to form a cemented layer in the lower part of the solum. The next soil is an example of this condition:

CRESTON

Location: Near Creston
Precipitation: 19"
Elevation: 1800'
Parent Material: Glacio-lacustrine
Classification: Orthic Eutric Brunisol

Hor.	Depth	Texture	Color	pH H_2O	pH $CaCl_2$	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%
Bm1	0 - 4	sil	7.5YR4/4m	7.1	6.54	0.53	0.37	0.17	0.17
Bm2	4 -18	sil	7.5YR4/4m	7.2	6.65	0.71	0.60	0.10	0.10
BC	18 -24	sil	10YR6/4d	7.5					
Ck1	24 -31	loam	2.5Y8/2d	8.1					
Ck2	31+	sil	10YR8/3d	8.5		0.12	0.06	0.01	0.05

In this particular instance the soil is a Eutric Brunisol developed on silty glacio-lacustrine sediments high in lime. The silica cemented pan was only ½ inch in thickness and occurred at the contact with the Ck1 horizon. A root mat had formed immediately above. The pan did not soften with HCl. There would appear to be some merit in considering the need for a subgroup to denote soils with silica cemented pans.

The next soil is included to illustrate what is considered to be a typical high elevation Podzol from the Interior "Wet Belt" area of British Columbia.

SWEHAW

Location: Near summit on Salmo-Creston Highway
Precipitation: 800" snowfall record 1970-71 (35"+)
Elevation: 5900'
Parent Material: Glacial Till
Classification: Mini Humo-Ferric Podzol

Hor.	Depth	Texture	Color	pH H_2O	pH $CaCl_2$	Oxalate Fe %	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%
Bfh	0 - 5	sl	7.5YR4/4m	5.2	4.56	1.24	1.32	0.87	1.08
Bf	5 -20	sl	10YR4/4m	5.5	4.92	0.89	1.55	0.35	0.83
BC	20 -26	gsl	7.5YR4/4m						
CB	26 -42	c.g.s.	10YR4/3m						
C1	42 -60	c.g.s.	10YR4/3m						
C2	70+	gls-gs	10YR5/2m	5.5	5.30	0.33	0.39	0.02	0.11

On the tour there was no disagreement that this was a Humo-Ferric Podzol. The content of organic matter in the upper part of the Bf increases with increasing elevation, and is quite high at this elevation. The Ae is discontinuous and seldom reaches 1". We would prefer the depth of Ae not be used as a criteria for Orthic Podzol, and if the Mini subgroup is retained, it should be based on the properties of the Bf horizon.

Another problem frequently encountered when mapping in mountainous terrain is the classification of drainage. A sequence of three soils subject to varying degrees of seepage were exhibited to illustrate the problem.

SENTINEL

Location: - Near summit on Salmo - Creston Highway
Precipitation: Similar to Swehaw
Elevation: 5200'
Parent Material: Glacial till
Classification: Gleyed Sombric Ferro-Humic Podzol

Site A

Hor.	Depth	Texture	Color	pH H_2O	pH $CaCl_2$	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%	%O.M.
LH	3 - 0			5.3	5.00					76.33
Ah	0 -10	loam	10YR3/2m	5.3	4.47					15.86
Bhfgj	10 -21	fsl	10YR3/4m	5.3	4.54	1.32	1.55	1.21	1.58	10.14
Bfgj	21 -33	sl	7.5YR4/4m	5.3	4.48	1.05	1.29	0.80	1.03	4.60
BCg	33 -45	sl-fls	10YR5/6m	5.6	4.79					
CBg	45 -52	sl	10YR6/4m	6.5	5.90					
Cg	120"	scl	10YR6/2m	6.2	5.64	0.35	0.48	0	0.11	

Site B - Gleyed Sombric Ferro-Humic Podzol

Hor.	Depth	pH H_2O	pH $CaCl_2$	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%	Dithionate Fe%	Dithionate Al%	%O.M.
Ah	0-14	5.2	4.42			1.08	2.10			26.93
Bhfgj	14-23	5.4	4.53	1.17	2.20	1.02	1.93			17.04
Bfg	23-27	5.7	4.77	1.44	1.88	0.72	0.75	1.54	1.75	4.32
Cg	120"	6.1	5.65	0.32	0.49	0.03	0.08	0.28	0.23	

Site C - Orthic Humic Gleysol

Hor.	Depth	pH H_2O	pH $CaCl_2$	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%	Dithionate Fe%	Dithionate Al%	%O.M.
Ah1	0-6	5.5	4.67							14.53
Ah2	6-16	5.6	4.69							12.32
Bg	16-22	5.4	4.58	0.71	0.89	0.62	0.75	0.84	0.88	4.42
Cg	120"	6.2	5.54	0.38	0.49	0.03	0.08	0.28	0.23	

In this area, as the amount of excess seepage water passing through a soil increases, the organic matter of the Bf horizon increases, and an Ah horizon develops. (Some question as to whether this is an Ah or Bh). These soils generally lack the characteristic gleying and mottling which signifies poor drainage. However, in terms of excess moisture these soils are in excess of field capacity for a large part of the year. This would meet the requirements of poor drainage as now defined.

The next two soils are located in the Columbia River Valley, and are included mostly for general interest to show Sombric Brunisol development.

GLADE

Location: Near Castlegar
Precipitation: 29"
Elevation: 1600'
Parent Material: Sandy valley train outwash
Classification: Orthic Sombric Brunisol

Hor.	Depth	Texture	Color	pH H_2O	pH $CaCl_2$	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%	%O.M.
Ah	0-6	fls	10YR3/3m	5.3	4.76	0.29	0.69			2.07
Bm	6-12	ls	10YR5/6m	6.4	5.81	0.40	0.84	0.04	0.10	
BC	12-28	med.snd	10YR6/3m	6.5	6.07	0.21	0.18			
C1	28-42	"		6.2	6.13	0.13	0.12	0.02	0.02	
C2	42+	crs. "		6.1	6.04	0.14	0.11			

GENELLE

Location: Near Trail
Precipitation: 24"
Elevation: 1400'
Parent Material: Gravelly valley train outwash
Classification: Orthic Sombric Brunisol

Ah	0-6	sl	10YR3/1m	5.0	4.68	0.53	1.32	0.07	0.55	6.85
Bm	6-16	gsl	10YR6/4m	6.2	5.75	0.49	1.37	0.05	0.25	2.34
C	16+	cgs		6.1	5.76	0.38	0.22	0.03	0.06	

In both these soils a Bf is indicated by the Oxalate procedure. However these high values are again due to volcanic ash, and the Brunisol designation is preferred. These soils occur sporadically and are associated with Dystric Brunisols on the same terraces. The Ah appears to be anthropic - likely caused by Indians setting repeated fires to keep the area clear of trees.

TRAIL

Location: Near Nancy Green Lake on Highway 3
Precipitation: 30" approx.
Elevation: 4300'
Parent Material: Surficial till
Classification: Mini Humo-Ferric Podzol

Hor.	Depth	Texture	Color	pH H_2O	pH $CaCl_2$	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%
LH	1-0			4.8	4.31				
Ae(Ash)	trace		10YR6/2m						
Bf	0-4	gsl	7.5YR4/4m	6.1	5.35	0.97	1.61	0.09	0.46
Bm	4-13	gsl	7.5YR5.3m	5.9	5.19	0.71	0.62	0.13	0.15
BC1	13-25	gls	10YR5/4m	5.8	5.13				
BC2	25-50	gls	10YR5/4m	5.8	5.11				
C	50+	gls	10YR5/3m	6.1	5.50	0.69	0.30	0.14	0.06

The next part of the tour took place in the Lower Fraser Valley, and the following seven soils are located in this area. Precipitation is generally between 40 and 60 inches in the main part of the valley, varying up to 120" or more along the foot of the Coast Mountains on the north side. Development is normally toward a Podzol, unless influenced by factors such as poor drainage, very fine textures, and recent deposition.

The first two soils are included to illustrate variations in Brunisolic development found on the more recent alluvial deposits.

BATES Series

Classification: Gleyed Degraded Melanic Brunisol

Horizon	Depth	Color	pH H_2O	pH $CaCl_2$	O.M. %	NH_4Ac C.E.C.	B.S.	Oxalate Fe.	Oxalate Al	Pyrophosphate Fe	Pyrophosphate Al
Ap	0-7	10YR3/2m	5.9	5.1	9.3	23.5	47.8	1.16	0.85	0.46	0.46
Aejgj	7-14	10YR4.5/2m	6.0	4.9	1.9	14.1	48.8	1.07	0.64	0.25	0.23
Btjgj1	14-23	10YR3.5/2m	6.0	5.2	1.0	14.9	69.2	1.60	0.68	0.13	0.09
Btjgj2	23-31	2.5Y5/2m	6.2	5.4	0.6	12.7	81.8	1.44	0.48	0.14	0.08
BC	31-38	2.5Y5/2m	6.3	6.5	-	17.2	76.4	2.04	0.68	0.17	0.09
Ab	38-48	2.5Y4.5/2m	6.2	6.4	-	33.9	60.3	1.30	0.96	0.07	0.59
Cg	46-60+		6.3	5.5	-	-	-	0.95	0.56	0.10	0.10

MATSQUI Series

Classification: Degraded Eutric Brunisol

Horizon	Depth	Color	pH H_2O	pH $CaCl_2$	O.M. %	NH_4Ac C.E.C.	NH_4Ac B.S.	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%
Ap	0-8	10YR4/2m	5.7	5.2	6.0	18.9	47.4	0.96	0.57	0.65	0.42
Aej	8-11	10YR4.5/3m	6.1	5.2	1.7	14.2	53.9	1.22	0.70	0.63	0.38
Btj orBm	11-15	10YR4/3m	6.4	5.2	0.7	10.7	77.2	0.94	0.49	0.23	0.15
IIBM1	15-21		6.2	5.5	0.6	5.1	60.6	0.86	0.33	0.14	0.13
IIAej	21-26		6.1	5.1	0.1	2.7	56.0	0.46	0.29	0.07	0.09
IIBM2	26-29		6.0	5.5	-	5.9	62.7	0.66	0.40	0.13	0.10
IIAe&II Bm	29-39	10YR4/2.5m	6.1	5.9	-	3.7	73.8	0.39	0.20	0.05	0.06
IICgj	39-45		6.2	5.8	-	2.4	58.3	0.43	0.28	0.03	0.06

In both these soils the $CaCl_2$ pH's are somewhat low in the upper part for Melanic and Eutric Brunisols, but the base saturation (NH_4Ac) is 70% or more within 12". The Bates has a good Mull-type Ah as a result of earthworm activity.

The following soil is an example of Bisequa development. Considerable clay translocation and the development of Bt horizons takes place in the Fraser Valley on Marine and Glacio-Marine materials which have nearly neutral pH.

NICHOLSON Series

Parent Material: Glaciomarine
Classification: Bisequa Gray Luvisol

Horizon	Depth	Color	pH H_2O	pH $CaCl_2$	O.M. %	NH_4Ac C.E.C.	NH_4Ac B.S.	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%
Ap	0 - 4	5YR3/6m	5.4	4.6	7.2	23.9	25.4	-	-	-	-
Bf1	4 - 8	5YR4/6m	5.7	4.7	3.9	19.4	12.6	1.09	1.45	0.27	0.51
Bf2	8 -12	5YR4/6m	5.8	4.9	3.9	16.9	8.9	1.22	1.65	0.22	0.42
Ae	12 -17	10YR5/4m	5.0	4.2	0.9	21.5	30.3	0.95	1.03	0.06	0.17
AB	17 -21	10YR4.5/2.5m	5.1	4.4	0.3	22.0	48.4	0.82	0.89	0.04	0.11
Bt1	21 -31	10YR4.5/2.5m	6.2	5.9	0.3	20.4	98.7	0.74	0.60	0.03	0.02
Bt2	31 -40	10YR4.5/2.5m	6.5	6.2	-	20.8	100.0	0.79	0.55	-	-
BC	40 -48	10YR4.5/2.5m	6.7	6.3	-	-	-	0.42	0.31		-
C	48 -60+	10YR4.5/2.5m	6.7	6.4	-	-	-	0.36	0.26	0.01	0.01

The chroma in the Bf horizon does not fade with depth, so is not considered a Spodic B in the U.S. system. However, there is sufficient Fe and Al to meet our requirements.

The Podzols which have developed in the main part of the Fraser Valley under 40 to 60 inches precipitation all belong to the Humo-Ferric Great Group. Along the foothills of the Coast Mountains where the precipitation increases to 80 inches or more, the soils are mainly Ferro-Humic Podzols. Along with the increase in organic matter is the general formation of cemented pans. Such pans occur even in coarse textured deposits. The following two soils illustrate these conditions:

<u>BUNTZEN</u> Series

Parent Material: Glacial Till - some loess in surface
<u>Classification</u>: Orthic Ferro-Humic Podzol

Horizon	Depth	Color	pH H_2O	pH $CaCl_2$	O.M. %	NH_4Ac C.E.C.	NH_4Ac B.S.	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%
L	1½-1		3.9	3.5	80.4	139.4	12.1	-	-	-	-
HF	1 - 0		3.8	3.0	80.6	132.5	6.6	-	-	-	-
Ae	0 - ¾	10YR4/1m	4.2	3.4	5.2	15.7	7.8	0.36	0.48	0.21	0.15
Bhf	¾ - 3	5YR3/3m	5.4	4.6	14.2	50.5	1.2	1.34	4.26	0.71	2.15
Bfh1	3 - 8	5YR4/6m	5.5	4.9	9.1	36.1	0.7	1.33	4.20	0.31	1.48
Bfh2	8 -15	5YR4/4m	5.5	5.0	8.2	33.4	0.8	1.62	4.08	0.40	1.46
Bfhgj1	15-24	7.5YR5/5m	5.5	5.1	5.4	25.3	0.7	1.11	3.56	0.24	1.01
Bfhgj2	24-31	7.5YR3/3m	5.5	5.0	5.4	-	-	0.83	2.92	0.31	0.99
BCcgj	31-39	10YR4/2m	5.6	5.3	2.1	-	-	0.71	1.98	0.24	0.59
Cgj	39+	10YR4/2m	6.0	5.7	-	-	-	0.50	0.98	0.01	0.20

<u>ROACH</u> Series

Parent Material: Gravelly Glacial Outwash
<u>Classification</u>: Orthic Ferro Humic Podzol

Horizon	Depth	Color	pH H_2O	pH $CaCl_2$	O.M. %	NH_4Ac C.E.C.	NH_4Ac B.S.	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%
FL	3 - 0		3.8	3.0	-	117.3	15.4	-	-	-	-
Ae	0 - 3	5YR5/2m	4.9	3.1	2.3	10.2	10.0	0.22	0.15	0.02	0.05
Bhf	3 - 8	2.5YR2.5/4m	5.6	4.1	10.1	30.9	2.1	1.28	2.09	0.73	1.03
Bfc1	8 -21	5YR4/6-3/3m	5.8	4.6	4.5	20.4	2.6	0.81	2.15	0.30	0.79
Bfc2	21 -33	5YR5/8m	5.9	5.0	1.3	8.3	1.9	0.32	1.37	0.06	0.36
BC(c)	33 -45	5YR5/8m	5.9	5.9	-	3.0	1.7	0.36	0.84	0.02	0.20
CD	45 -60		5.9	5.4	-	-	-	0.29	0.57	0.01	0.13
C	60 -80+		5.8	5.4	-	-	-	0.34	0.50	0.02	0.11

In the case of the Roach, the cementation is analagous to what was called ortstein and is brightly but variably colored. In some localities the cementation can extend downward for several feet. With the Buntzen, the cementation results

In a very abrupt contact with the underlying till. In both instances the pans are practically impervious to water and roots and irreversibly indurated. There is no way to indicate these pans in the present classification system above the series level.

The following two soils illustrate a drainage sequence in this high precipitation area at elevations above 2,500 feet. At these elevations, organic matter accumulation reaches a high level.

GOLDEN EARS Series

Parent Material: Glacial Till
Classification: Orthic Ferro-Humic Podzol

Horizon	Depth	Color	pH H_2O	pH $CaCl_2$	O.M. %	NH_4Ac C.E.C.	NH_4Ac B.S.	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%
LF	8 - 7½		3.9	3.1	100.0	128.6	21.6	-	-	-	-
H1	7½-3		3.5	2.9	100.0	157.0	18.5	-	-	-	-
H2	3-0		3.6	2.8	100.0	150.2	3.0	-	-	-	-
Ae	0-3	5YR4.5/1.5m	4.0	3.3	4.9	11.5	6.8	-	-	0.11	0.13
Bhf	3-7	10YR2/1-3/3m	4.6	4.0	13.4	38.5	2.2	2.19	2.36	1.29	1.45
Bfh	7-12	5YR3.5/4 - 7.5YR5/8m	5.1	4.6	5.1	28.3	1.6	1.94	4.59	0.46	1.24
Bf	12-20	7.5YR5/7m	5.3	5.0	2.9	16.6	1.8	1.09	3.23	0.17	0.79
Bfgj	20-25	10YR5/6m	5.4	4.7	3.0	14.2	2.2	-	-	0.18	0.81
BC1	25-32	5Y5.5/1.5m	5.4	4.9	-	12.5	2.5	-	-	0.11	0.70
BC2	32-45	10YR5/4m	5.4	3.4	-	-	-	0.41	1.10	0.07	0.54
C	45-65	5Y5/2m	5.5	4.6	-	-	-	0.45	0.59	-	-

WHONNOCK Series

Parent Material: Glacial Till
Classification: Gleyed Humic Podzol

Horizon	Depth	Color	pH H_2O	pH $CaCl_2$	O.M. %	NH_4Ac C.E.C.	NH_4Ac B.S.	Oxalate Fe%	Oxalate Al%	Pyrophosphate Fe%	Pyrophosphate Al%
L	11-8		4.0	3.3	100.0	78.7	9.2	-	-	-	-
H1	8-5		3.5	2.8	100.0	124.5	4.5	-	-	-	-
H2	5-0		4.1	3.5	81.6	118.2	1.4	-	-	-	-
Ahe	0-1½	5YR3/1-5/1m	4.5	3.9	16.0	36.1	1.0	0.57	1.09	0.63	1.0[illegible]
Bh	1½-7½	2.5YR2/2 - 5YR3/3m	4.9	4.1	15.7	45.1	0.7	0.78	2.32	0.73	2.06
Bhfgj	7½-19	5YR4/4 - 2.5YR2/4m	5.2	4.3	9.5	30.0	0.3	0.70	2.29	0.50	1.60
Bfhgj	19-32	2.5Y5/3m	5.2	4.6	4.4	17.2	0.3	0.53	1.26	0.33	1.3[illegible]
BC1	32-43	5Y5/2.5m	5.2	4.7	1.8	7.9	1.0	0.30	0.82	0.04	0.48
BC2	43-60	5Y5/1m	5.6	5.2	-	4.2	1.2	0.43	0.78	0.02	0.27
C	60-70+	5Y6/1.5m	5.9	5.5	-	3.2	71.7	0.52	0.14	0.03	0.11

See table on next page for Dithionite

Horizon	Dithionite Fe%	Dithionite Al%
L	-	-
H1	-	-
H2	-	-
Ahe	0.77	1.32
Bh	1.00	2.44
Bhfgj	1.02	2.53
Bfhgj	0.57	1.66
BC1	0.30	0.92
BC2	-	-
C	0.30	0.14

The Golden Ears is the better drained associate. There is an uneven distribution of color and organic matter content, which gives these soils a blotchy appearance. They are moist for a large part of the year.

The Whonnock soils are subject to almost continuous seepage. The excess moisture does not show up in the usual form of gleying and mottling; rather this is evidenced by increased organic matter content and duller profile colors. The organic matter distribution can be uneven, and may even reach a maximum near the lower part of the solum. Contents may reach and even exceed 30%. Soil probably poorly drained from sandpoint of length of saturation. Some pan formation at contact with underlying till.

The remaining part of the British Columbia tour took place on Southeast Vancouver Island. Conditions here are fairly similar to those in the Fraser Valley, and the soils exhibited generally reinforced the points made in the valley, e.g. the Hart is a good example of cemented outwash. In addition several profiles were run which exhibited fragic properties, e.g. Lazo, Memokoy, Fairbridge. For a detailed account of these soils refer to the tour guide "Podzolic Tour of Western Canada - Vancouver Island Tour".

2. Proposed Classification Changes

In requesting changes in the classification of Brunisols and Podzols, I received, in some instances, conflicting comments and suggestions. While some of this may be due to regional bias, I have the impression this is not entirely the problem. It appears we lack clearly defined concepts of the purpose of the different categorical levels in the classification scheme; also what properties constitute valid criteria at the various levels. The main problem revolves around the properties identified at the Subgroup vs the Family or Series. In an attempt to resolve this subject, and to initiate discussion, I would like to propose the following: "Permanent soil properties resulting from pedogenic processes which exert (or infer) an appreciable influence on the behaviour of a soil should be identified at the Subgroup category or higher, whereas inherited properties belong to the Family or Series."

If we could agree on some such generalization, it would help with some of the proposed changes.

Before outlining any new suggestions, I would first like to deal with the three main proposals made at the Eastern Meeting. This is necessary because of the implications of one of the proposals on some of our suggested changes. The three proposals were passed in the form of motions and were as follows:

A) A revised definition of the Podzolic Order. This definition is as follows:

The Podzolic Order consists of well and imperfectly drained soils that have developed mostly in cold to temperate climates under coniferous and mixed forest vegetation or heath. They are formed mostly in coarse, moderately coarse, and medium-textured, acid parent materials.

These soils are characterized by podzolic B (spodic) horizons in which the main accumulation products are organic matter (dominantly fulvic acid) combined with various proportions of iron, aluminum and clay. These amorphous materials occur as coatings on mineral grains and commonly as silt-sized pellets. The podzolic B (spodic) horizon has an abrupt upper boundary and may be cemented. Hues and chromas of this horizon may remain constant with depth, if the horizon is thin and overlies bedrock, or the sub-horizon with the reddest hue or highest chroma is near the top of the horizon or below a thin black horizon with values of 2 or less. Hues become yellower or chromas become lower, or both, within 20 inches (50 cm) of the top of the horizon. Colors of the podzolic B (spodic) horizon are mostly redder than 10YR in hue, with moist values and chromas of 5/6, 4/4, 3/2 and 2/1, or with these values in higher chromas.

Under undisturbed conditions the soils have organic surface horizons (L-H) dominantly of a mor or moder type. They may have an Ah horizon below the L-H horizons. Generally they have an eluviated, light-colored horizon (Ae) overlying the podzolic B (spodic) horizon, but this may be indistinct or absent.

Under cultivated conditions the Ap horizon may be underlain by remnants of an Ah, Ae, or a podzolic B (spodic) horizon. The sola are acid (usually $<$ pH 5.5) and have a high pH-dependent cation exchange capacity (usually >8 me/100 gm) in the B horizon.

The Podzolic Order is divided into the Humic Podzol and Podzol great groups based on the presence or absence of a Bh sub-horizon that lacks sufficient iron to turn redder on ignition.

The stated intent of this revision is to provide a means of identifying Podzols in the field without reference to chemical criteria. If this were the case, I would recommend its immediate rejection. We had ample opportunity to test this approach prior to 1968. For our conditions this definitely would be a retrograde step as mapping on morphology alone does not permit for logical differentiations. However, excluding this intent, then it can be supported as a better definition than the present one in the S.S.C.C.

With this latter concept in mind, the proposed definition was generally accepted with the following suggested modifications:

1) Increase range of drainage to cover the poorly drained Humic Podzols and some of the Gleyed Podzols occurring on seepage slopes in British Columbia.

2) Delete reference to "Spodic" unless we decide to use the same criteria as in the U.S. definition. Our Podzolic B may or may not be the same.

3) Reference to hues and chromas changing within 20" should be prefaced by "usually".

   One suggestion re color of the Podzol B indicated it should be at least 3 units of moist chroma greater than the Ae horizon. However an Ae horizon may not be present, hence a definition of color should be discrete for the B horizon.

4) The last paragraph concerning the number of Great Groups should be deleted and the original retained until such time as the matter of Great Groups has been decided.

B. Combining the Ferro Humic and Humo Ferric Great Groups. This motion concerns only British Columbia, and the consensus of opinion here is to retain these two Great Groups. They signify an important environmental change, which is desirable and consistent with Great Groups in some other Orders, e.g. Chernozems.

C. Dropping the Mini Podzol subgroup. Unanimous agreement with this proposal.

The following items are proposals that have resulted from the September tour, and from subsequent correspondence. Some are definite proposals for modifications; others are presented more as items requiring discussion and more study before definite proposals can be made.

A. That a new Great Group called "Ferric Podzols" be established to take care of some of the sandy soils of the Great Plains region with distinct "Podzolic" morphology. The Ae would be 4 or more inches in thickness, underlain by a distinct B horizon which is usually redder than 10YR hue, and either have a chroma of 4 or more (Saskatchewan) or be at least 3 chroma units higher in color than the Ae horizon (Alberta). The Δ Fe + Al of the B horizon should be greater than the C (no amount specified).

It was also suggested this type of Podzol B be used in the Bisequa Gray Luvisol definition.

The above is generally supported by Alberta and Saskatchewan, but opposed by British Columbia on the grounds it would allow inclusion of numerous soils from Brunisdic areas.

B. It is generally agreed in British Columbia that the Oxalate method for determining Fe and Al to characterize Bf horizons is unreliable and misleading. The Pyrophosphate method is supported instead. However the .65% level suggested by McKeague (1967) is not satisfactory everywhere. It excludes a large number of soils in the Interior "Wet Belt" which we would like included as Podzols, but lowering the value includes soils which are not. The relationship appears more complicated than a simple Fe +Al determination.

The best criteria for recognizing a Podzolic B horizon should emphasize the relationship between OM, Fe, Al and clay. It is suggested we adopt the criteria of the spodic horizon in determining our Podzol B horizon, or at least use this approach. Since the chemical criteria is a ratio, it may fit some of our sandier soils better. Considerable study wuld first be necessary to set appropriate limits.

C. There is a general consensus in British Columbia that more of our indurated pans require recognition at the subgroup level. Unfortunately data is too limited to make specific recommendations at this time, but priority should be given to the study of their genesis and the cementing agents.

D. Lateral movement of water through soils on steep slopes is commonplace in Podzol areas, and this excess moisture is not reflected by the usual morphological evidence. Studies are required on the effects of seepage on soil genesis and plant growth, with a view to devising a drainage classification system for field application.

E. There is a widespread occurrence of volcanic ash over Souther British Columbia. Its exact implications on the physical, chemical and mineralogical properties of the soils is unknown. However it is evident that in some cases Si, Fe and Al is present in greater abundance than normal; also low bulk densities are commonplace. Study is required to identify the sources, distribution and content of ash and to determine if its influence on soil properties under different environmental conditions is sufficient to justify a separate subgroup.

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The following material is a report of the discussion on the Podzolic Committee by Norm Sprout. Sprout started the discussion by referring to the proposal for an Order definition prepared at the Eastern Regional Committee Meeting by Bruce Cann. He asked Bruce Cann to comment on this proposal for a new definition of the Order.

Cann: Indicated the reason for the proposed change in wording of the Order was to enable a soil surveyor to identify a Podzol in the field. It is felt that at the Order level one should be able to identify a Podzol or a Chernozem or a Brunisol without resorting to chemical criteria. Using the U.S. definition of a Spodic horizon would permit this to be done.

Regarding the Ferro-Humic and Humo-Ferric Podzols, it appears there is a need in British Columbia for this distinction, but in the east this separation presents problems. Wondered if we were on the wrong track by using organic matter.

Sprout: Did not think that adopting the definition as outlined would eliminate the need for chemical criteria except for some stated possible exceptions. With the concept of a Podzol B or Spodic B being a horizon with an accumulation of active amorphous material, then organic matter would be one of the important properties.

Expressed a reluctance to depend strictly on field observations to identify a Podzol. Past experience with this approach did not allow for good distinctions either between Brunisols and Podzols or within these Orders. Did not feel we should be afraid to lean on chemistry as a classification tool.

McKeague: Reiterated that with the U.S. system you commonly cannot distinguish whether a soil is a podzol on morphological criteria alone, and that you have to use micromorphology or chemical criteria.

Sprout: Pointed out the U.S. do have certain stated exceptions, e.g., Placic horizon which does not have to meet the chemical criteria. Using the approach of defining certain exceptions may be a method of handling the Prairie Sandy soils. While this approach does not conform with having a high content of active amorphous material, perhaps with soils in which it is difficult to obtain a high content of active amorphous materials we need such exceptions.

Pawluk: With many of these soils separated at the Great Group level on a regional basis, it may help if the chemical criteria were brought in at this level. For example, if the soils which look like Podzols on the Prairies were taken out as a separate Great Group, their fairly consistent chemistry would allow criteria to be developed specifically for this group and exclude them from other groups.

Sprout: Expressed the opinion he was against any kind of regionalism in the classification scheme. This would be a fundamental mistake in philosophy. We should be able to agree roughly on what kind of soils we want in the Podzolic Order so that the classification can be applied uniformly everywhere.

Coen: Indicated that the U.S. went to the pyrophosphate extraction procedure because they could not agree in the field on whether they had a Podzol. With their experience we should be careful in proposing to throw out chemical criteria.

Shields: The point being made is that the U.S. do make exceptions in certain cases and the suggestion is that we do the same, perhaps with a little different angle, to accommodate our situation.

Sprout: That was the intent. Also, we do not have reliable chemical criteria, so we must ascertain what soils we want included as Podzols and then define them.

Proposal B made by the Eastern meeting which suggests elimination of the Ferro Humic Great Group is generally opposed by people in B.C. The proposed working group could look into the limits presently set for organic matter and ascertain if changes are necessary to better fit the situation.

Regarding Proposal C, there is no disagreement in deleting the Mini Podzol Subgroup.

If we can go now to the Recommendations for Revisions to the Classification of Podzolic Soils, we should try to resolve the whole problem by approaching it from a concept standpoint and obtain some consensus of opinion on where we would like to go. Even if we do agree on some of these recommendations, we are not adopting them, but only agreeing to study them.

The first recommendation is to accept the U.S. concepts of a Spodic horizon (read Summary of Limits of the Spodic Horizon). There appears to be considerable merit in following this approach. We can set up our chemical criteria, then if we have exceptions we wish to include, these can be set up as well.

Day: Using the U.S. concept, how many sandy soils in the Prairies would be classified as Spodosols?

Acton: There was one.

Day: If that is the case, then are we kidding ourselves that these exceptions will accomodate the sandy soils on the Prairies.

Sprout: The present U.S. definition would not. The suggestion is that we can make our own definition to include them. This would involve defining them on some property other than chemical criteria as we do not want to lower this too drastically.

McKeague: What is this actually changing? Our concepts are just about the same. We take out the soils with an accumulation of amorphous material in the B horizon and call them Podzols.

Sprout: There is a fairly strong opinion that certain sandy soils should be Podzols, and this might be a way of doing it. It is much easier to define this order if we were not worrying about these sandy soils.

Pawluk: Everyone seeing these sandy soils (and this includes a wide range of Canadians and people from other countries) agrees they are Podzols. The fundamental question is whether we are prepared to call them Podzols.

Clark: Conceptually the American definition will allow us to make the exceptions to include them. The main thing is how far we are going to go. What is proposed is some approaches to the solution of this problem and we should look for an opinion and take the group attitude on this.

Sprout: The second recommendation is that we add to or modify our Podzol Great Groups and Subgroups. There is particular need for subgroup distinction for some of our pans. These are important pedological features and the suggested subgroups are duric and fragic. Their definition would require work on this genesis.

McKeague: After going on the field trip there is no question that we have pans in some of these soils and there has to be some way of taking them out in the system, and certainly this is an Eastern problem as well. There are all kinds of soils with some kind of hard layer in Quebec and the Maritimes but there is often the problem of deciding whether it is a characteristic of the parent material or whether it is a soil horizon. Perhaps it does not matter very much as these things have to be taken out anyhow at some level in the Classification. You cannot call all the things fragipans and it is going to be hard to set up subgroups until there has been some pretty good characterization. We do not have to understand their genesis but they have to be thoroughly characterized.

Sprout: At this point may we focus attention on the last recommendation. This may not be a legitimate topic to bring up at a regional meeting as the proposal is to form a working group which would be national in scope. However, there are enough unknowns in this whole subject that it requires a high priority for study, and somebody should be delegated with the task of resolving some of the problems.

Clark: This one is easy to resolve if this is your feeling and you accept the idea of designating an Ottawa correlator. Or do you want to keep this in your own hands regionally?

Sprout: It was suggested this way as it should be headed up by someone who has authority to travel both to the east and west in order to avoid some of the regionalism. He should also work with representatives from the provinces.

Rennie: Indicated we should reach some decision today on the Sandy Prairie soils, as they have been fairly well characterized and everyone fairly well agress they look like Podzols.

Sprout: The recommendations were set up with the hope they would be adopted in principle. The sandy Podzol-like Prairie soils would then be studied with the view for their inclusion. The problem is how to best facilitate their classification without disrupting the other Podzol soils in the remainder of Canada.

Pawluk: The previous suggestion to bring in the chemistry at the Great Group level would allow you to keep the chemistry on the present Podzol Great Groups. We can some up with a unique chemistry to define the Podzols in the Prairie region that would keep the other Podzols out. We can set up a definition for this Great Group of sandy Podzols that would exclude the other Podzol soils.

Sprout: This has not been done yet and is the reason for the suggestion to have a working group study this proposal and make sure it does not affect the other soils.

Clark: To meet Dr. Rennie's criticism that no decision had been made and one should be, we propose to add a sixth recommendation as follows "That criteria be established to include the Podzols-like soils on sandy or coarser textured soils within the Podzolic Order of the Canadian Classification System". We can poll your opinion on this, and pursue it through a working group under an Ottawa correlator. How this is to be done has yet to be ironed out. The proposal is to accept the American concept of the Spodic horizon re accumulation of amorphous products and that we use this conceptual definition in broad terms.

Shields: This also includes confirmation that these Prairie sandy soils be included in the Podzolic Order, and that we write the definition so this is possible.

Clark: The purpose of this group is to develop criteria to be recommended to the National Committee. This is essentially all this group can do, and you can avoid any confusion by considering this as "recommendations for study of revisions of the classification of Podzolic Soils". This group cannot ensure that this classification change can be brought about.

Sneddon: Objected to Recommendation No. 6. We can stop at Recommendation 5, and the study group will come up with what is in the best interest in the logic and philosophy behind our classification system.

Motion: Moved by Rennie, seconded by Coen, that Recommendation one to six for Studies of revisions to the Classification of Podzolic soils be adopted.

Motion carried.

Report on The Classification of Organic Soils

J. H. Day

A number of proposals for changes in the classification of organic soils were adopted after the tour of organic soils in Eastern Canada by the Eastern section of the Canada Soil Survey Committee which met in Fredericton in October 1971.

The proposals adopted, with the understanding that they would be considered first at this western regional meeting and second at the next national meeting were the following:

A. Revised definition for the surface tier.

The surface tier, exclusive of loose litter or living mosses, is 24 inches (60 cm) thick if there is on the surface,

1) 24 inches (60 cm) or more of fibric organic material that has a bulk density of less than 0.1, or

2) a mesic or humic Ap horizon thinner than 6 inches (15 cm) underlain by 18 inches (45 cm) or more of fibric organic material that has a bulk density of less than 0.1, or

the surface tier is 12 inches (30 cm) thick if there is on the surface 16 inches (40 cm) or more of any material that has bulk density greater than 0.1, or it extends to a lithic contact if deeper than 4 inches (10 cm) but shallower than 12 inches (30 cm) or 24 inches (60 cm).

B. Revised definition of organic order necessitated by the above (p. 8, revised organic chapter, SSCC).

a) if the surface layer consists of fibric organic material having a bulk density of less than 0.1 (with or without mesic or humic Ap thinner than 6 inches or 15 cm), the organic material must extend to a depth of at least 24 inches (60 cm).

b) if the surface layer consists of organic material having a bulk density of 0.1 or more, the organic material must extend to a depth of at least 16 inches (40 cm).

The Chairman drew attention to the fact that the Ap horizons should read Op.

C. Revision of textural classes for underlying mineral soils.

That "The textural classes which have been recognized at the family level for mineral soils be adopted for mineral material underlying organic soils "in terric subgroups", namely, coarse-skeletal, coarse, medium-skeletal, medium, fine-skeletal, fine and fragmental".

I would suggest that the words should be added after "organic soils".

Other topics discussed at the Eastern meeting were:

1) Reaction classes in organic soils and sulferous families.

2) Clastic families - are present limits too high or too low?

3) Clastic layers - need for terminology.
A motion was carried that the Subcommittee for horizon nomenclature be charged with amending the horizon designations for organic soils.

4) Should marl be treated as a mineral soil rather than organic? Should coprogenic earth be maintained in the organic order?

The following material is the discussion of proposals for change in the organic soil order.

Day: Proposed that Proposal A be accepted as read provided that Ap be changed to Op. There was very little discussion and in the end there were no objections so the proposal was taken as adopted.

Day: The second proposal follows from the first and that is that we should change a couple of paragraphs in the definition of the order, specifically A and B.

a) if the surface layer consists of fibric organic material and the bulk density is less than 0.1 (with or without a mesic or humic Op thinner than 6") the organic material must extend to a depth of at least 24", and

b) if the surface layer consists of organic material with a bulk density of 0.1 or more the organic material must extend to a depth of at least 16".

It follows from the idea of changing the surface tier. In the request for criticisms that came back, Alberta agreed in principle, B.C. Agriculture agreed, the B.C. Feds in general agreed but proposed an alternative definition. Day proposed that the Proposal B be adopted as read. A show of hands carried the motion.

The third proposal for a change dealt with revision of textural classes for the underlying mineral soils. The proposal adopted by the Eastern Regional meeting said that "the textural classes which have been recognized at the family level in mineral soils, (that's the mineral soils underneath the organic soils) be adopted for mineral material underlying organic soils, namely, coarse-skeletal, coarse, medium skeletal, medium, fine skeletal, fine and fragmental". I suggest that the words "in terric subgroups" should be added after "organic soils". To re-read that in a coordinated manner "The textural classes that have been recognized at the family level for mineral soils be adopted for mineral material under organic soils in terric subgroups, namely coarse skeletal, coarse, medium skeletal, medium, fine skeletal, fine, and fragmental". Day moved that this statement be adopted by the Western region for consideration at the next national meeting. Clark asked all those who were not in favour of adopting this motion to raise their hands.

The motion was declared adopted.

Day: At the Eastern Regional meeting, we also discussed other topics but we did not find that we wanted to recommend anything. The question about the need for reaction classes in organic soils in sulferous families was raised because we saw a soil on the tour that appeared to be sulferous. It smelled of H^2S, the pH was reported to decrease on oxidation. This was probably one of the few cases in Eastern Canada where sulferous organic soils had been looked at. The U.S. system has the sulfi-family and the sulfo-family which represent the different oxidation states, sulfo when oxidized and sulfi- when reduced. As soon as you put that name on it you say something about the pH. I thought that if we are classifying organic soils at the family, and we say a sulferous family we do not need to say anything about pH. That was the way I put the argument. Opinions varied and we ended up not recommending anything.

Sneddon: Responded that he does not see why soils in sulfurous families should not be given reaction families. Further, for interpretative purposes, reaction class in the natural undrained state may be significant. From the ecological point of view, where reseeding for example is being considered.

Luttmerding: Said we have some sulferous series on the West Coast, that is, the underlying mineral material is sulferous and he would recommend keeping something similar to the sulferous family. The Kelowna group have made a similar suggestion to Michylana re soil families.

Kjearsgaard: Replied that they have no opinion since thesesoils do not occur in Alberta.

Day: Yesterday when Luttmerding and I were discussing this problem I asked him if he would be prepared to say something today about the sulferous organic soils in British Columbia.

Luttmerding: I do not have very much to say except that the pH's in the natural undrained state are generally around neutral or slightly below. On oxidation and drying they drop drastically, to as low as pH 2.5 to 3. The only place that we have mapped them so far is in the Delta area east of Vancouver. They are associated with sulferous deposits in which jarosite is often visible. I think Dr. Clark has done wome work on these kinds of soils. The sulfur content of some of these soils may be in excess of 500 ppm. Would Osborne describe the extraction and analysis of sulfur?

Osborne: It is an ammonium acetate extraction colorometric analysis, but the thing is the ammonium acetate is adjusted to around pH 3 or 4 thereabouts.

Day: Well it seems to me that this is the problem that we have to cope with. I think it would be perfectly appropriate if we pursued this problem and attempt to gather information to determine the characteristics of these soils at an early date so that we can consider the possibility of guidelines or limits for these kinds of soils.

Luttmerding: One of the things I have noticed in these analyses is that when you have very high levels of sulfer the conductivity is well above what is considered saline, that is 15 or 16 mmhos.

Day: Now, Herb, what is your thought about sulferous mineralogy and sulferous as another family characteristic to reflect pH and salinity. Can you do with one or the other or would you need both? Do your sulferous soils in the lower Fraser Valley have sulphurous mineralogy?

Luttmerding: They are high in sulphur. There is either jarosite or iron sulfides. They go together I think.

Day: The point I would like to make here is that we do need some characterization of these kinds of organic soils. Similarly we need the same kind for mineral soils too. Who is going to stick their neck out and do it, Herb?

Several other topics were talked about. We talked about clastic families. We saw quite a few soils that had quite a lot of mineral or sedimentary material in them. There is some question whether the limits are right. Is 55% appropriate? Seventy per cent to stay the way it is because it is the break between mineral and organic soils. But is 55% right? Should it be lower? Nobody was prepared to suggest that it should be moved. In the replies received, Sneddon had no comment, and Kjearsgaard had no comment but asked why there was any question of moving the lower limit? The reasons for raising the question was that we took these limits from the Americans and we don't really know whether or not it is correct.

Smith: Well, didn't MacKinzie indicate that they were considering changing the mineral content of clastic layers, so in typical Canadian fashion why don't we wait for them to make the change.

Day: Well, if we get cracking and do something about it we can influence what they do, and I am sure they would be anxious to know what we found out. We also talked about marl; whether it should be treated as a mineral soil rather than an organic soil especially in the case where marl makes up a very large percentage of the control section. By and large marl of itself does not meet the requirements for an organic soil in terms of organic content. The reaction from Alberta was that these should be treated as a mineral soil and I believe this is what Sneddon said also. There is a series in British Columbia, at the Cheam marl deposit which does not look like an organic soil.

Smith: There was some discussion about this in Manitoba just before the meeting and Charles Tarnocai is of the opinion that phenologists are treating this material as a form that has originated as a result of biological activities, and in a sense is framed in an organic layer, and not through a simple process of precipitation and deposition. If you want to defend this idea Charles, go ahead.

Tarnocai: Well, we have always stated that it is a marl layer and designated it as Lm and we used the Lm designator because the organic matter content is less than 30% and we never gave them an Olm or anything like that, but we never called them cumulic or something. We never recognized them as a mineral layer because of the origin.

Day: Am I correct in assuming that this layer doesn't meet the requirements of an organic layer?

Tarnocai: Yes, that's right. If the marl was over 30% organic matter we call it Om or whatever it was. If it was under 30% organic matter we designate it as Lm and we just call it for example, Limno Mesosol or something like that.

Day: I imagine that is pretty fair for limnic layers in organic soils, but there are the other case where the limnic layers are thick enough and continuous enough that you are thinking about something that is not really an organic soil.

Tarnocai: We ran into these soils in Northern Manitoba and we talked to the Fisheries limnologist and he felt that this is part of the deposition of the early stage of lake filling and so on, and so this is also the process of peat deposition. It is not something foreign like an alluvium layer.

Day: OK, but right now we have got ourselves in the position where we have more than just one thing in the limno layers. We have coprogenic earth marl, and distomaceous earth. This coprogenic earth is quite familiar to me because we have some real good examples in Ottawa. I plugged about 5 profiles early in the summer that had thick coprogenic or sedimentary peat layers. The one near Ottawa that I have done the most analysis on had a saturated water holding capacity of about 2500% and based on oven-dried material the organic matter was high. Based on a wet wegith of course it would be very low. The fiber has characteristics you wouldn't believe, feels like nice brown, real hard jeoo, can't get it through a sieve. So we have a coprogenic earth as one thing and marl as the other thing.

Tarnocai: Maybe I should add one more thing to the marl. It is quite common that we have a foot or more of marl in the profile and we have to consider a mineral layer, and we have to call it the terric layer, and that cuases all kinds of difficulty because then we have to recognize the terric contact, or we would have a mineral marl easily that I could show you in a profile.

Day: The Americans are considering establishing a Limnist suborder to cover this coprogenic earth group. They have quite a few of them. They are saying that they do not regard marl as an organic soil. They would classify it as some kind of an Aquent.

Tarnocai: What do they do if the marl is over 12" thick?

Day: It depends where it comes in the profile. If it comes in the middle of the profile this would have to be some kind of terric layer.

Tarnocai: Oh no, we never considered it as a terric layer but we consider it as a mineral layer, not a terric layer. We called marl as an organic layer.

Day: Marl as an organic layer? I do not think we can do that because it is contrary to our definition. Do you think that this is a sufficiently important problem that we should do some work on it?

Tarnocai: I think so.

Day: One other thing, these marl layers do not have the other characteristics on which we are classifying such as bulk density, water holding capacity and there is no fiber or very little. They are different. Sorry, Charles.

Smith: The Americans are going to exclude marl as a limnic type layer then.

Day: This is the way I understand the discussion, Bob. The soil which is predominantly marl they would already classify as some kind of an Entisol. I think we should classify that soil is a Regosol. Would anybody like to recommend that further work be done on this question of marl and limno layers in organic soils.

Smith: Well, since the Manitoba contingent brought up the question I quess we should recommend that this be studied and since Charles is a logical candidate ....!

Tarnocai: Well, I think the problem is that what we consider the genesis. If we consider this part of the peat deposition it is part of the organic profile and I am a genetic person.

Day: But you have to think about thickness limits. Where do you cut off Regosol and an organic soil? Have you not come to that yet? I think we already have that partly covered in our definition of organic order.

Tarnocai: I have never run into that problem because I have never considered marl as a mineral layer.

Day: I think you have to. We now have organic soils defined on the basis of organic matter contents.

Manitoba recommends the investigation of marl and clastic layers in organic soils.

Surveys of Forest Land and Permafrost Areas

L. M. Lavkulich

This report attempts to present a consensus of responses from several soil survey units and other professionals in resource fields following the memorandum that was circulated in December 1971. The report examines and attempts to develop rationale and guidelines for soil survey in areas where standard reconnaissance and detailed surveys are not appropriate because of accessibility, objectives or economics. Specifically this report is oriented towards consideration of four interrelated problems, namely:

1. Levels of taxonomic classification appropriate to exploratory and broad reconnaissance surveys that depend heavily on air-photo interpretation,
2. Mapping scales appropriate to exploratory and broad reconnaissance surveys,
3. Soil map legend appropriate to such surveys, and
4. Role of the biophysical approach to these kinds of surveys.

The assignment, quite clearly, was to appraise the current situation in preparing inventories in areas that do not warrant at this time a more detailed inventory as has been carried out in much of the settled portions of Canada. This implies that such inventories are necessary and also that in areas where more detailed information is required these would be handled much like in the past. It must be remembered, however, that we cannot consider exploratory and broad reconnaissance surveys without due attention to the entire methodology of soil survey and the various facets, objectives, scales, etc. involved.

In the memorandum of December, 1971, nine interrelated points were raised; these were:

1. Objectives of exploratory and broad reconnaissance soil surveys,
2. Scales of mapping for exploratory and broad reconnaissance soil surveys,
3. Level of cartographic detail (taxonomic) appropriate to the objectives and scale,
4. Terminology applicable to such surveys -

   (a) at the soil series level
   (b) at the soil family level
   (c) at higher levels of generalization
5. Feasibility and desireability of defining a working unit (e.g. soil series or soil families) and devising nomenclature that would describe the mapping unit and be descriptive of the soils delineated, e.g. "soil geographic unit."
6. Comparison of exploratory and broad reconnaissance soil surveys with the biophysical approach, as to information presented compatible with your stated objectives,
7. Role of the biophysical approach in exploratory and broad reconnaissance surveys,
8. Examples of soil mapping legends consistent with objectives, taxonomic level and scale of mapping,

9. Other comments useful in providing guidelines for exploratory and broad reconnaissance soil surveys.

The remaining section of this report will deal principally with the above points.

I. Objectives

An assessment and inventory (maps and reports) of the soil resource for use in understanding broad soil properties, behavior, capability and applicable to broad land use planning. The objective stresses generalized information being collected rapidly and at low cost. The emphasis is placed rather heavily on interpretation of information from sources other than direct observation of the soil, especially airphoto interpretation.

It is recognized that a relatively small scale is necessary with consequent large delineations. Small scale invariably requires that unlike soils be included in the same delineation. Soils of different properties, genesis and capabilities are often found adjacent to each other and no manipulation of classification criteria can change this basis geographic pattern. Thus it becomes imperative that some kind of descriptive soil geographic unit be defined to describe the spatial arrangement of the soil resource and the properties of the delineated soils. Such a survey acts, in fact, as a basis for more detailed study or interpretation in those areas where more effort is warranted.

These objectives met with general approval. Some respondents to this problem indicated that objectives can vary from year to year, depending on the use of the survey, i.e. do we carry out user-oriented surveys or more basic theoretically oriented surveys? It appears to me that what we must do is to inventory the resources objectively and carry out research and analyses that are user-oriented, if the user or users are known. It was also mentioned that an important consideration in soil resource inventories is field truthing of soils and boundaries. In other words the reliability and the amount of ground truth should be indicated in the survey. Another consideration in exploratory and broad reconnaissance objectives is that the survey is intended for broad land use planning and as such should not convey the impression that only soils are inventoried; when in fact, additional terrain features are used and incorporated.

2. Scale of Mapping for Exploratory and Broad Reconnaissance Soil Surveys

In general it was felt that the scale of mapping should be left open and be determined by the specific objective of the survey and general terrain features of the area. Some feel that only two scales need to be considered, namely:

reconnaissance	-	1:50,000 to 1:63,360
broader surveys	-	1:250,000

Others feel that scales should range from 1:125,000 to 1:175,000 with 1:125,000 or 1:250,000 probably being the most important. Although one respondent felt that a map at a scale of 1:500,000 is only good for hanging on a university wall, another group of respondents felt that this scale has proven to be quite useful for a variety of interpretations. Once again many respondents felt that the degree of reliability of the mapping and the enclosed map units was more important than scale. This could conceivably allow definition of levels of cartographic detail including not only scale but information as to degree of field truthing of soils and boundaries, precision of the map units and accuracy of the map.

Since there was no obvious consensus regarding scale of mapping, recommendations as to scale <u>per se</u> can not be made but will be presented later in this report.

3. <u>Level of Categorical Detail (taxonomic) Appropriate to the Objectives and Scale</u>

In the memorandum of December, 1971, it was suggested that two alternatives were possible in application of categorical detail to reconnaissance mapping, namely:

(a) Identification, naming and describing soil series and then arranging them in a manner that will fit the landscape, illustrate the relationship of one series to another and still not be too cumbersome to place within a delineated area, or

(b) Use of the family or higher levels of taxonomic generalization.

Comments ranged from most definite use of only the soil series level to nothing finer than the great group. Although many respondents did not seriously consider the application of soil families to these kinds of surveys, the replies indicated that the family level is the lowest taxa that could be used (with appropriate phases), as the soil series level is too specific for this kind of survey. If subgroups are used they should be modified by texture, at least. It was also mentioned that certain subgroups may be difficult to apply in exploratory and broad reconnaissance surveys. These subgroups include:

Gray Luvisol	-	ignore brunisolic
Humo-Ferric and Ferro-Humic Podzol	-	ignore "mini"
Eutric and Sombric Brunisol	-	ignore "degraded"

	SURFICIAL DEPOSIT			LANDFORM *			**	SOILS ***		
Map Symbol	Name	Material	Estimated thickness	Topography	Drainage pattern	% water	Land Region	Texture U.S.D.A.	Unified Classification	Micrc relie cm (ir
Mp Mpv,Mv)	Morainic plain	Glacial till	Mp: 5-15m (20-50') Mpv: 3-10m (10-30') Mv: 2-5m (5-15')	Gently sloping or undulating plain 0-5% slope;	Downslope seepage in more or less parallel runs	5	0			
							1	CL (some L and C)	CL	Hummoc 20-6C (8-24
				Relief to 3m (10')			2	CL (some L)	CL	Hummoc 10-4C
							3	CL (some L)	CL	Hummoc 0-30 (0-12
Mv_1	Morainic veneer	Glacial till	2-6 m (5-20')	Moderately to strongly sloping; 5-20% slope; relief to 50m (150')	Downslope seepage, usually in runs	0-5	0	SiCL (some L-C)	ML	Hummoc 30-60 (12-24
							1	CL-C	ML to CL	Hummoc 20-75 (8-30"
							2	CL-SiC (locally some L)	ML to CL	Hummoc 20-60 (8-24"
							3	CL	CL	Hummoc 0-30 (0-12"
							0			
Md	Drumlinized moraine	Glacial till	2-20m (5-50')	Undulating to rolling fluted plain; 5-25% slope; relief to 10m (30')	Deranged to parallel	5	1	CL-L	CL to CL-ML	Hummoc 20-60 (8-24"
							2	GL-CL	GC to CL	Hummoc 0-30 (0-12"

Depth of thaw cm (inch)	Drainage (deciles)	VEGETATION **** Stable	After fire	GROUND ICE[Δ] Disseminated	Segregated	% of Region	COMMENTS
50-80 (20-30")	Mod. well 2	wS-lichen	wB-wS	Moderate			Area adjacent to Delta dissected
	Imperfectly 4	bS-wS-lichen	wB-wS-Wi	to	Scattered	25	by seepage runs and has generally
	Poorly 4	tL-bS-sedge	sedge-Al-Wi	high			high ice content.
50-150 (20-60")	Mod. well 2	bS-wS-wB	wS-wB-bS	Moderate;			Drainage ways have slowly seeping water
	Imperfectly 5	bS-lichen	wS-wB-Wi	locally	Scattered	50	Organic mat must complete under bS-lichen
	Poorly 3	tL-bS-sedge-Al	Serge-Al	low to high			
50-200 (20-80")	Mod. well 2	wS-bS-bPo	wB-wS-Al	Moderate;			Drainage ways have slowly seeping
	Imperfectly 5	bS-Lichen	bS	to	Rare	20	water. Organic mat most complete
	Poorly 3	tL-bS-sedge	tL-wi-sedge	low			under bS-lichen.
50-75 (20-30")			--	Moderate			
	Imperfectly 9	Cottongrass-sedge		to	Common	30	
	Poorly 1	Sedge-Sphugum	--	high			
50-150 (20-60")	Mod. well 3	wS-lichen	wR-wS	Moderate			
	Imperfectly 6	bS-wS-lichen	wR-wS-Wi	to	Scattered		
	Poorly 1	tL-bS-sedge	Serge-Al-Wi	high			
50-100 (20-40")	Mod. well 5	bS-wS-wB	wS-wB-bS	Low			
	Imperfectly 4	bS-lichen	wS bS-Wi	to	Scattered		
	Poorly 1	bS-tL-sedge	Serge-tL	moderate			
50-200 (20-80")	Well 5	wS-bS-wB	wB-wS-Al				
	Imperfectly 4	bS-Lichen	bS	Low	Rare		
	Poorly	tL-bS-sedge	tL-wi-Sedge				
50-90 (20-36")	Mod. well 2	wS-lichen	wB-wS	Moderate			
	Imperfectly 4	bS-wS-lichen	wB-wS-Wi	to	Scattered	>1	
	Poorly 4	tL-bS-sedge	Sedge-Al-Wi	high			
50-150 (20-60")	Well 3	bS-wS-wB	wS-wB-bS	Low			Lineation of land forms separates this
	Imperfectly 4	bS-lichen	wS-wB-Wi	to	Scattered	1	unit and can be used to advantage.
	Poorly 3	bS-tL-Sedge	Sedge-tL	moderate			A very variable unit.

It should be emphasized that we do require a uniform level of mapping at certain levels of cartographic detail. The units used in mapping have to be specifically defined so that the information and data collected on each delineated unit can be computerized. This applies at any level of categorical detail.

4 to 7. Terminology, Mapping Units, Biophysical Approach as Applied to Exploratory and Broad Reconnaissance Surveys

Much confusion exists regarding terminology used in soil survey mapping units, especially at exploratory and reconnaissance levels. Terms like soil complex, soil association, soil catena, soil phase are used in different ways in different geographical areas and in different contexts, largely through historical development of soil survey.

Most respondents felt that with the exception of the Canadian definition of soil association, the mechanism of naming mapping units was available and only one respondent felt that the concept of "soil geographic unit" may be useful. It was generally felt that a change in definition of soil association to that used by the U.S.D.A. would be very useful in solving the terminology problem as this unit by definition "fits the landscape" regardless of the complexity (Definition of the U.S.D.A. Soil Association* is as follows: "Soil associations are mapping units each of whose delineations is dominated by the same combination of two or more different kinds of soil, which occur together with some regularity of pattern and individually occupy areas large enough to be delineated separately at conventional scales and field methods of detailed soil surveys"). There was some hesitation, however, in changing the definition of "association" by some survey units as it was felt that the Canadian

* Personal Communication: R.W. Simonson

definition was more precise than the general term "association" as used by the U.S.D.A.

Recently, Simonson (1971) has presented the possibility of using various kinds of "associations" for what he terms "four universes" and suggests possible terminology applicable to these universes. By "universes", Simonson refers to "geographical areas within which the soil resources must be comprehended." These universes range from the size of individual farms to continents. His suggested terms and universes are as follows:

Megasociation	-	250,000 km^2 or more. Scale generally smaller than 1:1,000,000. In most cases these soil associations can be named in terms of great groups, suborders, or orders.
Macrosociation	-	Ca. 2,500-250,000 km^2. Scale generally between 1:300,000 to 1:1,000,000, inclusive. In most cases these soil associations can be named in terms of subgroups.
Mesosociation	-	Ca. 250-2,500 km^2. Scale generally between 1:100,000 to 1:300,000. In most cases these soil associations can be named in terms of series.
Microsociations	-	Less than 250 km^2. Scale generally larger than 1:100,000. In most cases these soil associations can be named in terms of series.

This is an attempt to form an hierarchy in the same manner as the categories in soil taxonomy. Thus the Megasociation is the broadest and most general comparable to the higher levels of taxonomic generalization; while the microsociation is the narrowest and least general soil association comparable to the soil series (or type) as a set of classes in the lowest category. This approach is essentially what is required of soil maps going from broad to specific groupings of soils for resource information. It must be kept in mind, however, that an inherent assumption in Simonson's proposals are: the acceptance of the definition of soil association as outlined earlier and that the term is not genetic; and, that these maps must have the same amount of cartographic detail at all four levels or universes.

Since most of us have not had sufficient time to digest the context of Simonson's proposals nor have totally accepted the U.S.D.A. definition of soil association, it is felt that this matter should be left open for discussion.

Regarding the use of the biophysical classification system (National Committee on Forest Lands, 1969), the majority of the replies indicated that the approach, i.e. interdisciplinary teams and greater vegetative inputs, were desireable. It was generally felt that such an approach would tend to make pedologists more aware of the "Bio" factor than has been demonstrated to date. There was also an expression that the methods and the maps from both a soil survey point of view and from the biophysical approach would be essentially the same. In fact, Jurdant _et al_. (1971) in presenting this paper at the Proceedings of the National Committee on Forest Land - Work Meeting (May 6-7, 1971, Kamloops), stated: "The _Soil Series_ is the framework upon which the whole ecological classification (biophysical) is based since it is the major identifying component of the _Land Type_, and subsequently, of the Land System.

The above statement does not mean that soil series as commonly mapped by agricultural soil surveyors can always be readily used for defining Land Types... Nevertheless, the soil series is the most useful concept when used by a team which consider the integration of the factors of climate, landform and vegetation in addition to those commonly used by the field pedologist. Essentially what it means is that decisions on soil series boundaries are based on their ecological significance rather than their pedological significance."

From the above quotation it seems that the real difference in the biophysical approach and soil survey is in terminology and the sometimes vague and broad application of the soil series by agricultural soil surveyors. I feel confident that if pedologists would strictly adhere to the recognition of polypedons then soil series boundaries would be the same whether considering ecological or pedological significance; if, in fact, we believe that:

soil = f (climate, vegetation, relief, parent material and time)

A more significant point, however, is that in essence the two approaches to physical resource inventories (soils or land) are more similar than different.

As was indicated by several soil survey units the biophysical approach reflects, to a greater degree than soil surveys, the present state of dynamic systems such as vegetation. It was generally felt, however, that "land classifications" should concentrate on physiography, geology, landforms, soils, hydrology, climate and water bodies, the "semi-permanent" features of the landscape. There were, also, suggestions that, although we require information about the total environment, an interdisciplinary approach aimed at separate but complementary maps of soils, geology, vegetation, hydrology, climate, etc. would be more suitable.

These should meet the requirements for land use planners as well as single use objectives. In addition, this could, conceivably be easier to handle by new methods being developed in remote sensing and computer coding of resource information, than an all-embracing environmental inventory.

Regarding my suggestion of developing mapping unit nomenclature, such as "soil geographic unit", met with little support. Some respondents suggested this approach was unnecessary, while others proposed a similar concept but applied other terms, e.g. "geounit." For the present it appears that no new mapping terminology is necessary. There was, similarly, little discussion relative to using the family level as a mapping unit and devising nomenclature for this approach.

From the replies received and from consulting the literature it appears that the following may be an approach to defining mapping intensity, scale and mapping units:

Type of Survey	Scale	Mapping Units	Location of Mapping Unit Boundaries	Acreage Mapped /man year
Detailed	1:31,680 to 1:63,360	series, complexes and phases	all prelocated stereoscopically, greater than 50% field checked	20,000
Reconnaissance High Intensity	1:63,360 to 1:100,000	catenas (Can.) associations (U.S.D.A.) or families	all prelocated stereoscopically, at least 50% field checked	250,000
Reconnaissance Medium Intensity	1:100,000 to 1:125,000	catenas (Can.) associations (U.S.D.A.) complex families	all prelocated stereoscopically, at least 30% field checked	750,000 to 1,000,000

Type of Survey	Scale	Mapping Units	Location of Mapping Unit Boundaries	Acreage mapped /man year
Reconnaissance Low Intensity	1:125,000 to 1:250,000	associations (U.S.D.A.) catenary families or subgroup and texture	all prelocated stereoscopically, at least 25% field checked	3,000,000 to 4,000,000
Exploratory	1:250,000 to 1:500,000	associations (U.S.D.A.) great group and texture	all prelocated stereoscopically, at least 10% field checked	10,000,000 to 15,000,000
Schematic	1:500,000 to 1:1,000,000	associations (U.S.D.A.) of great groups	all prelocated stereoscopically, 5% field checked	20,000,000

If the above were accepted for trial, this would involve changing the definition of soil association as used in Canada, but would not involve the introduction of any new terms for mapping units. I feel it is imperative that we agree on terminology and approach if we are serious about our efforts!

8. Examples of Soil Mapping Legends

A number of organizations responded to this portion of my previous memorandum indicating minor modifications of the legend I presented. Several people indicated the importance of the both identification and descriptive legends. The latter is, of course, most important in that it is explantory. This legend states that unlike soils have been delineated in the same mapping unit and it insures that there is a careful record of the soils mapped, their characteristics, qualities and performances under management. It was, also, suggested that the soil survey report must continue to be the prime source of information to fully explain the composition of the map unit and the nature of the land, vegetation, soil, etc. therein.

people along with our own pedologic bias lead to the development of the legend. I think "user" and objectives of survey play an important role in preparing legends and reports. Apparently my colleagues felt the legend was useful for their purposes.

I am including several legends that were submitted to me b, various groups. It would be helpful if we could decide on a common format, even though details would depend on the geographic location of the survey, objectives, etc.

(a) <u>Geounit</u>

Geounit Tdl is gently undulating till plain composed mainly of slowly permeable silty clay, derived from bentonitic shales. The mineral soils (70%) on the undulating surfaces are dominantly Gleysols peaty phase - moderately fine, mixed, neutral, weakly calcareous, cold subaquic family with vegetation composed of black spruce, Labrador tea, bog birch and crowberry. The organic soils (30%) developed on 1.5 - 3m of sphagnum over mixed forest peat in level depressions are dominantly Cryic Fibrisol - sphagnic, dysic, very cold peraquic family with vegetation of black spruce, Labrador tea, sphagnum and reindeer moss. The permafrost in the organic soils is usually at a depth of about 0.3m but merely may be as

deep as 1.5m.

Other details (e.g. depth to bedrock, minor soils, water bodies) should be built into this kind of descriptive legend.

(b) Alberta Examples

(i) Detailed Reconnaissance mapped at 1:31,000, published at 1:125,000

Medium textured, dark yellowish brown to olive brown till of Continental origin (Edson till); moderately to weakly calcareous; topography varies from undulating to moderately rolling; found at elevations below 3,400 feet.

Association	Mapping Symbol	Dominant Soils	Significant Soils	Possible Minor Inclusions
	EDS 1	Orthic Gray Luvisol[1] (Hubalta)	Orthic Gray Luvisol[2] (Ansell)	weakly gleyed soils
EDSON	EDS 2	Orthic Gray Luvisol[2] (Ansell)	Orthic Gray Luvisol[1] (Hubalta)	weakly gleyed soils
	EDS 3	Bisequa Gray Luvisol (O'Chiese)	Orthic Gray Luvisol[2] (Ansell)	weakly gleyed soils

1 - uniformly colored Ae horizon.
2 - Ae horizon with considerable leaching in upper portion.
- Names in brackets are series names.

(ii) Reconnaissance in mountains mapped and published at 1:50,000

Symbol	Landform	Materials	Vegetation	Soils
11d	Bench 5-25% slope	Thin aeolian deposit gravelly sandy loam till (outwash)	Pine-buffaloberry (Arnica)	Orthic Gray Luvisol (degraded Eutric Brunisol, Gleysols)

- Brackets indicate minor associates.

(iii) Exploratory to Reconnaissance - Biophysical approach.
- essentially a helicopter survey with detail for 1:125,000 to to 1:250,000 publication.

Vegetation	Soil Subgroup(s)
Landform	Drainage - topography

e.g.

A	GW
Tg	3-c

where A = predominantly aspen
GW = Orthic Gray Luvisol
Tg = Till - ground moraine
3 = moderately well drained
c = 2 - 5% slopes

(iv) Exploratory - mapped and published at 1:125,000

This is the Mackenzie project. With the field control it would have been preferable to map at a scale of 1:250,000.

(b) Exploratory - 1:750,000 - Northern Alberta.

Maps are published page size in the report. Legend is imprinted on the map as follows:

(i) Area designation - I, II, etc.
(ii) Surface material - outwash, till, bog, etc.
(iii) Topography by hatchuring.
(iv) Texture and profile information at ground check points.

- general desciption of each area in the report.

(c) C.D.A. Vancouver: Example

(i) LEGEND

Map Color and Symbol	Mapping Unit[1]	Geologic Material and Topographic Expression[2]	Significant Characteristics[3]
		GLACIAL TILL MATERIALS	
Ac	ALCAN Orthic Gray Luvisol	Grayish, clay loam and clay, somewhat saline deposits occurring on gently rolling and moderately sloping till plains	Moderately well drained, strongly acid soils on convex slopes; lime cartonates and gypsum at 6-10 ft.; associated with Buick, Jedney and Wonowon soils
Bu	BUICK Low Humic Eluviated Gleysol	Grayish, clay loam and clay, somewhat saline deposits occurring on gently rolling and moderately sloping till plains	Poorly drained, very strongly acid soils in low-lying depressions and concave sites; loamy, often peaty surface soil overlies massive, mottled clay subsoil; associated with Alcan, Boundary and Beatton soils

Map Color and Symbol		Mapping Unit[1]	Geologic Material and Topographic Expression[2]	Significant Characteristics[3]
Je		JEDNEY Lithic Gray Luvisol	Thin mantle (1-4 ft.) of grayish clay loam overlying sandstone and shale on moderately to strongly sloping till plains	Moderately well drained, strongly acid soils over bedrock at 4-20 in.; associated mainly with Alcan soils
Wo		WONOWON Gleyed Gray Luvisol	Grayish, clay loam and clay, somewhat saline deposits occurring on gently and moderately sloping till plains	Imperfectly drained, strongly acid soils on nearly level slope positions; acid; lime carbonates and gypsum may occur at 6-10 ft.; associated with Alcan and Jedney soils
Bd		BOUNDARY Orthic Gray Luvisol	Dark gray compacted clay overlying bedrock; occurring on gently to moderately sloping plains; confined to elevations of 2500 to 3000 + ft.	Moderately well drained, very strongly acid soils on convex slopes; associated mainly with Buick soils
Eg		EAGLESHAM Terric Mesisol	Semi-decomposed organic materials occupying depressions and level sites	Dark brown organic deposits (<52 inches thick) over mineral soil; strongly acid
Kz		KENZIE Terric Mesisol (sphagnic phase)	Semi-decomposed organic materials occupying depressions and level sites	Fibrous moss overlying strongly acid organic deposits (<52 inches thick), over mineral soil

Map Color and Symbol	Mapping Unit[1]	Geologic Material and Topographic Expression[2]	Significant Characteristics[3]
		LAND TYPES	
RB	ROUGH BROKEN LAND	A land type that includes irregular, steep side slopes, rock outcrops, dissected terraces and abandoned channels along stream courses; mainly undifferentiated Regosols	

MAPPING UNIT

A mapping unit delineates components described in the legend. It comprises one dominant component as symbolled (Ac), and may contain limited inclusions of others. A multiple unit shows the components by tenths, e.g. $Ac^6 - Bu^4$. The soils are classified according to "The System of Soil Classification for Canada".

(ii) This legend example is connotative and as such would have to be modified to fit a non-connotative legend at a higher level of abstraction. The example could be considered as an interim or local legend that could be correlated as follows:

Natural Vegetation | Wooded | Conifers | Boreal Forest | White spruce - blueberry

$$\frac{363\ .\ \underline{12}\ \underline{357}}{2a\ D\ .\ 2\ \underline{74}\ \underline{61}}$$

Rolling and Moderately Dissected Lands (<u>Macrorelief</u>) | Level to rolling upland | Till plain | Fine textured slightly arid basal till | OGL soils (Alcan = Ac

Geologic Material and Topog. Expression | Significant Characteristics

Map Color and Symbol	Technical Description	Description Legend	Interpretive Legend
7461 (Ac)	Ac:OGL (Alcan Orthic Gray Luvisol)		

Legend should be <u>closed</u> not open or "uncontrolled"

(d) Saskatchewan. Example

Name	Class	(Parent) Geologic Material	Map Unit	Dominant >40%	Significant 40-15%	Vegetation
Waitville	Association	Glacial Till (medium to mod. fine textured, moderately calcareous)	Wv1	Orthic Gray Wooded		Aspen, white spruce
			Wv9	Orthic Gray Wooded and Gleyed Gray Wooded	Gleysolic (Peaty) soils	Aspen, white spruce, birch, black spruce on poorly drained sites.
Arbow	Complex	Variable (Texture indicated)	Aw, say Aw:Loam	Gleysolic (usually peaty phase)		Black spruce, feather moss and sphagnum mosses.

(indicate landform and topography by additional symbology in map unit area designation)

(e) U.B.C. Examples - Two examples of mapping legends in two kinds of areas

MAPPING LEGEND FOR
TETCHO LAKE AREA

Geologic Material	Symbol	Landform	Texture	Soil Association	Symbol	Dominant Soil	Significant Soil	Characteristic Vegetation	Additional Notes
Alluvium	A	Flood-plain	Var-iable	Creek	C	Orthic Regosol (well drained)		White spruce, balsam, poplar, willow, alder, rose, bunch berry, feathermosses	Small floodplains along creeks, includes Peaty Gleysols and Organic terrain
Glacial Till	T	Till plain	Silty clay	Island River	Id	Peaty Gleysol (poorly drained)		Black spruce, alder, bog birch, Labrador tea, cinquefoil, crowberry, cowberry, feathermosses and reindeer mosses	Imperfect to poorly drained soils along drainageways on long slopes (10%). Appears as Black stringers (flow lines) on mosaic. Lower slopes in a more receiving position, also have black stringer appearance
							Cryic Fibrisol (poorly drained)	Black spruce, Labrador tea, crowberry, baked appleberry, leatherleaf, cowberry, sphagnum with reindeer moss	Slope bog. Ice at 33 cm. Black spruce are more stunted than those on Peaty Gleysol soil
		Drumlin-ized Till plain	Silty clay	Trainor Lake	Tr l	Brunisolic Gray Luvisol (moderately well drained)		Lodgepole pine, aspen, bunch berry, rose, cowberry, kinnickinnick, some feathermosses	Moderately well drained soils on till plain
							Peaty Gleysol (poorly drained)	Black spruce, Labrador tea, cinquefoil, willow, crowberry, cowberry, feathermosses and reindeer mosses	Receiving areas on lower slopes and drainageways
							Cryic Fibrisol (poorly drained)	Black spruce, Labrador tea, crowberry, leatherleaf, baked appleberry, sphagnum, and reindeer mosses	Open bogs in depressions. Ice at 33 cm

Geologic Material	Symbol	Landform	Texture	Soil Association	Symbol	Dominant Soil	Significant Soil	Characteristic Vegetation	Additional Notes
					Tr_2	Brunisolic Gray Luvisol (moderately well drained)		Vegetation similar to Tr_1 - Cryic Fibrisol	Ridges appear as islands in a matrix of organic soils
							Cryic Fibrisol (poorly drained)	Vegetation similar to Tr_1 - Cryic Fibrisol	Hummocky peat deposi mantle area
							Peaty Gleysol (poorly drained)	Vegetation similar to Tr_1 - Peaty Gleysol	Receiving areas. Muc more organic terrai in this association than Tr_1
Organic									
Ombro-trophic Bog	O_o	Peat Plateau	Fibric	Mackenzie Lowlands	Ml_1	Cryic Fibrisol (poorly drained)		Stunted black spruce, Labrador tea, baked appleberry, leatherleaf, crowberry, sphagnum and varying amounts of reindeer moss	Hummocky peat deposi Often burnt with collapse scars. Appears as pock-mar brown color on mosa
							Cryic Mesisol (Very poorly drained)	Scattered tamarack, black spruce, bog birch, willow, sedges	Minor component of a peat plateaux
Minero-trophic Fen	O_m	Fen	Mesic		Ml_2	Terric Mesisol (very poorly drained)		Bog birch, willow and sedges.	Infilling ponds in depressions or majo blocked up drainage channels
Trans-itional Bog	O_t	Slope Bog	Fibric	Tetcho Lake	T_o	Cryic Fibrisol (poorly drained)		Stunted black spruce, Labrador tea, baked appleberry, crowberry, sphagnum and reindeer mosses	Slope bog. More black spruce than Ml_1 assoc iation and more rei deer moss. Gray appearance on mosai
							Peaty Gleysol (poorly drained)	Black spruce, bog birch, alder, Labrador tea, feathermosses and reindeer mosses	Appears as black stringers on mosaic following drainagewa

Geologic Material	Symbol	Landform	Texture	Soil Association	Symbol	Dominant Soil	Significant Soil	Characteristic Vegetation	Additional Notes
							Gleyed Brunisolic Gray Luvisol (imperfectly drained)	Black spruce, lodgepole pine, balsam poplar, cinquefoil, rose, feathermosses	imperfectly drained soils found along drainageways, also appear as black stringers on mosaics

MAPPING LEGEND FOR MOORE CREEK BASIN

Environment or Geologic Material	Mapping Symbol	Texture	Dominant Soil	Significant Soil	Drainage	Characteristic Vegetation	Additional Notes
Alpine (A)	A-Tg	Gravelly loam	Alpine Dystric Brunisol		Moderately well drained	Scattered alpine fir, alpine bear berry, blueberry, arctic lupens, crowberry, cowberry, lichens	Shallow till derived from granitic bedrock, around and above tree line. Includes bare rock. Talus slopes and cirque headwall Slopes grade from gentle (5-15%) to very steep (70%
	A-Tgc	Gravelly sandy loam to loamy sand	Orthic Humo Ferric Podzol		Well drained	Alpine fir, lodgepole pine, dwarf birch, crowberry, cowberry, lichens	Cirque basins; dominant soi found on coarse textured moraines derived from granitic bedrock
				Alpine Dystric Brunisol	Moderately well drained	Alpine fir, dwarf willow, fescue, blueberry, anemone, lichen	Higher elevations - more op parkland type vegetation, scattered clumps of alpine fir, often many snow melt channels with bare rock showing.
Steepland Till (S)	S-Tg	Gravelly sandy loam	Degraded Dystric Brunisol		Moderately well drained	Alpine fir, lodgepole pine, white spruce, crowberry, bunch berry, feathermosses, lichens	Mixtures of till (slopes 20-60%) and colluvium. Sou east aspects have more tal slopes or snow melt channe while northwest aspects ha colluvium (soil wash mixed in with till)
				Peaty Gleysol	Poorly drained	Black spruce, alpine fir, willow, Labrador tea, crowberry, cowberry, feathermosses	Drainageways and lower slop (receiving areas). Slopes 5-20%
Alpine Meadow (glacial drift)	Go	Sandy loam to loamy sand	Degraded Dystric Brunisol		Well drained	Willow, dwarf birch, scattered alpine fir, cowberry, arctic lupens, fescue, lichens, feathermoss	Alpine meadow, headwaters f Moore Creek. Outwash or k deposits and eskers. Slop 5-20%. Erosion following fires evident in soils (cu ic or added horizons). Hummocky terrain with some ponded water

Environment or Geologic Material	Mapping Symbol	Texture	Dominant Soil	Significant Soil	Drainage	Characteristic Vegetation	Additional Notes
				Peaty Gleysol	Poorly drained	Willow, Labrador tea, crowberry, feathermosses	Found along drainageways and depressions
Glacial Fluvial	Gk	Gravelly sandy loam	Degraded Dystric Brunisol		Moderately well drained	Lodgepole pine, white spruce, bunch berry, feathermosses, lichens	Series of old terraces of Rancheria River adjacent to the Alaska Highway
				Peaty Gleysol	Poorly drained	Black spruce, alder, willow, Labrador tea, crowberry, cowberry, feathermosses	Depressions and drainageways

9. Other Comments

I solicited other comments for consideration. Replies included:

(a) problems of mapping of organic soils, organic terrain and terrain affected by permafrost. (Hopefully this can be settled by adoption of Landform Classification.)

(b) prior preparation to field work is essential, e.g. photo interpretation, geologic, climatic data, etc.

(c) consult with other disciplines to determine specific characters they require, e.g. depth of L-H, depth to permafrost, amount of coarse fragments, ground water discharge features, etc.

(d) more consideration should be given to data collection, such as what type of information should be collected, how should it be compiled and stored for use?

(e) if these surveys are considered as "initial" with future more detailed surveys a distinct likelihood would it not be advisable to develop a system in the initial survey which would avoid duplication of effort in subsequent studies?

(f) limit the amount of information in the map legend and force the users to use the report.

(g) obtain better air photographs of various scales, imagery, filter combinations, etc. to speed up the work and increase reliability.

All of the above comments are valid;some hopefully were answered in the preceeding report, others require further clarification and thought and all of them require discussion. I personally feel that our most pressing problem is to develop national and uniform guidelines for soil mapping and we should attempt to develop these guidelines as quantitatively as possible for utilization by all resource personnel. It is imperative that techniques and methodology associated with computer data handling and various kinds of remote sensing be kept in mind in our deliberations.

Recommendations:

1. That the C.S.S.C. adopt in principle the scheme for mapping presented in the report on Page 10 on a trial basis with the intention of complete evaluation at the next National Meeting.

2. That the various soil survey units implement and encourage interdisciplinary communications and studies with both professional resource personnel and users of soil survey information.

3. That the continued development of methodology of soil survey procedures be congruent with the advances being made in the areas of remote sensing and computer data handling.

4. That the C.S.S.C. approach the N.C.F.L. and strike a joint committee to develop a land classification system that is satisfactory to both national committees and that the system have a common terminology.

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The following segment is a discussion of papers presented on topic of Surveys of Forestland and Permafrost Areas led by L.M. Lavkulich.

Acton: A very interesting presentation Dr. Rutter. I am glad to hear that you recognize the need for a pedologist as part of our inventory of physical resources in these areas. Looking at the logistics I was wondering what your reaction would be to the approach where the Pedologist was the main person on the ground with the geologist coming in to interpret some of the basic data which the pedologist had collected and interpret the data in a geological manner. Is there a need for the geologist to go through and make a broad map and the pedologist to pick up the detail or can the pedologist virtually make most of these observations?

Rutter: If it's accepted that geology is necessary for the pedologist or if the pedologist must have surficial geological maps available, I think we're after the same thing. In other words, your question is what discipline do you put to coordinate this activity. You could put a pedologist in charge of this kind of program or you could put a geologist. The question is defining the basic unit that you are going to use. Are you going to start with the soil or are your going to start with the geological unit? It's what you put first, isn't it? I see nothing wrong with either approach. It's just a matter of what the policy is or will be. I think the final product comes out about the same.

Acton: But is there a duplication of effort here?

Rutter: I don't think so. I think if you reverse the situation, it could be quite different. In other words the reconnaissance geologist would be looking at everything and more or less guiding other scientists and they should not duplicate in adding their work to the geologist's work, but to me there is no duplication here.

Acton: Wouldn't a lot of the basic geological features that you would be recognizing be more or less obvious in the detail that the pedologist would be picking up?

Rutter: To me it isn't obvious. If it was the case that all you had to do was interpret air photographs this would be fine, but even with 200 or 300 stops on an entire map sheet you can still make bad mistakes in interpreting landforms.

Lavkulich: I think Rutter is saying that thelogistics of the northern program requires that, rather than having any one discipline per se arguing for a major disciplinary approach, the area must be mapped quickly. Four map sheets per year for a geologist is a big task. Rutter is mapping very quickly and has not much time to fool around. Not much time to examine micro observations, when you have to mape this much area.

Smith: Looking at the legend that Pettapiece has worked out in conjunction with Hughes of the GSC, I notice that the biological input in this survey has been confined to observations on the present vegetation and micro-topographic features and some information on the distribution of drainage patterns but there is nothing at all about soil as we understand it. This seems, to me, to be the only real lack in the approach taken. I assume that the reason for providing pedology information was to characterize the habitat for the production of shelter and food for any living thing. I want to conclude by saying that apparently the objective of the survey has been overlooked.

Rutter: We are looking at the problem from the physical science approach. We haven't considered at all the wildlife and the sociological side. We have certain things we can look at with the time and money available. The people of the Canadian Wildlife Service have copies of our map and they are now occupied with constructing wildlife habitat maps on our base, to provide information for different animals in the North.

Pettapiece: Just some concluding remarks. Looking at mapping first. Whether or not you realize it, the legend and survey is almost identical in approach with the biophysical approach, at the land region and land system levels. In other words we had broad climatic zones and we broke those up. I think it worked and I don't think it is any different than our broad reconnaissance soil surveys, except for the lack of soil classification criteria which I agree is a definite limitation. The point is we can map and describe soils within a prescribed system without classifying them taxonomically. We can do this, although it is an inferior product. The biophysical approach works very well and I would suggest that an expanded soil section is probably the right compromise at this scale of mapping. Second, on classifications. Certainly there is a problem. We have to come to some solution to this problem and we can't ignore it. We can continue in the same manner that we have but we would not improve the product. I can't offer any solution because after one summer, and in one geological province, it's just not a broad enough approach to appreciate the whole situation. It is however enough experience to know that a problem exists and to realize that if this problem is not dealt with there is no real advantage for a trained pedologist to be included in the resource inventory team, apart from this trained ability to impart observations. Now let me briefly comment on some of Rutter's comments. I do believe that a pedologist can add considerably to any study of this kind. We may have to bend a little bit, and sometimes quite a bit, but I do think we can contribute and this will be beneficial both ways. If you want to get a little selfish we should use every opportunity that arises to extend our knowledge of what soils we have in this country, but I also think it behooves us to take some responsibility in the realm of adequately recognizing, understanding and classifying new soils. I was quite happy with the way the survey went last year. I thought it was a good approach. I don't see anything wrong with, as Don Acton was indicating, one person taking the lead and going it on his own with a little bit of input from other people. Essentially this is what we were doing last year with the geologists taking the lead. I think the pedologist could take the lead equally well. I see no problem here at all. The only problem is that of policy at this moment.

Peters: Devon Island is a three year job with IBP. The Canadians are working on Devon Island, the Americans are working at Point Barrow, and there are some people in Scotland, Sweden, Finland and Russian on similar projects. Also there is work being done on the Mackenzie Delta and at other IBP sites scattered across the continent. For instance, at Matador. The base at Devon is at Cape Sparbo and is quite isolated. It is 75° north, about 2 1/2 hours flying from Resolute Bay. The base is on the north shore of Devon Island and one can see Ellesmere Island to the north, so that gives you an idea of where we are. You can even see the glaciers on Ellesmere Island.

The program is a multidisciplinary approach. A study of the ecosystem. We have soils people, geologists, hydrologists, antomologists, botonist galore, zoologists, climatologists, you name it we've got it. They may not be there all for the same length of time but they do come in and have an input into the whole system. The idea is to study the energy that is going into the system and that which is coming out, and so every expert who goes has a compartment in this model and he has to contribute his bit to the whole thing. Mine happens to be connected with mineral silting and also to look at the soils in this area and see if it can help soil classification.

We have a very primitive camp., We live in parkalls of Jamesway huts. We have to have everything flown in. The logistics of the program are fantastic especially the cost of flying in. Getting these boys in with their basis equipment is very expensive. Our project costs between $275,000 and $300,000 a year, which is not including the salaries of the researchers themselves. This is just feeding, analyses of samples, travel and equipment.

It is quite an interesting area. Devon Island itself is quite bleak. The lowlands that occur, especially on the northern coast, are quite fertile and this particular project area was selected because the Arctic Institute of North America had already established a camp there and they had a landing strip on one of the beaches. We had a place to start and set up our own camp. This was done in the early 60's. We have enlarged the camp quite a bit. We have an area that there is sort of a closed system in one sense. It's about 16 aq. miles, in an area in which muskox graze in the fall and winter and the polar bears play around there in the wintertime, not in the summer time. It was really exciting. We had four foxes on it this year and one of the guys wanted to go out and shoot them, but there was quite a storm blown up. After all you lose 25% of your population if you shoot one of these poor little fox which is eating up all the eggs of the old squaw and the eider ducks. The birdman was going crazy and so it's a very delicate system up there. You are in the high Arctic, you don't have trees. The highest tree I saw there was Salix and it was about 6 inches high and that was in a fovorable spot, but they do creep along the ground and they provide a lot of food for the muskox. Muskox are quite important in this area. Muminologists want to see if the carrying capacity can be increased on the lowland for these animals as the muskox fur is quite high-priced. People collect it and they weave skirts out of it. The girls and the women make yarn out of it and you have something that you can't buy. They are expensive but its so light and warm, and the muskox provide a little meat for some of the Eskimos that live on Ellesmere. We do not have any Eskimo families on Devon Island because the government moved them all to Greis Fjord, where they could handle them a little better and service them with liquor and all the social amenities that we have in our civilization.

The elevation on the lowland runs from sealevel to about 90 feet on the lowlands itself. Its composed primarily of marine beaches and beach lines interlaced with settling basins in which we have meadows, Carex being the chief vegetation, very productive in the sense that they are green and the rest of the country is brown. On the beach ridges in some of the more sheltered spots there is quite a vegetative growth of Saxitroge, Solastium and all these things, alpine plants which you see up in our mountains here.

Maybe I better say something about the hydrology of the area. Between these beach ridges we often have lakes. They vary in depth from a few feet to maybe 50 feet and the deeper ones do not freeze to the bottom. You get a few arctic char. You know, a real delicacy and once or twice a year they are allowed to fish because there are not that many there. If you take too many out you upset the balance. I think last year was the first year that some of the lakes managed to become clear of ice. Ordinarily there is always ice so you get chilled water for your drinks. We make it up there, by the way, we are allowed!

We are in a very dry area, precipitation-wise. With two months of growing season we have up there, about 80 days, you may get one-half inch of rain. The winter snowfall may come up to 20 inches. You find it blown into huge drifts on one side or the other of the beach ridge so you have a lot of exposed beach ridges on which the muskox will travel and browse. The granite outcrops that occur in this are shelter spots for the muskox and they can also browse on some of the mosses that occur in rocky areas. This area is quite a good muskox habitat. During the summer and early fall they come down and browse around some of the meadows. As I said the growing season on the top of the beach ridge is roughly 80 days. As you come down the slopes of these beaches it gets shorter and shorter until it runs down to about 40 days, and so these plants have really got to buzz along. They start blooming practically before the snow is off the ground and you can look under the clear snow and see the flower buds forming and the next day the snow will be gone and the plants will be practically in flower.

With regards to permafrost the active layer varies in depth. In the latter part of August it may be 10 inches to the frost. On the top of the beach you will get maybe 30 inches. The soils on the beach ridges are quite alkaline. They are very low in available nutrient; nitrogen, and phorphosurs. Potassium is not so bad, sulphur now and the, and phosphorus is very low. We have been doing work on ammonia release. Nitrates are quite low but in some of the meadow sites you will find that the ammonia release is quite high but as a rule conditions are so cold up there that it doesn't get a chance to be released.

There is a great deal of water moving through these soils just above the permafrost even in some of the regosols that are found at the top of the beach ridge. This water is very cold, just above freezing. It contains a maximum amount of oxygen. The gleysols that occur down slope do not show the colours that you expect to see, not the grey or anything like that, they are just wet soils. You do not get mottling except in spots where iron comes out from somewhere. So we have quite a problem in mapping these soils. I have been sort of playing around with the biophysical approach down to land type but we have not really decided how we are going to handle this until we get some more of our analyses and get some of these soils mapped in greater detail. So far we have been helping other people to relate the soils and vegetation to other factors. It is a very interesting project. It is a lovely spot to go for 2 or 3 weeks to get away from the radio and television and newspaper and just be a slob.

Dumanski: Comments on Lavkulich paper. I think that in the kind of change you are trying to develop we have to decide and define the unit that is going to be used. You have proposed the USDA definition of the Soil Association. We have used the Soil Association in Canada now for a number of years. I think that the principal thing that must be done is to have all people use the same unit so that we can then tell each other what we mean.

Clark: I would like to make a comment on your last recommendation. We have laready had some discussion with personnel of the Canadian Forest Service about the question of getting together to de essentially what is recommended in Item 4. Perhaps our Committee structure is wrong. What we really need is a National Committee on Lands involving all the discipline interested in land survey. Possibly the Canada Soil Survey Committee should be a sub-committee of that Land Committee rather than a part of the Canadian Agricultural Services Coordinating Committee. We have made some recommendations to the Research Branch Executive to go ahead with that. I would like to know what your reaction is, the reaction of the group, to this kind of a possibility. In other words taking the location of the survey out of an agricultural context to a land context. I think it would help us to attract non-agriculturists to this group. I would like to add this as a possibility, if you are willing, to your recommendation No. 5. That is, that the establishment of a National Committee on Lands be promoted and that we attempt to incorporate the National Soil Survey Committee as a sub-committee of that organization.

Acton: A question to Lavkulich. I understand that in the proposal for reconnaissance names, you would like to see anyone using the term Soil Assocation use it within the content of the USDA definition.

Lavkulich: Yes, this is the idea Don. I would really like people to seriously try it. If we do not want to change the term Soil Association in Canada then we should find another term for Northern Reconnaissance Survey because there are areas where the complexity of the terrain does not allow us to group similar materials together.

Acton: Seriously though, didn't the term Soil Association start in Canada? And hasen't it been used more or less in this context? Why go changing something like that now?

Lavkulich: I have nothing against that Don, we can stick with it. The only thing that I would like to point out is that we need some term that is a little broader than our Association. If we can use our Association or catena by all means use it, because it may give us more information. In some of the cases we can. If the terrain is too complex than we need another term. What I am afraid of is that the Americans are using the Soil Association in another context. I am going back to the users of information. If you start talking to managers who are comparing maps from all over the place, not only Canada, and they look and say, Ah, Soil Association we know what this means because that's the way it is used in Canada, however it they pick up an American map and it is all different we will just have nothing but confusion with respect to our users. In the multilingual dictionary of Soil Science the Canadian definition of Soil Association doesn't even show up.

Acton: Can you imagine the confusion in Western Canadian Soil Survey information if we were to introduce a new term.

Lavkulich: This is why I suggested some other term than Soil Association, for example, Geounit.

Smith: We have handled complexes of soil catenas and I know that in Saskatchewan they have had complexes of soil associations. Why cannot we use this basic unit, catena. Even if you have to employ complexes of them in a description of these land systems as units in the type of legend that has been developed for the Mackenzie River.

Lavkulich: Because we are not being consistent in our definition of catenas or complexes. We use complex at the detailed level and at the reconnaissance level and the exploratory level.

Clark: Are we not being caught up in detail and couldn't we give this unit, the association or catena, another name and give the whole system a trial?

Day: I looked at Lavkulich's submitted legend and I didn't like the way he put it together because I thought there were some things that he didn't say. I also wanted to beat the drum for using some elements of soil family, some combination of great groups or subgroups. I sent him the version which is on the bottom of page 12 and I suggested the geounit simply because I didn't like the sound of soil geographic unit. It was too long. But at the same time I could just as easily have called the thing a mapping unit. That's the kind of approach that I have argued in Western Canada recently, particularly with the Federal people for example Terry Lord's map in the Tulameen. I think he just could as easily have called the units on his map geounits as mapping units. I don't think it matters a heck of a lot what name you put on them provided that you describe adequately what is in there. For this geounit on the bottom of page 12 I used the words that

Les put in his legend and I also dreamed up some characteristics that he may not have commented on. One of the things that I did attempt to do was describe as fully as possible all the kinds of things that would be within that boundary on the map. I think one of the things that you didn't say, Les, was what percentage within this map unit were mineral soils and what percentage were organic soils. To me that is an important part of the description. Now, one could just as easily argue that this paragraph on page 12 is too long and too cumbersome for a legend. I will agree that that is perhaps true, but you could use a much more restricted version in a mapping legend and put a much more expanded description of that mapping unit in the report. My idea would be that the mapping unit and all the things that are in there, the characteristics of the soils, the depth to permafrost, vegetation, etc. need to be described fully. There is some happy ground to be reached on what you put in the map legend.

Lavkulich: I am sorry there is one mistake we made in our legend and that was in the definition of dominant and subdominant. We have that in our mapping legend so we do give an indication of that in the report.

Day: Related to dominant and significant, one tends to get set concepts. I would prefer to see your best estimate of all the components of the mapping unit or geounit. I would like you to estimate them for me because geounit Tdl may have a slightly different percent distribution than another geounit with the same kinds of materials and the distinction would only be a matter of distribution. This is where you come close to the American definition of Soil Association. I would sooner stay away from all kinds of names like geounits and American association, Canadian association on a job of this type.

Clark: Has anybody serious objection to this idea of substituting geounit for the American soil association, defined in the same term as the American Association.

Day: I take exception to that because I wouldn't like geounit to mean the same thing as American Soil Association. I want to have the ability to describe what is in that block. American Soil Association isn't going to fit what I think needs to be done, for example, if there are 60% of mineral soils and 30% of organic soils in an area that is outside of the definition of the American Soil Association.

Lavkulich: If you look at their surveys in forested areas you will find that their association is defined in terms of 70% of this and 20% of that on various parent materials.

Coen: The term geounit has been included in the literature as a geological term. I fear that we would be infringing on the geological term.

Sneddon: Since these proposals were to be put on a trial basis for evaluation prior to the next National Meeting I think the present recommendations are pretty good. If someone comes up with something better that they can define specifically I think this should be considered.

Clark: We could leave the recommendation if you are willing stricking out the term USDA which is specific and we could leave the rest of the thing as an appropriate mapping unit with associations, catenas, families, texture, leaving it in a loose sense with the idea that this is not the final development, but that it is an interim attempt for trial. This recommendation put by Clark was adopted by a show of hands.

Report on the Status of the Canada Soil Information System (CanSIS)

J. Dumanski

At the 1970 C.S.S.C. meetings it was recommended that a soil data bank for Canada be developed. It was further recommended that the Central Data Bank be located at the Soil Research Institute and that coordination of the data be one of the responsibilities of a National Soil Correlation Service. This report outlines the progress that has been made in this field.

Successful land use planning involves, among other things, evaluations and interpretations of soils and soil information. Pedologists have been collecting and manually cataloguing information on Canadian soils for the past half century. Although some of this data has been published, the largest proportion of it has been stored in individual filing systems. Experience has shown that information in this form unfortunately is accessible only with considerable difficulty, and sometimes not at all. This subcommittee was formed, therefore, to examine computer methods of data storage and retrieval.

To date, the activities of the subcommittee have been confined to the preparation of a coding system for soil pedon data. This was considered to be the problem of greatest immediate concern, in view of the fact that various provincial soil data systems were already being developed. It was felt that a national soil code was needed so that collection of data proceded in a uniform manner. However, before delving deeply into these aspects a few observations on the position of computers in relation to soil survey operations may be pertinent.

The Computer and the Pedologist

To be fully effective any computerized soil information system (soil data bank) must be developed in the total content of the science of pedology, and not simply carried out as an isolated excercise on the computerization of soils information. A properly oriented data system has to be comprehensive, but yet sufficiently flexible to allow for the incorporation of the unforeseen. At the same time, there arises a need for a certain degree of rigidity and control in the collection of data and in that way the system may affect the development of the science. Therefore it is important that the particular system be developed thoughtfully.

The systematized storage of data implies the need for more stringent controls on the quality, quantity and character of the data collected than has been experienced in the past, and this may require some adjustment on the part of all individuals concerned with soil survey. The mechanics of computers, however, necessitate such controls, and the strict adherence to these in relation to the success of the data system cannot be overemphasized. This is true in particular when CanSIS is interfaced with other computer oriented systems such as C.L.I., CANFARM, U.S.D.A. and F.A.O. systems, etc. Because a data system involves a good deal more than the orderly collection and storage of data, there must be a certain degree of central coordination of data collection, storage and retrieval.

A second point which is of paramount importance is the compatability of data. Difficulties in data compatibility arise because of: (a) imperfect correspondence of attributes with the same label. This is common for laboratory data, e.g., pH in H_2O vs. pH in $CaCl_2$; iron extracted with oxalate or dithionite, etc. Compatibility in this category is achieved either by different people using the same method, or by using methods which give the same answer. Failing this, then the method must be indicated; (b) imperfect coincidence of classes with the same label within an attribute. This applies mainly to descriptive data, e.g., terms such as very stony, etc. must mean the same thing to all people. Compatibility is achieved by specifying as clearly as possible the boundaries between classes, and by all people using the same limits.

It is important to realize that the success of any computer oriented information system is generally a direct function of the degree of involvement that people have with the system. Each partner in a man-computer partnership needs to decide what he or it does best and then do it! A computer when used as a tool can alleviate considerably the drudgery from one's work, but it requires a certain amount of initial individual effort to understand and use the system. Without a considerable amount of serious involvement, the data information system outlined herein would likely prove to be a disappointment.

Finally, there appears the question of the place of a computer in relation to data processing for soil survey. Dillon quoted by Moore (unpublished) states that the characteristics of a problem whose solution can be aided by a computer should be one of the following:

(a) the problem involves complicated mathematical solutions;
(b) a large volume of data is to be used in solving the problem;
(c) a high frequency of retrieval of information from a large file is of prime concern.

Common to all three is an enormous number of operations, many of which may be repetitive. In using computers one must be realistic and not look to a fictional system whereby all things are available at a single command. There are many things which are possible with computers, but only a soil scientist can effectively evaluate the output. Computers increase rather than decrease the need for trained pedologists, because so many more things are possible so much quicker.

The CanSIS Approach to Soil Data Processing

It is proposed that the soil information contained in CanSIS be structured in a hierarchical fashion on the basis of files, records and modules. A file is a collection of records each of which contains information on a particular member of a set of objects. A record is a string of data pertinent to the characterization of the object that constitutes the record, e.g., a pedon description is a record and it in turn is part of the soil data file. A module is a logical subdivision of the data that makes up the record.

At present the total number of data files has not been decided. From the standpoint of data input it is envisaged that possibly four files would be advantageous. These could be a soil data file, soil cartographic file, an administrative/geographic file and a performance/management file. At the output end there could be a number of generated files, examples of which are a soil series file, soil classification file, soil productivity file as per certain groups of crops, soil engineering file for various uses, etc. At this stage of development of the system the number and types of files will be kept flexible, until such time as experience has indicated the optimum arrangement. A collection of computer programs will be written to make use of the files.

The files will be made compatible with related data files that are presently developed or being developed. They will also be made compatible to each other.

1. The Soil Data File

This file has received considerable attention in the past few years. The various soil data banks established by the B.C., Alberta, Saskatchewan, and Manitoba soil survey units as well as the ecological data base of Quebec all fall within the realm of this file. By combining certain aspects of the above listed data systems with the varied proposals gathered by this subcommittee, a first draft of a soil site coding scheme has been prepared, and is circulated for your comments. The coding scheme essentially describes the structure and content of the soil data file.

Information contained in the soil data file is restricted to that which is site specific; it is arranged according to 14 modules. The modules include identification, classification, geographic location, site description, interpretation, methods, morphological description, chemical data (for survey considerations), chemical data (for fertility considerations), physical data (for survey consideration), physical data (for engineering considerations), non-routine chemical data, non-routine physical data and mineralogy modules. Each module may cover part of a card, an entire card or several cards. The modules are arranged somewhat according to the sequence of data collection that is commonly employed in soil survey operations, with some adjustment to computer needs. Also, some of this information is based on common methods of describing soils in soil survey reports. Content in this file will be restricted to data collected on a named soil basis, preferably by horizons.

The soil coding system is circulated at this time in the hope that comments on it will be received before the beginning of April. At that time it will be revised, after which it must be checked by the Data Processing Branch of C.D.A. for verification of computer compatibility. Upon completion of these aspects the code will be released for general circulation.

By itself, the uses of this file may be:

(1) Print-out of soil profile descriptions, with or without analytical data, in a form suitable for publication.

(2) Retrieval and rapid scanning of data for specific purposes, e.g., papers, speeches, etc.

(3) Development and print-out of a soil series file. This file would be used for provincial and national correlation, but it would also serve for quality control on series separations.

(4) Development and print-out of a soil classification file to be used for provincial, national and international correlation.

(5) Development and print-out of new classifications tailored to specific needs, e.g., soil performance groups for specific crops, engineering applications, etc.

(6) Research on soil properties some of which may be:

  (a) trend analysis and computer mapping techniques.

  (b) defining mean limits for soil classification at any level of abstraction.

  (c) development of techniques for special purpose classifications.

  (d) numerical, statistical, etc. analysis of data.

2. <u>Soil Cartographic File</u>

The soil cartographic file will contain information about the geographic distribution of soils. This file will be important for locating soil data for any specified geographic or administrative boundary. Output will generally accompany output from one of the other files, may be in either tabular or graphic form, and may be for any purpose.

Input into this file will involve digitizing all systematically drawn soil maps, regardless of scale, that have been, are being or will be produced. Also, the soil and soil climate maps of Canada will be included as will any other maps which have a direct bearing on the distribution of soil properties. Essentially, the file will consist of a series of digitized soil maps.

In the creation of this file, use will be made of the extensive computer oriented cartographic experience which has been gained by the cartography section of S.R.I. in the C.L.I. program. It is visualized that maps will be digitized in a manner similar to that used in the C.L.I. program.

This file will have limited application by itself, although it could be used for such things as calculating acreage, color separations, etc. It will be of greatest value when used in combination with the soil data file and other files for local, regional or national land use studies. In the latter instance it would compliment other files and permit planning and decision making on the basis of a physical soil base. It may also prove to be of advantage in the application of remote sensing to soil and land inventory.

Very little work has been done on the soil cartographic file to-date. However, because many of the computer programs which were originally written for the C.L.I. program will be equally applicable to the soil data bank, rapid development of this file will be possible if sufficient resources are made available. Digitizing tables would need to be purchased, the cartography section of S.R.I. would need to be greatly expanded, and additional professional expertise would be necessary.

3. Administrative/Geographic File

This file is visualized as essentially a reference file for data output. The boundaries of all potentially important administrative maps, e.g., provinces, municipalities, counties, etc., as well as non-soil geographic boundaries, e.g., water-sheds, geology, physiography, climate, etc., will be digitized and stored. Soil information within the boundaries of each of the units could then be made available upon request.

4. Performance/Management File

Soil productivity relative to specific crops (agricultural and woodland) obtained under specified levels of management will be stored in this file. Response of soils to various kinds and levels of manipulation under forestry, recreation, engineering, agriculture, etc. will also be included. Ideally such information will need to be collected on a soil and/or an area basis to allow for the interfacing of this file to the soil data and soil cartography files.

The importance of this file to the overall CanSIS system cannot be over-emphasized. The application and utility of the CanSIS system will to a large extent depend on the success achieved in defining concise relationships between soils and their performance as reflected by yields and carrying capacities, and between soils and their behavior under various manipulations or treatments.

Regional Concepts of CanSIS

Development of soil data banks should not be viewed as the job of a single institution or of any one individual. Soil data has application principally in areas other than those which are of concern at the national level. It would be advantageous, therefore, for each regional soil survey unit, which has the resources, to establish their own data bank provided that the provincial data banks be made compatable with CanSIS. This would allow for the easy exchange and dissemination of information, and ensure that the banks are complementary to each other and mutually supportive. CanSIS, therefore, is viewed not as one but as a number of cooperative data banks linked together on a national basis through agreement on organization, files and codes, and coordinated by the central data bank located in Ottawa.

One of the greatest operational problems in any data system is the drudgery involved in data logging for input. To alleviate this, it is proposed that one person in each province or soil survey unit whichever the case may be, be charged with the responsibility of ensuring that their data be coded. He need not do the coding himself, but it is his responsibility to ensure that it is done and done correctly. The adoption of a single code has an obvious advantage here in that having coded the information once, it then serves as input to either the central or regional data bank. Also, having people in regional offices encode information imposes a certain amount of quality control on the data that goes into the system. Further, it involves more people in the system and thereby ensures success.

Recommendations

1. That soil data banks be made compatable by agreement on structure, files and codes, and that coordination of the banks be handled by the central data bank.

2. That a minimum of one person from each regional unit be assigned the responsibility of ensuring that soil data be coded.

3. That the soil site coding scheme be accepted for a one year trial.

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Clark: What I would like to entertain is a motion for the adoption of these first two recommendations and I would like a vote on this because it means a commitment which we will take to mean general acceptance of these two approaches by those concerned.

Day: I move these recommendations 1 and 2 be adopted as read.

Seconded by Cann.

Motion was adopted by a show of hands.

Dumanski: I would like to rephrase recommendation 3 and have it read that the soil site coding scheme as revised after April 1 be accepted for a one year trial basis.

Clark: I will entertain a motion from the floor for the adoption of Dr. Dumanski's recommendations on the soil site coding system as revised. The motion was put by Pawluk and seconded by Beke. The motion was adopted by a show of hands.

Report on Remote Sensing Experiments

A. R. Mack

In 1971 under the National Aircraft Program of the Canada Centre for Remote Sensing a number of sites were selected in western Canada where survey units were able to provide ground observation information. The availability of multi-band camera systems and high altitude aircraft provided the opportunity for a number of individuals to become more familiar with developments in multi-spectral imagery and better informed on what additional information may be obtained to supplement present use of standard aerial photography. Low level (< 10,000 ft. altitude) multi-band photography did not become available in sufficient time in 1971 to be generally included. Some thermal I.R. Scanner imagery was obtained, but quality of imagery was not up to expectations and consequently results are rather preliminary. In general interpretative technology is still very rudimentary and developmental work is required to provide reliable identifiable information. Compared to a year ago we are in a much better informed position to discuss and evaluate significance of physical features in imagery taken at different parts of the electro-magnetic spectrum. It is expected that with the proposed plans to up date the capability of the National Air Photo Library Production Unit (Department of Energy, Mines and Resources) and increase the capability for low and high altitude sensing in Canada in 1972 under the Canada Centre for Remote Sensing that more effective use can be developed for much of the multi-spectral imaging technology that is currently latent in the country awaiting improvements in techniques for it to provide effective information in a timely and efficient manner.

In 1972, for the first time, imagery on a macro scale will become available for all of Canada (Scale 1:1,000,000). It is hoped that by fall of 1972 at least one complete set of imagery will be available having a resolution of ca 100 meters.

Without the active support of many of the members of the CSSC, familiarity with multi-spectral imagery for soils and crops in Canada would have been much less. Many of the papers related to soil and terrain features presented in technical papers at the First Canadian Symposium on Remote Sensing in February, 1972, were by members of the Committee, and copies of the Proceedings are expected to be available by August.

Attached are papers and summaries presented at this Western Section meeting (G.F. Mills, G.J. Beke, C. Tarnocai, W. Michalyna, P. Crown, G.G. Runke).

The following recommendations were presented at the Western Section meeting:

1. That CaSCC support studies on development and improvement of remote sensing methodology that may be useful for increasing the efficiency and accuracy of acquiring and distributing information on our soil resources.

   - moved by Don Acton
   - seconded by R. Hedlin
   - Agreed

2. That the CSSC Chairman establish a committee on remote sensing methodology to recommend on new technology studies and to assist in coordinating national remote sensing experimental programs associated with soil resource surveys.

   - moved by R. Hedlin
   - seconded by Rowles
   - Agreed

3. That the CSSC recommends that a consideration be given to interphasing ERTS imagery with the soil bank data system.

   - moved by S. Pawluk
   - seconded by P. Crown
   - Agreed

THE APPLICATION OF REMOTE SENSING TECHNIQUES TO THE STUDY OF SOIL PROPERTIES

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ABSTRACT

Medium and high altitude multispectral photography and low altitude thermal infrared scanning was obtained for the Wellwood area of Manitoba during the summer of 1971. An evaluation of the various kinds of imagery was carried out to determine if these techniques could be applied successfully to identify soil properties.

Preliminary analysis of the imagery in light of the ground truth obtained in 1971 indicate that no single film-filter combination or image type is best for identifying or mapping soil properties. None of the image types were dependable for differentiation of soil texture. Variation in soil organic matter content could be identified by colour infrared, red band and thermal infrared imagery. Soil moisture properties could be differentiated on the near infrared black and white and colour imagery as well as with the thermal infrared data. An assessment of topographic pattern and slopes could be accomplished on all image types, but most easily with panchromatic black and white, red band and colour infrared imagery.

INTRODUCTION

During the course of the 1971 field season various pilot projects with respect to remote sensing were carried out by the Manitoba Soil Survey.

"Remote sensing" as currently used by a number of scientists is a term to describe the study of remote objects from great distances[1/]. It is the measurement of environmental conditions at or near the surface of the earth by means of sensors on airborne and space vehicles. Remote sensing of the earth's surface brings together such varied technology as modern sensors, data processing equipment, communication devices, information theory and processing methodology and space and airborne vehicle technology.

With the proximity of the launching of the first Earth Resources Technology Satellite (ERTS A) by the United States National Aeronautics and Space Administration early in 1972 it seemed necessary for soil scientists in Manitoba to become familiar with the use and interpretation of the new kinds of imagery which will shortly become available to us. It was felt that as we gain expertise in remote sensing, we may gain access to a valuable tool for obtaining soil information quickly and more efficiently in our exploratory and reconnaissance soil surveys.

Although several approaches are possible when one starts out to use remote sensing in soil studies, the method used in this pilot project was to try to evaluate the relationships between soil properties and the response on various kinds of imagery. Only soil properties which are expressed at or near the soil surface are likely to have a very pronounced effect on the imagery. There is the possibility of identifying such soil properties directly if the imagery is remotely sensed from a bare soil surface or indirectly as the property in question may affect vegetative

1/ Remote Sensing with Special Reference to Agriculture and Forestry, Chapt. 1, p. 1. Committee on Remote Sensing for agricultural Purposes, Agricultural Board, National Research Council, National Academy of Sciences, Washington, D.C., 1970.

cover on the soil. Remote sensing techniques present possibilities of determining soil properties on various kinds of imagery by sensing particular portions of the electromagnetic spectrum. The visible portion of the spectrum can be divided into narrow wavelengths by means of various photographic film-filter combinations. Thermal-moisture relationship of a soil can be sensed by infrared wavelengths. The shape of a landscape can be measured by SLAR techniques.

METHODS AND MATERIALS

Description of Study Area

A portion of the upper Assiniboine Delta in southern Manitoba was chosen for this study (Wellwood Study Area). Detailed ground truth collection to ascertain the relationship between soil properties at the time of flight and the image obtained was carried out at eleven sites on an east-west transect through the Delta. The location of the sites for ground truth data collection with respect to the various kinds of imagery and to the soils of the area are shown in Figure 1. The ground truth information involved the assessment of the following factors:

- soil type and texture
- soil drainage
- soil moisture content (surface and 20 cm)
- soil temperature (surface and 20 cm)
- soil colour
- surface condition (% trash cover, direction of cultivation, degree of roughness, cloddiness and aggregation)
- vegetative cover

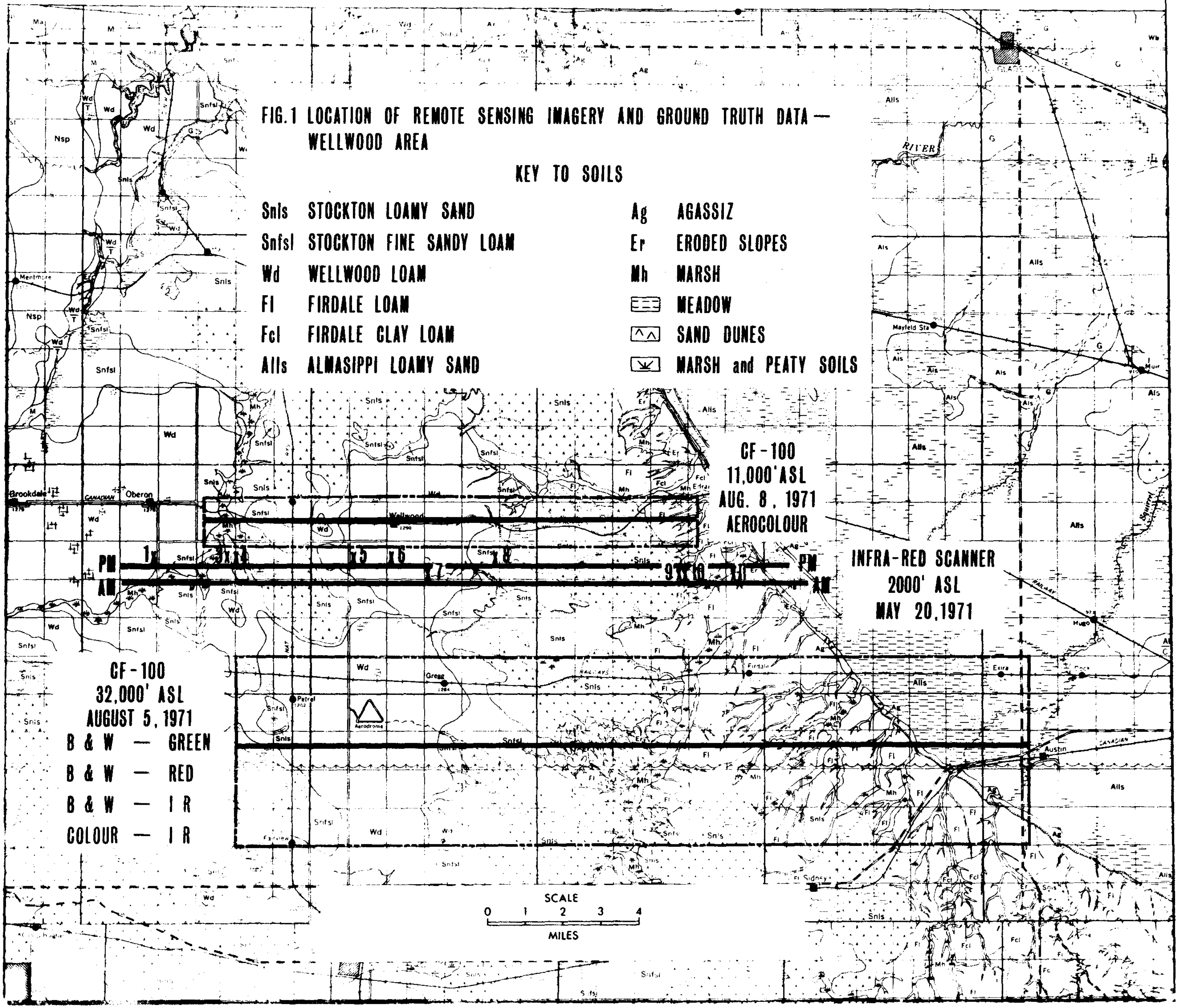

FIG. 1 LOCATION OF REMOTE SENSING IMAGERY AND GROUND TRUTH DATA — WELLWOOD AREA

The soils of the area occur in the Stockton and Wellwood Associations (Chernozemic Black) and the Firdale Association (Chernozemic Dark Grey)[1/]. Soil textures vary from moderately coarse (Stockton loamy sand) to medium (Stockton fine sandy loam) to medium and moderately fine (Wellwood loam and Firdale clay loam). Soil drainage varies from well through imperfect to poor. In general, topography of the Stockton fine sandy loam and Wellwood loam is level; the Stockton loamy sands are undulating to level and Firdale loams and clay loams are level to rolling. Erosion varies from none to slight in the Wellwood loams and Stockton fine sandy loams and from moderate to severe in some areas of Firdale loams and clay loams and Stockton loamy sands.

Description of Imagery

The remote sensing data used in this study were of two kinds: (1) thermal infrared scanning obtained from low altitude flights and (2) photographic imagery obtained from medium altitude and high altitude CF-100 flights. In addition, panchromatic black and white photographs obtained in July, 1948, October, 1958, and September, 1964 at an altitude of 8,000 feet a.s.l. were used in this study. The specifications of the imagery obtained from the various flights are presented in Table 1.

1/ Ehrlich, W.A., E.A. Poyser and L.E. Pratt. Report of Reconnaissance Soil Survey of Carberry Map Sheet Area. Soils Report No. 7, 1957. Manitoba Soil Survey.

Table 1

Specifications of Imagery Obtained for the Wellwood Study Area

Date	Altitude	Film	Filter	Wavelength (μ)	Band	N.A.P.L. Roll No.
July, 1948	8,000 ft. a.s.l.	Pan. B & W	Minus Blue	0.5-0.7	Visible	A 11553-63
October, 1958	8,000 ft. a.s.l.	Pan. B & W	Minus Blue	0.5-0.7	Visible	A 16398-173
September, 1964	8,000 ft. a.s.l.	Pan. B & W	Minus Blue	0.5-0.7	Visible	A 18595-63
August 8, 1971	11,000 ft. a.s.l.	Aerocolour	NAV	0.5-0.7	Visible	CN 1221-280
"	11,000 ft. a.s.l.	TRI X B & W	W-12 + 44	0.5-0.6	Green	BN 1220-280
"	11,000 ft. a.s.l.	TRI X B & W	25-A	0.6-0.7	Red	BN 1219-280
"	11,000 ft. a.s.l.	IR Aerographic	89-B	0.7-0.9	Near infrared - black & white	BN 1218 IR-280
August 5, 1971	32,000 ft. a.s.l.	TRI X B & W	W-12 + 44	0.5-0.6	Green	BN 1208 -396
"	32,000 ft. a.s.l.	TRI X B & W	25-A	0.6-0.7	Red	BN 1207 -396
"	32,000 ft. a.s.l.	IR Aerographic	89-B	0.7-0.9	Near infrared - black & white	BN 1206 -396
"	32,000 ft. a.s.l.	Aerochrome IR	W-12	0.6-0.9	Near infrared - colour	CP 1209 IR-396
May 20, 1971 07:50 13:00	2,000 ft. a.g.l.	Infrared scanner image	-	3.0-5.0	Intermediate infrared-thermal	-

RESULTS AND DISCUSSION

For purposes of a preliminary evaluation of the usefulness of the various kinds of imagery, comparisons were made to the soil data as depicted on the reconnaissance soil map of the area (Figure 1) and to a set of available black and white panchromatic photography. No field studies or ground truth collection were carried out with respect to evaluation of the CF-100 imagery.

There appears to be certain soil properties which can be determined from multi-band techniques with varying degrees of success. A preliminary evaluation of the various kinds of imagery in the visible, photographic IR, and thermal IR bands as applied to the Wellwood area is presented in Table 2.

The properties of the soils at the detailed ground truth sites used in evaluation of the thermal infrared imagery are summarized in Table 3. It was difficult in many instances to establish a precise relationship between the ground truth data and the imagery obtained. Problems arise in the interpretation of the imagery due to: (1) the wavelength used, i.e. it is sensitive to reflected as well as thermal energy; (2) incomplete overlap between AM and PM flights and (3) the AM flight took place after sunrise.

Soil Texture - Differences in texture of an order of magnitude from moderately fine- to moderately coarse-textured didnot provide consistent characteristic signatures on any of the imagery. Inferences can be made about the texture of a soil as it may be reflected in the evidence of past erosion.

Table 2

Qualitative Evaluation of Imagery in the Visible, Photographic IR and Thermal IR Bands

(Wellwood Area - 1971)

Type of imagery Filter Wavelength (μ) Band	Panchromatic B&W Minus blue 0.39-0.76 Visible	Colour NAV 0.39-0.76 Visible	Black & White W-12 and 44 0.39-0.52 Green	Black & White 25-A 0.56-0.70 Red	Black & White 89-B 0.7-0.9 Infrared	False colour W-12 0.7-0.9 Colour IR	IR Scann - 3.0-5.0 Thermal	
							AM	P
<u>Factor analyzed for-</u>								
1. Erosion								
- fallow fields	2	3	2	3	1	3	1	1
- cropped land	1	3	2	2	1	3	1	1
2. Textural differentiation not dependent on relief	1 if a higher erosion incidence	2 if a higher erosion incidence	0	2 if a higher erosion incidence	0	3 if a higher erosion incidence	3 if a higl erosion incidenc	3
3. Drainage								
- relief change	3	3	2	2	1	3	4	1
- no relief change	2	-	1	2	1	3	4	3
- veg. change	3	3	1	2	1	3-4	3	3
- on fallow fields	2	2	1	2	1	2-3	4	3
4. Salinity	3 if pronounced salt crusts	-	-	-	-	4	-	-
5. Relief features	3	3	2	3	1	3	3-4	1
6. Vegetation identification - state of health	3 with ground truth	3 with ground truth	1	2	1	3-4 with ground truth	-	-
7. Present land-use								
- summerfallow	3	3	1	1	4	4	-	-

Evaluation scale: 0-very poor; 1-poor; 2-fair; 3-good; 4-very good; - not evaluated.

Table 3

Soil Properties and Surface Condition at the Detailed Ground-Truth Sites in the Wellwood Area

Soil Type and Classification*	Site No.	Soil Property: Surface Texture	Colour	Depth (cm)	Soil Temp. °C AM	Soil Temp. °C PM	Soil Moisture % AM	Soil Moisture % PM	Surface Condition: Topography Slope	Topography Aspect	Trash cover (%)	Direct. of Cult.	Roughness	Aggregation**
Wellwood (O.Bl)	1	VFSL	10YR3.5/1	1 20	1.0 7.0	31.0 9.0	5.8 29.3	2.8 26.7	level		0	N-S	Crests 8" apart, 3" troughs	fgr, some cogr & vco sbky
Stockton (O.Bl)	3	LVFS	10YR3/1	1 20	- 2.0 6.0	26.5 10.0	2.6 15.7	1.0 15.4	0-½%	E-NE	0	N-S	Crests 6" apart, 3" troughs	vfgr - single grain, some cogr & vco sbky
Wellwood (O.Bl)	4	L-VFSL	10YR3.5/1	1 20	- 1.0 7.0	25.0 9.5	4.3 31.1	2.0 30.0	level		0	N-S	Crests 6" apart, 3" troughs	m & cogr, some vco sbky
Wellwood (O.Bl)	6	Loam	10YR3/1	1 20	0.0 7.0	27.0 10.0	13.6 30.1	3.5 31.1	level		30	NNE-SSW	Crests 10" apart, 1" troughs	f-mgr, some vco sbky
Wellwood (O.Bl)	7	Loam	10YR3/1 & 10YR3.5/1	1 20	3.0 7.0	22.0 10.0	18.5 30.2	9.3 29.9	level		90	N-S	Smooth	silt wash on surface of aggregates
Firdale (O.DG)	9	Loam	10YR5/2	1 20	10.0 11.0	29.0 12.0	4.3 20.2	1.9 21.7	12%	S-SE	0	N-S	Crests 6" apart, 3" troughs	m-cogr, some co-vco sbky
Firdale (O.DG)	10	Loam	10YR5/2	1 20	7.0 8.0	27.5 11.0	3.6 21.2	1.9 21.7	12%	N-NW	0	N-S	Crests 6" apart, 3" troughs	m-cogr, some co-vco sbky
Firdale (O.DG)	11	VFSL	10YR4/2-5/2	1 20	11.5 9.0	26.0 12.0	2.7 21.0	1.1 19.6	0-½%	E-SE	40	E-W	Crests 12" apart, 5" troughs	m-cogr, some co-vco sbky

* O - Orthic
Bl - Black
DG - Dark Grey

** f - fine
m - medium
co - coarse
vco - very coarse
gr - granular
sbky - subangular blocky

Organic Matter Content - This soil property is generally reflected in the surface soil colour. The ability of multispectral photographic imagery to differentiate soil colour depends on moisture content, vegetative cover and various other conditions of the surface at the time of flight. Inferences of organic matter content from thermal infrared imagery depends on soil temperature as affected by reflectance and absorbance properties of the soil. The Firdale soil at site 11 had a greyish brown surface colour and a soil temperature of 26.0° C (Figure 2b, PM imagery). The Wellwood soils at sites 1 and 6 with similar level topography, had very dark grey to black surface colours and soil temperature values of 31.0° C and 27.0° C, respectively on the PM imagery (Figure 2a). The signature at site 11 is partly due to reflected energy. Aerocolour, colour infrared and red band black and white imagery show the surface soil colour quite well under both crop and summerfallow conditions.

Soil Moisture - This soil property is reflected both by darker tones of moist soils compared to that of dry soils, and by the response of vegetation to varying moisture conditions. Colour photographs and black and white near infrared imagery show good tonal differences for soil areas with higher moisture contents. On the colour imagery the higher moisture content in drainage channels than in the surrounding areas is indicated by a more luxuriant dark green vegetative growth. The more vigorous vegetative growth at moister sites also shows a stronger signature on the near infrared black and white imagery. Similarly, luxuriant vegetative growth provides a stronger signature on the colour infrared imagery in the form of bright pink colours. Panchromatic black and white

Figure 2a. Thermal infrared imagery (3-5 μ, 13:00 hours) of ground-truth sites on the Wellwood soils. Ground-truth sites indicated by X.

Figure 2b. Thermal infrared imagery (3-5 μ, 07:50 and 13:00 hours) of ground-truth sites on the Firdale soils. Ground-truth sites indicated by X.

photography was less useful for depicting variation in soil moisture as the signature obtained is highly dependent on conditions at time of flight.

Soil moisture is one of the most important factors influencing the thermal properties of a soil. The kinds of soil properties which may be differentiated using thermal infrared imagery are those which affect soil temperature and moisture relationships. In evaluating the extent to which thermal infrared sensing can be used under Manitoba conditions, it was necessary to ascertain the magnitude of possible temperature and moisture differentiation. Three distinct signatures are evident at sites 1, 6 and 7 in Figure 2a. The three sites occur on well drained Wellwood soils with level topography. Although there was some variation in surface condition among the three sites, it is likely that the differences in signature are largely due to variations in the surface moisture contents. The values obtained for surface moisture content and temperature at sites 1, 6 and 7 are 2.8, 3.5 and 9.3 percent moisture and 31.0° C, 27.0° C and 22.0° C, respectively. A Stockton very fine sandy loam (site 3) and a Wellwood loam (site 4) occurred both within one field, and therefore had the same management history. Ground truth data from these two sites at the time of the PM flight showed only slight differences in moisture content and temperature values (1.0 percent moisture, 26.5° C and 2.0 percent moisture, 25.0° C, respectively). Such slight variation did not provide visual differences in the imagery. This does not preclude that with the use of more sophisticated electronic analysis that these slight differences could not be detected and even measured quantitatively. By establishing the degree of response to various temperature-moisture relationships such as these, it should be possible to infer which soils have a higher moisture content.

Slope and Topographic Pattern - These properties are external to the soil but nevertheless are properties which can be determined by remote sensing. The use of panchromatic black and white photography with stereoscopic coverage has long enabled a ready determination of overall topographic pattern. Black and white imagery in the red band and near infrared colour imagery show the overall topographic pattern and provide approximately as much topographic information as the panchromatic black and white photography. The stereoscopic image on the red band and near infrared colour imagery, although not as sharp as that found on good quality panchromatic photographs, did provide much more clearly defined stereo images with sharper boundaries than those found on the green band or on the near infrared black and white imagery.

The effect of slope and topographic pattern on the thermal infrared imagery is shown in an area of Firdale loam with moderately rolling topography (site 11, Figure 2b). In the AM imagery the effect of temperature differences and low sun-angle shading combine to produce a marked three dimension picture of the relief. In the PM imagery the relief is washed out (due to levelling out of temperatures and higher sun angle) so that the entire field shows as a uniform high energy source.

If the thermal infrared scanning is carried out shortly before sunrise when temperature differences are at their maximum, the three dimensional effect noted in Figure 2b is produced. This technique could be used to delineate topographic pattern and length of slopes. It will be noted that this expression of relief is very similar to imagery produced by SLAR.

CONCLUSIONS

(1) The preliminary results obtained from these studies indicate that more detailed ground truth collection under controlled conditions is needed in order to adequately assess the overall application of remote sensing to the study and evaluation of soil properties.

(2) The relationship between the image obtained at a particular wavelength and the physical factors producing it, can only be understood through measurement and quantification of the ground condition at time of sensing.

(3) A single wavelength cannot provide all the answers to terrain and vegetation analysis. The greatest possible amount of information can undoubtedly be gleaned from a multispectral approach using thermal infrared sensing as a supplement to colour, and black and white photography in various wavelengths.

(4) It remains for future research to decide how costs in terms of investigation time and imagery processing, balance off against the additional benefits of having other kinds of spectral imagery available. The use of multispectral remote sensing techniques will undoubtedly stand in better perspective when applied to the study and evaluation of the complete spectrum of resources to be found in an area.

QUALITATIVE EVALUATION OF MULTIBAND RESPONSE PATTERNS FOR RESOURCE AND LAND-USE INVENTORIES

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ABSTRACT

Multiband remote sensing was conducted during the summer of 1971 over the Neepawa and Thompson-The Pas test sites of Manitoba. Sensing was carried out with a multilens photographic system and an optical-mechanical scanner. The test sites contained cultivated as well as wildland areas. Resource inventories of these areas had been conducted in previous years. Ground-truth data were gathered in pre-selected locations approximately at the time of multiband data acquisition. The ground-truth and resource-inventory data were used to obtain a qualitative evaluation of the multiband response patterns from portions of these Manitoba test sites for resource and land-use inventories.

The use of multiband data was found to improve the accuracy of resource inventories and was considered to be more efficient for producing resource-based maps. However, the multiband specifications varied with inventory objective and with the resource-base of the area. Effects of land-use and management practices were clearly evident on some of the data but required extensive ground-truth information for proper interpretation. Patterns due to land-use and management practices tended to complicate interpretations of resources patterns.

INTRODUCTION

The rapid socio-economic expansion over the past decade has increased the need for faster and more accurate methods of inventory and mapping of resources. A considerable improvement in the accuracy and efficiency of resources mapping resulted when the use of plane tables was replaced by aerial panchromatic black and white photographs. This panchromatic aerial photography appears to be giving way to other kinds of remotely sensed data, commonly referred to as multiband data.

Multiband remote sensing denotes the use of more than one portion of the electromagnetic spectrum. It rests on the principle that everything in nature has its own distribution of reflected and emitted energy levels. The spectral characteristics of objects on the earth's surface will be best recorded, therefore, when the energy is partitioned in properly selected wavelength intervals.

Remote sensing of two or more portions of the electromagnetic spectrum has been found (cf. Anon., 1970; MacDonald, 1969; Lent and Thorley, 1969; Nunnally and Witmer, 1970) to provide better information than the sensing of single, wide energy bands. However, the practical value of multiband sensing appears to be highly dependent on the user's understanding of his information requirements.

In 1971, the Remote Sensing Centre of the Canada Department of Energy, Mines and Resources commenced a nation-wide test program to acquaint resource interpreters with the use of multiband data. Reported herein are results and evaluations of the multiband data obtained for a portion of the Neepawa and the Thompson-The Pas test sites in Manitoba.

DESCRIPTION OF THE AREA

The study was conducted in the Neepawa and The Pas areas of Manitoba. The Neepawa study area comprises the strip of land parallel to Provincial Trunk Highway #4 between the towns of Neepawa and Gladstone. The area is situated in the delta of the Assiniboine River and is referred to in the western portion of the study area as the Upper and in the eastern as the Lower Assiniboine Delta (Ehrlich, et al, 1957). The boundary between these two physiographic areas is located about mid-way between Neepawa and Gladstone. Surface deposits in the Upper Assiniboine Delta portion vary from moderately fine-textured lacustrine material and calcareous till to moderately coarse-textured deltaic and outwash deposits. Topography is undulating to gently rolling and the soils are dominantly Black Chernozems. Surface deposits in the Lower Assiniboine Delta consist chiefly of moderately coarse-textured deltaic deposits subjected to some beaching. A relatively small area of fine-textured alluvial-lacustrine deposits is encountered around the town of Gladstone. Topography is nearly level to gently undulating and the soils are dominantly Black Chernozems developed under aspen-grassland vegetation. Farming is diversified.

In the The Pas study area, the multispectral data obtained cover part of the Upper Saskatchewan Delta and part of the Moose Lake-Cedar Lake physiographic areas. Surface deposits in the Upper Saskatchewan Delta vary from moderately coarse to fine-textured alluvial materials, usually covered by thin organic deposits. Topography is nearly level to gently undulating and the soils are dominantly Gleysols (Ehrlich, et al, 1960). The area has been artificially drained and is being cultivated. In the

Moose Lake–Cedar Lake portion of the study area, the surface deposits range from medium- to fine-textured calcareous tills to fine-textured lacustrine materials. A considerable portion of the land surface is covered by organic accumulations. Topography is gently undulating to moderately rolling and the dominant soils in the better-drained positions are Degraded Eutric Brunisols developed primarily under dense forest.

MATERIALS AND METHODS

The multispectral data were obtained at different dates for the two study areas and had dissimilar specifications (Table I). In addition, the flight altitude of the aircraft collecting the data were not uniform, either within or between study areas (Table I). All flights collected photographic data, except for one flight in the Neepawa area which collected thermal infrared imagery.

The imagery obtained covered both cultivated and virgin land. The virgin lands were situated in the The Pas study area and had been inventoried for their forest resource in 1968. Resource inventories of the cultivated lands included soil surveys which differed in degree of intensity and in date of surveying. Thus, the soil survey of the Neepawa area was conducted on a reconnaissance basis in the early fifties (Ehrlich et al, 1957), whereas the Pasquia area near the town of The Pas was surveyed in detail in the late fifties (Ehrlich et al, 1960).

Ground-truth studies were conducted for all flights but only those pertaining to the thermal infrared data coincided closely with the actual flight time of the aircraft. The multispectral data obtained were

Table I

Specifications of the Multispectral Data

Study Area	Date	Altitude (ASL)	Film Type	Filtration	Spectral Range (μ)	N.A.P.L. Roll No.	Comments
Neepawa	May 20/71	2,000 ft.	Infrared Scanner Image		3.0 - 5.0		
	Aug. 8/71	11,000 ft.	Aerographic IR	89-B	.68 - .95	BN 1218 IR	
			Tri-X	25-A	.58 - .75	BN 1219	
			Tri-X	W-12+44	.50 - .58	BN 1220	
			Aerocolour	--	.45 - .75	CP 1217 IR	some fogging
The Pas	Aug. 7/71	10,000 ft.	Aerographic IR	89-B	.68 - .95	BN 1214 IR	under exposed
			Tri-X	25-A	.58 - .75	BN 1215	
			Tri-X	W-12+44	.50 - .58	BN 1216	under exposed
			Aerochrome IR	W-12	.50 - .75	CP 1217 IR	over exposed

evaluated in the laboratory and related to the field and file data gathered in the course of this study.

RESULTS AND DISCUSSION

Agricultural Lands

Thermal infrared imagery was available for the Neepawa area only. It did not prove satisfactory for delineating boundaries of landscape or soil units. This was due, in part, to the two-dimensional nature of the imagery and to the similarity in the signatures for high soil moisture content, heavy texture, and high soil organic matter content. Variations in relief were inferrable, however, from imagery taken at low sun-angles. In addition, the signatures of the afore-mentioned soil properties at high sun-angles provided a qualitative assessment of the incidence of certain landscape components and soil association members within a given landscape or soil unit.

Evaluation of the thermal infrared imagery in conjunction with ground-truth data proved useful for detecting differences in soil characteristics related to moisture conditions. However, these differences were specific to point sources. This limited their usefulness to qualitative interpretations; i.e. extrapolations of their areal extent. The results did not lend themselves to quantitative extrapolations owing to the limitations inherent in visual evaluations and to insufficient ground truthing.

The various multispectral photographic data obtained differed in their usefulness for resource inventory interpretation. Black and white photographs taken in the red spectral band were comparable in quality to panchromatic black and white photographs for the mapping of landforms and soils. The other available kinds of black and white multispectral imagery were less suitable for this purpose than the red-band black and white photographs. Aerocolour and colour infrared photographs were not as suitable for the mapping of landforms as red-band or panchromatic black and white photographs owing to a slight loss in resolution of relief features. However, these kinds of colour photography were more useful for soil interpretations as they provided better information on vegetation characteristics.

The greater suitability of aerocolour and colour infrared photography for evaluating the vegetation of agricultural areas was due to specificity of vegetation to one colour. These vertically-taken photographs did not lend themselves readily for identification of crop types. However, grain crops, as a group, were normally distinguishable from special (i.e. broad-leafed) crops on the colour infrared photographs by darker red hues. In addition, fields of perennial crops were distinguishable from annual crops by their fairly uniform colour pattern and the lack of a cultivation pattern. Identification of annual versus perennial crop as based on the presence or absence of a cultivation pattern was feasable also with the various kinds of black and white photography. Black and white photographs taken in the red spectral band proved most satisfactory for this purpose.

In addition to the aspects of "present" land use discussed in the previous paragraph, all the available multispectral data were suitable for identifying areas of summerfallow, although to varying degrees. The near-infrared black and white photographs were most effective. Images of fallowed fields on these photographs were most times so intense that all terrain features were blotted out. Colour infrared photography proved also very useful for the identification of summerfallow areas. Parcels of land under summerfallow were characterized by a blue image. Variations in the blue colour between summerfallow fields of similar soil texture and drainage appeared to reflect the time lapse since the last cultivation. In other words, the more recent the cultivation of a field, the darker blue the image on the false-colour photograph.

The aerocolour and colour infared photographs showed variations in colour hue within any one piece of farm land that supported an annual crop. These variations reflected crop and soil conditions as affected by management practices. A fertilizer experiment conducted for remote sensing purposes by the Department of Soil Science, University of Manitoba, showed that a fertilizer application of 90 lbs. N + 40 lbs. P_2O_5 per acre gave a darker green image on aerocolour photography than an application of 90 lbs. N per acre, or of 40 lbs. P_2O_5 per acre, or no application of fertilizer. Within a soil mapping unit, cropping after summerfallowing provided a darker hue of green or red, respectively, than successive cropping. However, cropping after green manuring produced a darker colour hue than when cropping succeeded summerfallowing. The signature of an annual crop became progressively lighter in colour with increase in the length of time of continuous cropping. Variation in seeding date of a particular crop within a field resulted in a lighter image for the more recently seeded crop. Variations in colour hue within a field in the areas under study were also attributable to weed infestation, to soil drought, and to spring flooding.

Forested Lands

The multispectral photography available provided rather unsatisfactory data for resource interpretations owing to improper exposures (Table I). As a consequence, they proved less useful for these purposes than the panchromatic black and white photographs taken in 1953. Nevertheless, the red-band black and white and the colour infrared photography were of sufficient quality to evaluate their interpretation potential.

Red-band black and white photography seemed comparable to panchromatic black and white photography for the delineation of landforms and the interpretation of soils. Colour infrared photography appeared less useful for landform evaluations than these kinds of black and white photography, owing to a loss in the resolution of relief features. However, the more distinctive signature of vegetation patterns on the false-colour photographs seemed advantageous for soils interpretation.

Colour infrared photography appeared to provide greater accuracy in delineating forest cover types and wetland vegetation communities than either red-band or panchromatic black and white imagery. Delineation of forest cover type on false-colour photographs was facillitated by the black image of softwood vegetation as opposed to the reddish signature of hardwood vegetation. Wetland plant communities were identifiable by variations in hue, value and chroma. Thus, a willow-sedge community in an artificially drained location provided a blotched image of dark red (willow) and light red (sedge) colours. In their natural habitat, sedge communities provided very light reddish signatures whereas sphagnum ones had bluish hues. However, determinations of forest cover sub-types and of species composition of forest stands seemed generally better served by the black and white kinds of photography as well as by the aerocolour imagery.

The sharply contrasting signatures of softwood versus hardwood vegetation on the colour infrared photographs improved interpretations of soil distributions and properties. For instance, areas of limestone rock outcrop, when supporting softwood vegetation, normally provided a black image with patterns of reddish hues. These reddish patterns of the hardwood vegetation seemed to reflect rock fracture lines. Beached areas were readily identifiable by a pattern consisting of alternate bands of black and red images. In addition to these soil-significant vegetation patterns, the colour infrared photographs were better suited for evaluating effects of land management practices such as clear-cutting and road construction. Furthermore, false-colour photography had some water-penetrability as evidenced by the depiction of sand-banks in shallow waters. This feature of colour infrared photography should prove very useful in delineating recreation capabilities of wildland areas.

CONCLUSIONS

(1) The results obtained lend support to the contention that the use of multispectral data improves the accuracy of resource inventories.

Aerocolour and colour infrared photographs as well as black and white photographs taken in the red spectral band provide better imagery for resource interpretations than the other kinds of multiband data obtained during 1971.

(2) The efficiency of producing resource-based maps may be improved through the use of multiband data. Colour infrared photography appears most useful for the interpretation of vegetation types and soil conditions. Aerocolour imagery and the various kinds of black and white photography lend themselves well for the identification of landforms and species composition of forest stands.

(3) Multispectral data vary in their usefulness for present land-use interpretation. Near-infrared black and white photography is most accurate for delineating fallow fields from fields under crop. Aerocolour and colour infrared photography are most suitable for differentiating between summerfallow, annual crops and established perennial (forage) crops.

(4) Present and past management practices are reflected in the signature of the vegetation, particularly on aerocolour and colour infrared photography. Without knowledge of these practices it will be extremely difficult to ascertain crop and soil conditions by multispectral techniques.

(5) Different inventory purposes are served best by one or more kinds of multispectral imagery. This is of importance in cases where the photographic equipment available does not accommodate multiband

photography. It is necessary, therefore, to select and specify the kind of photography that is likely to provide optimum accuracy and efficiency for the inventory purpose at hand.

(6) Data from ground-truth studies conducted at the time of thermal infrared remote sensing aid in establishing qualitative relationships with imagery signatures. Evaluations of quantitative relationships would require either a comprehensive knowledge of the area or detailed ground-truthing as well as access to sophisticated equipment for mechanical interpretation.

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The Use of Remote Sensing Techniques to Study Peatland and Vegetation Types, Organic Soils and Permafrost in the Boreal Region of Manitoba

C. Tarnocai

Multispectral imagery obtained in northern Manitoba was analyzed to determine the usefulness of remote sensing techniques in studying peatlands and permafrost. Dependable differences were found in the multispectral response patterns obtained from thermal infrared, near infrared color, color, panchromatic black and white and near infrared black and white photographs of the various peatland types. These differences made possible the separation and mapping of the peat landforms, vegetation, organic soils and permafrost.

The cyclic nature of permafrost was also monitored using remote sensing data obtained in 1946, 1968 and 1971 and it was found that the area of permafrost decreased at a rate of 1 percent per year over the 25-year period studied.

Effect of Various Soil Properties and Management Practices on the Infrared Imagery from Portage la Prairie, Manitoba

W. Michalyna

Summary

Data and imagery will be presented to show the effects of various soil factors, surface conditions and soil management practices on the response on infrared and panchromatic imagery. The reasons for the differences in response in relation to reflection, absorption and emittance of energy from the soil surface will be discussed.

Remote Sensing for Soil Resource Inventories

P. H. Crown

When interpreting aerial photographs for information on the soils in an area, the pedologist relies on his powers of deductive and inductive reasoning. In the former case soil profile features are assessed by studying landform, topography, drainage patterns, and vegetation and this is usually accomplished satisfactorily by the stereoscopic examination of black-and-white panchromatic aerial photographs. In the latter case, which is usually the more difficult, tonal patterns found to be associated with specific soils in one area are recalled when studying the soils in another area. The basic concept underlying the use of remote sensing for soil surveys is that different soils will reflect or omit energy from different portions of the electromagnetic spectrum in varying amounts thereby producing unique spectral signatures for each soil. When recorded on photographic film these unique signatures produce the familiar tonal variations. While black-and-white panchromatic film records reflected energy for the entire visible spectrum, the use of various film-filter combinations allows for the sampling of reflected energy in more narrow spectral regions.

In 1971, multiband photography (a set of black-and-white similtaneous photographs of the same scene) was obtained in May, July and October for a 48 square mile research area immediately southeast of Edmonton. The reflected green, red and near-infrared energy was recorded on 70 mm film which was later used to produce 9 x 9 inch enlargements. Assuming a scatter-free atmosphere, the film exposure is directly proportional to the reflected energy from the scene at a given instant of time. Therefore the fiom exposure (i.e. gray tone) will be proportional to the object reflectance in each wagelength band. By visually comparing the photo tones for fields of bare soil with a photographic gray scale, the relative reflectance from various soils in the three bands was measured. Generally as surface colour darkened and as surface organic matter and moisture content increased, the reflectance decreased in each band on each date. The general order of response in each band was Humic Gleysols, the lowest, followed by Black Chernozems, Dark Gray Chernozems, Dark Gray Luvisols and Orthic Gray Luvisols, the highest. Statistical analysis revealed that for the responses from two soils to be significantly different at the 5% level there must be at least one-half a gray scale step difference in gray tone. Using this approach it was found that for the soils in the research area classified at the Subgroup level (Orthic Humic Gleysols; Orthic[1] Eluviated and [2]Solodic Black Chernozems[3]; Dark Gray Chernozems; Dark Gray Luvisols; Orthic Gray Luvisols) significant differences could be found between all soils with the exception of the three different Chernozems. The lack of any significant differences being observed between the Black Chernozems indicates that a more refined method of discrimination is necessary. This would involve a study of the reflectance in much narrower bands. Significant differences in response resulting from a change in parent materials was not evident. This is probably due to the similar clay loam surface texture of the soils developed in lacustrine and till materials in the research area. An area of outwash sand occurred within the research area but it was too small to be sampled statistically. However, the response from soils developed in this outwash were higher than that from soils developed in till or lacustrine materials. Future research into the identification of unique spectral signatures will involve:

- studies of the reflectance from various soils within narrow spectral regions as measured with a spectroradiometer in the field.

- studies of the thermal infrared emissions from the various soils in the area on the basis of seasonal and diurnal variations.

- studies of additional multiband photography with a more qualitative approach.

Recommendations for an <u>Experimental</u> Program

1. Continuation of Multiband Photography which would include simultaneous black-and-white panchromatic photographs and gray scales printed on each roll of film to quantitatively define spectral signatures in the green, red and near-infrared bands. The Multiband Photography should correspond to the multiband ERTS imagery.

2. Multispectral line scanning in small research areas.

3. Experimentation with terhmal infrared line scanning in the 3 to 5 and 8 to 14 micron bands to test the use of each alone and together for specific projects. This would include studies id diurnal and seasonal variations in thermal infrared response.

Ektachrome Infra-red and Ektachrome Aerial Photography Project - Pitt Meadows

G. G. Runka

The following is a brief summary of observations and first impressions re the use of ektachrome infra-red and ektachrome photography in detailed soil survey and related interpretive work. These comments are based on a rapid once-over (approximately one week) by H.A. Luttmerding, P.N. Sprout, Dr. L.M. Lavkulich, and myself. The men directly involved with the field mapping are using the three different types of photography at present and no doubt will be able to add to the comments regarding advantages, disadvantages, etc..

1. The transparencies are extremely difficult to handle under field conditions. They have to be used on a light table or held up to the sunlight which will eventually cause deterioration of the photographs.

2. It was generally accepted that part of the colour range reported in the literature appeared to be missing in the ektachrome infra-red photography. Workers in this field report that because of high infra-red reflectance, healthy foliage will photograph as various shades of red, with perhaps a slight bluish cast. As the infra-red reflectance is lost, the colour will change towards magenta, purple or green depending on the magnitude of loss.

   *The infra-red photographs used in this project for some unknown reason seemed to miss the blue, magenta and purple part of the spectrum. Vegetation appeared as shades or red and green only.

3. It was noted on the ektachrome infra-red photographs that soil characteristics (such as drainage) were masked where high protein (high chlorophyll) begetation was present. An example would be newly seeded high legume forage crops (deep red colour masking soil characteristics) versus abandoned or poorly managed pasture fields (pink and light shades of green with soil characteristics, artificial drainage patterns and vegetation patterns appearing quite distinct).

4. Often soil and management characteristics visible on both the ektachrome infra-red and ektachrome colour were visible on black and white on giving them a second inspection. In many cases these characteristics may not have been identified if only black and white photographs were available. In most cases soil boundaries and management differences were more distinct on the colour photography than on black and white.

In this case the time may have been too early as vegetation such as sedges and hardhack having little new growth reflected different shades of green indicative of dead vegetation. This is a bit confusing, because field work at the time of year the photographs were taken indicates that there was new growth on these plants. Also, the coniferous trees reflected a dark green colour, which is a bit hard to understand.

6. It appears debatable as to whether the extra cost of infra-red and ektachrome colour photography could be justified for use in detailed soil surveys of the kind carried out in the Lower Fraser Valley. This, of course, may change with more experience in handling the unnatural colours of the infra-red and if the central part of the spectrum becomes more visible. Ektachrome colour prints were favoured by field personnel. The value of this infra-red photography is in the sharp distinctions visible re land management on the farms. Photointerpretation from a management classification standpoint could be very worthwhile utilizing infra-red photography.

A more detailed report is forthcoming pending completion of field-work in the area this season.

Farm Management Interpretations towards an Economic Land Classification and the use of Color Infra-red Photography - 1969-71

G. G. Runka

B.C. Soil Survey was interested in developing an Economic Land Classification for the Fraser Valley along the lines of that done by Conkin in New York State. Much of the necessary information was available - a detailed soil survey, Farm Management data related to management levels, incomes, crop productivity and numerous economic surveys.

Our experience in Pitt Meadows indicated that through the interpretation of infra-red photographs of the valleys we could assess known management levels on farm management farms and extrapolate management to other areas of similar soil and climate characteristics.

B.C. Air Surveys agreed to fly 40 chain ektachrome infra-red photography during the early part of June (maximum plant growth, response, etc.).

Interpretations were based on known land use, cropping, fertilizing, drainage, field operation timing, etc. and the extrapolation to unknown management. Predictions proved possible, but error was high for certain crops (especially cash crops). We are still working on this project and much remains to be done. Sequential photography would improve our interpretation a great deal and in fact the usefulness and accuracy of such an inventory might be questioned until we do have sequential photographs. Certainly management can be separated into 2 or 3 classes.

Some difficulty was experienced with the photography in that different tonal keys were necessary for the two separate rolls of film. One film had much more blue tone than the other.

We are hoping to continue this project using 1971 infra-red photography and a more direct involvement by farm management and land economics personnel.

Report on Miscellaneous Land Types

J. G. Ellis

The term "Miscellaneous Land Type" has been defined by various organizations. These definitions are primarily a description of the utilization of Miscellaneous Land Types for the particular discipline practiced by the organization defining the term.

The trend, at present, is to delete any feature which can be classified as soil from the context of Miscellaneous Land Types. In 1971, Committee 8 (U.S.D.A.) proposed that only the following features be retained as Miscellaneous Land Types. They also suggested that the phrase "Areas with little soil" be substituted for the name Miscellaneous Land Type in the revised Manual.

<u>Badland</u> is steep or very steep nearly barren land, ordinarily not stony, broken by numerous intermittent drainage channels. <u>Badland</u> is most common in semiarid and arid regions, where streams have entrenched themselves in soft geologic materials. Local relief generally falls between 25 and 500 feet. Runoff is very high, and geological erosion active. <u>Badland</u> has practically no agricultural value, except for small areas of soil with some value for grazing that may be included in the mapping unit.

<u>Beaches</u> are sandy, gravelly, or cobbly shores washed and rewashed by waves. The land may be partly covered with water during high tides or stormy periods. <u>Beaches</u> support little or no vegetation and have no agricultural value, although they may be sources of sand and gravel.

<u>Blown-out land</u> consists of areas from which all or most of the soil material has been removed by wind--a condition resulting from an extreme degree of soil blowing or wind erosion. The areas are shallow depressions that have flat or irregular

floors formed by some more resistant layers, by an accumulation of pebbles or cobbles, or by exposure of the water table. Some areas have a small proportion of hummocks or small dunes. The land is barren, or nearly so, and useless for crops. Small areas of Blown-out land are often called "blowouts" and are shown with symbols.

Coquina land consists of cemented shell fragments, mainly from the coquina clam but with lesser amounts from the conch, oyster, and other shell-bearing mollusks and coral. This land is not useful for crops but commonly supports a few trees. The material has been used for building and for roadbeds.

Dumps are areas of smoothed or uneven accumulations, or piles, or waste rock incapable of supporting plants because of particle size or toxicity. A subclass is Mine dumps--areas of wasterock from mines, quarries, and smelters. Commonly, dumps are so closely associated with pits that complexes or undifferentiated units such as Pits and dumps or Mine pits and dumps are needed.

Dune land consists of ridges and troughs that are composed of sand-sized particles that are virtually devoid of vegetation, and that shift with the wind. Sand dunes that have been stabilized by vegetation should be named as a kind of soil rather than as dune land.

Lava flows are areas covered with lava. In humid regions the flows are of Holocene age, but in arid regions they may be older. Most have sharp jagged surfaces, crevices and angular blocks characteristic of lava. A little earthy material may have blown into a few cracks and sheltered pockets, but the flows are virtually devoid of plants except for lichens.

Oil-waste land includes areas where liquid oily wastes have accumulated. This miscellaneous land type includes slush pits and adjacent uplands and bottoms affected by the liquid wastes, principally salt water and oil. The land is virtually barren, although some of it can be reclaimed.

Pits are open excavations from which soil and underlying materials have been removed and which are either rock lined or too toxic to support plants. Subclasses would include Mine pits and Quarries. Commonly, pits are closely associated with dumps, and complexes or undifferentiated units, such as Pits and Dumps, may be needed.

Quarries (see Pits)

Rock outcrops consists of exposures of bare hard bedrock. Although very rarely needed, subclasses can be named according to the kind of rock materials, including: Chalk outcrop, Limestone outcrop, Sandstone outcrop, and Shale outcrop. Commonly, areas of Rock outcrop are too small to be delineated on the map and are shown by symbols. On the other hand, the areas can be extensive, broken by small spots with soil.

Rubble land includes areas of stones and boulders, virtually free of vegetation except for lichens. These are commonly at the base of mountain slopes and formed in Pleistocene or Holocene time.

Salt flats consist of low lying areas in arid climates, primarily where lakes existed during the Pleistocene. Evaporation of the lake left a layer of salt at the surface.

Scoria land consists of areas of slaglike clinkers and burned shale and fine-grained sandstone characteristic of burned-out coal beds.

Slickens are accumulations of fine-textured materials separated in placer-mine and ore-mill operations. Slickens from ore mills consist largely of freshly ground rock that generally has undergone chemical treatment during the milling process. Such materials may be detrimental to plant growth but are usually confined in specially constructed basins.

Urban land is land so altered or obscured by urban works, structures, and earth moving that identification of soils is not feasible. Soil boundaries should be extended into urban areas wherever it is possible to do so with reasonable accuracy. In areas where houses have lawns and gardens, urban land is commonly used as a part of a complex name, such as Beltsville-Urban land complex.

It is of interest to note that the preceding list of Miscellaneous Land Types contains not-soil features which have not been disturbed by man, e.g., rock outcrops; and not-soil features which have been disturbed by man, e.g., dumps; and other features which could be classified as soil, e.g., dune lands.

Assuming that all agree that Miscellaneous Land Types are not-soil features the decision therefore which must be made is what does the Canada Soil Survey Committee regard as non-disturbed not-soil features and man made not-soil features. When this decision is made the next step will be to resolve how these two different not-soil features will be identified on maps and recorded in legends.

The suggestion is therefore proposed that non-disturbed not-soil features such as rock outcrops which cover sufficient area to be delineated on a map be edited using symbols in the same manner as Series or Association names are edited. The man made not-soil features such as dumps, etc., could be shown using a symbol. The symbols could be patterned after those presently utilized by the

National Topographic Survey of Canada.

Questions we might think about are:

1) What does the Canada Soil Survey Committee mean by the term Miscellaneous Land Type? Does it include natural and man made not-soil features?

2) How do we utilize Miscellaneous Land Types?

3) If we agree that Miscellaneous Land Types are "not-soil" features can we show them on soil maps and legends according to the National Topographic System?

4) Do we proceed to obtain definitions for not-soil features which can be used both locally and nationally?

5) Is a Miscellaneous Land Type Committee to be formed and who will constitute its membership?

Ellis: Discussing miscellaneous land types. The Handbook of Soil Survey Manual was published in 1951 and that's how up to date I was on the subject of miscellaneous land types. The National Technical Work Planning Conference of the Cooperative Soil Survey issued a report of the committee on miscellaneous land types in January 1971 as a result of the meetings in North Carolina. Anyway Laurie Farstad had it in his back pocket. This committee had reviewed miscellaneous land types and as I understand this book they have come to the conclusion that any area that was previously called a miscellaneous land type has been discareded from that group if the soils could be classied. The miscellaneous land type category has been reduced from 34 to 16 entities. The committee members should study these 16 definitions in order to decide whether to accept or reject these definitions at our next National meeting. Those survey units in Canada that require other definitions shoubd prepare definitions and present them at our next National meeting for consideration. These 16 are: bad lands, beaches, blowout lands, coquina land, dunes and dumps, lava flows, oil waste lands, quarries and pits, rock outcrops, rubble land, salt flats, slickens and urban land. I do not think I have ever seen a map with a heading "miscellaneous land types" on it, but Dumanski replied that he is now creating a map with this heading.

Michalyna: In your study of this category you have found a definition to cover where land ends and water begins.

Ellis: replied negatively.

Day: I do not want to get into Dumanski's area of study but there are now areas on maps called sloughs, riverbanks, marsh or eroded river banks; those miscellaneous land types that will have to be digitized and which we will have to define. In the charge to your committee it was considered desirable to have some kind of definition of topsoil. This might eventually serve as a guideline to industry or companies who prepare topsoil for sale.

Ellis: The American committee had developed a definition for topsoil. In the same publication mentioned before this definition is:

1) That soil material which is used to topdress, slopebanks, lawns, etc. It excludes synomous meanings such as surface soil, etc.

2) Mineral soil or similar earthy material used as topgressing for houselots, grounds or for large buildings, gardens, road cuts or similar areas. The earthy material has favourable characteristics for production of desired kinds of vegetation or can be made favourable by treatment and lacks substances in amounts toxic to plants.

3) Encourage users to state specifications for materials which they plan to use as top soil, for example, texture, coarse fragements, reaction, organic matter content, exchangeable sodium percentage. The proposed definition given above is given in general terms. For this reason specifications are needed to meet locally intended use.

4) Encourage regional committees to develop a checklist that might be used in developing specifications for particular users of topsoils. This committee believes that the proposed definition is satisfactory and has no better substitute for now.

Ellis sontinued that he was not prepared to specify a content of sand, silt, clay, nitrogen, water holding capacity, etc. as suggested by Day because he thought these are regional problems.

Day: Would it then be better to develop these criteria on a regional basis. Should we encourage industry to adhere to at least some minimum standard. If so, should we ask provincial groups to prepare a definition for topsoil on the basis of soil region?

Ellis: I think it is up to each regional group to prepare their definition of topsoil. Are you concerned about the legal implications that might be involved?

Day: Yes, that is part of the problem but it also involves consumer protection.

Clark: I understand there has been some pressure from public groups to attempt to develop consumer standards. There are large concerns that are in the business of buying topsoil, and they would like some general guidelines.

Ellis: I suggest that every unit study the definition of the American Committee and prepare other definitions as required, for consideration at the next National meeting. This recommendation was moved for adoption by Day and seconded by Cann and adopted by a show of hands.

Report on Soil Family

W. Michalyna

(Editorial Note)

The report presented at the meeting differed considerably from that here presented. Dr. Michalyna has rewritten his report in the light of the opinions expressed by the participants. A transcription of some of the discussion is included.

I have also included a paper by C. Broersma because some interesting thoughts are expressed and such papers should be recorded in our proceedings. Unfortunately, this paper is evidently based only on the text contained in SSCC 1970. (end of editorial note).

During the Canada Soil Survey meetings held in Kelowna, B.C., February 15-17, 1972, some of the present problems of the Soil Family were outlined and discussed.

Some of the problems in soil family classification have arisen because we have extracted terms and philosophy from the U.S. soil classification system without the full consideration or investigation as to its consequence in the S.S.C.C., which differs in definition, concept, control section, textural criteria, reaction and calcareous limits.

A. The definition of the soil family was proposed as follows:

Soil Family: is defined as a category which differentiates soils within a subgroup on the basis of differentiating soil properties within the soil profile or control section developed from similar kinds of parent materials with similar lithology. The differentiating soil properties are particle-size, mineralogy, pedoclimate, reaction, calcareous and others defined under family criteria. The segment of the control section to which these family modifiers apply may vary for different soils depending on subgroup. The soil family criteria are considered on a fairly broad base and are used to define the limits on which the next category, the soil series, is established.

The Concept: Soil family is a taxonomic category between the subgroup and series which provides information on some physical and chemical properties of the materials (natural or altered) and environmental factors in which a particular soil developed. The physical and chemical properties consist of particle-size, mineralogy, reaction, calcareous; environment factors consist of pedoclimate; and depth classes which indicate depth of soil development or depth to a lithic or paralithic contact.

Because of possible misinterpretation of the use of the term control section for various depths in different categories, the following is proposed:

- Control secttion should be used to indicate some depth to which pedogenic and/or unaltered soil properties are characterized.

The control section for mineral soils is as follows:

(a) from the surface down to a lithic or paralithic contact if it is within a depth of 1 meter (40 inches).

(b) from the surface to a depth of 1 meter (40 inches) if the regolith is thicker, but the named diagnostic and subjacent Cca horizons are not.

(c) from the surface to 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 1 meter, but not below a depth of 2 meters (80 inches).

The term control segment is proposed for that portion of the control section (a) used in applying particle size, mineralogy, and other family criteria, (b) used in differentiating series within a family of mineral soils.

One of the main topics was the discussion on the adoption of the U.S. particle-size class criteria - both the limits and names. There was no objection to the use of the U.S. particle-size class limits, but some objection was raised to the adoption of the U.S. particle-size class names since the use of the name and mineralogy term in a Canadian soil family applied to a segment of the Canadian control section could lead to a different implication or interpretation by one familiar with the U.S. family or a U.S. pedologist or correlator. (We have published the U.S. equivalents for our subgroups). However, the U.S. particle-size class names and criteria were favored and are presented.

PARTICLE-SIZE CLASSES

Particle-size refers to grain size distribution of the whole soil in contrast to texture, which refers to the fine earth fraction of the soil, the fraction that is less than 2 mm. Particle-size classes are a kind of compromise between engineering and pedologic classifications. The limit between sand and silt is 74 microns in the engineering classifications, and either 50 or 20 microns in pedologic classifications. The engineering classifications are based on weight percentages of the fraction less than 74 mm, while textural classes are based on the less than 2 mm fraction.

The very fine sand separate, .05 to .1 mm, is split in the engineering classifications. The particle-size classes make much the same split but in a different manner. A fine sand or loamy fine sand normally has an appreciable content of very fine sand, but the very fine sand fraction is mostly coarser than 74 microns. A silty sediment, such as loess, may also have an appreciable component of very fine sand, but it is mostly finer than 74 microns. So, in particle-size classes, the very fine sand is allowed to "float". It is treated as sand if the texture is fine sand or loamy fine sand or coarser. It is treated as silt is the texture is very fine sand, loamy very fine sand, sandy loam, or silt loam, or finer.

The National Technical Work-Planning Conference of the Cooperative Soil Survey, Charleston, South Carolina, January 25-28, 1971, accepted in principle that the .05 to .10 mm size fraction be included in silt so that the limit between sand and silt would be 0.1 mm and that definitions of the family class limits be amended to coincide with this change.

No single set of particle-size classes seems appropriate as family differentiae for all kinds of soils. The classes that follow provide for a choice of either 7 or 11 particle-size classes. This choice permits relatively fine distinctions in soils if particle-size is important, and broader groupings in soils if the particle-size is not susceptible to precise measurement or if the use of narrowly defined classes produces undesirable groupings. Thus, in some families the term "clayey" indicates that there is 35 percent or more clay in defined horizons; but in other families the term "fine" indicates that the clay portion constitutes 35 to 60 percent of the fine earth of the horizons, and the term "very-fine" indicates 60 percent or more clay. "Coarse fragments" refers to particles larger than 2 mm and includes all sizes with horizontal dimensions less than the size of a pedon. The term "fine earth" refers to particles smaller than 2 mm.

Particle-Size Classes for Family Groupings†

1. FRAGMENTAL: Stones, cobbles, gravel, and very coarse sand particles, with too little fine earth to fill interstices larger than 1 mm.

2. SANDY-SKELETAL: Particles coarser than 2 mm are 35 percent or more by volume, with enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is that defined for particle-size class 5.

3. LOAMY-SKELETAL: Coarse fragments are 35 percent or more by volume and enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is that defined for particle-size class 6.

4. CLAYEY-SKELETAL: Coarse fragments are 35 percent or more by volume, and enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is that defined for particle-size class 7.

5. SANDY: The texture of the fine earth includes sands and loamy sands, exclusive of loamy very fine sand and very fine sand textures; and coarse fragments are less than 35 percent by volume.

6. LOAMY: The texture of the fine earth includes loamy very fine sand, very fine sand, and finer textures with less than 35 percent clay*; coarse fragments are less than 35 percent by volume.

    6a. Coarse-loamy: A loamy particle-size that has 15 percent or more by weight of fine sand (0.25-0.1 mm) or coarser particles, including fragments up to 7.5 cm, and has less than 18 percent clay in the fine earth fraction.

6b. Fine-loamy: A loamy particle-size that has 15 percent or more by weight of fine sand (0.25-0.1 mm) or coarser particles, including fragments up to 7.5 cm, and has 18 to 35 percent clay in the fine earth fraction.

6c. Coarse-silty: A loamy particle-size that has less than 15 percent of fine sand (0.25-0.1 mm) or coarser particles, including fragments up to 7.5 cm, and has less than 18 percent clay* in the fine earth fraction.

6d. Fine-silty: A loamy particle-size that has less than 15 percent of fine sand (0.25-0.1 mm) or coarser particles, including fragments up to 7.5 cm, and has between 18 and 35 percent clay* in the fine earth fraction.

7. CLAYEY*: The fine earth contains 35 percent or more clay by weight and coarse fragments are less than 35 percent by volume.

7a. Fine: A clayey particle-size that has 35 to 60 percent clay in the fine earth fraction.

7b. Very-fine: A clayey particle-size that has 60 percent or more clay in the fine earth fraction.

† Soil Survey, Soil Conservation Service, U.S. Department Agriculture.

* Carbonates of clay size are not considered to be clay, but are treated as silt.

(a) In applying particle-size classes use the weighed average particle-size of the control segment or of the horizons listed below, unless there are strongly contrasting particle-sizes within the control section. If there are strongly contrasting textures, both textures are used, e.g. fine-loamy over sandy.

(b) for lithic subgroups of mineral soils, the particle-size classes are applied to the whole control section.

(c) for all other mineral soils that lack Bt, Bnt, Bf or Bh horizons the particle-size classes are applied only to the mineral soil from a depth of 25 cm (10 inches) to a depth of 1 meter (40 inches) or to a lithic contact if shallower than 1 meter.

(d) for mineral soils that have Bt or Bnt that are non-contrasting with the C horizon, but have a contrasting A horizon less than 40 cm (16 inches) the particle-size classes are applied from the top of the Bt or Bnt to 1 meter (40 inches) or to a lithic contact if shallower than 40 inches.

(e) for mineral soils that have a Bt or Bnt horizon that is non-contrasting with theC horizon but have a contrasting A horizon deeper than 50 cm (20 inches), contrasting particle-size classes are applied.

(f) for mineral soils that have a Bt or Bnt horizon greater than 15 cm thick (6 inches) that have horizons or layers of strongly contrasting particle-size within or below the Bt or Bnt, particle-size classes are applied from the top of the Bt or Bnt to 1 meter (40 inches) or to a lithic or paralithic contact if shallower than 1 meter.

(g) for mineral soils that have Bf or Bh horizons, the particle-size classes are applied from the base of the Bf or Bh horizon to a depth of 1 meter or to a lithic or paralithic contact if shallower than 1 meter.

(h) for other soils in which the lower boundary of the Bt or Bnt horizon is shallower than 25 cm, particle-size class is applied from the upper boundary of the Bt to a lithic contact or to 1 meter, whichever is less.

The following particle-size classes are strongly contrasting if the transition is less than 12.5 cm (5 inches) thick.

Figure 1.

						loamy				clayey	
	fragmental	sandy skeletal	loamy skeletal	clayey skeletal	sandy	coarse loamy	coarse silty	fine loamy	fine silty	fine clayey	very fine clayey
	Over										
Fragmental						X	X	X	X	X	X
Sandy skeletal						X			X	X	X
Loamy skeletal										X	X
Clayey skeletal											
Sandy	X			X			X	X	X	X	X
Loamy	X	X			X					X	X
Clayey	X	X	X		X	X	X	X	X		

________ if underlined indicates that the broader term be used if desired.

A suggestion was made that if the particle-size classes were adopted that the soil texture classes be revised to incorporate the 18 and 35 percent clay limits. Since VFS (.1-.05 mm) behaves similar to silt, the present limits should be evaluated in relation to the engineering lower limit for sand of .074 mm. Having soil textures with similar limits as soil family particle-size classes would facilitate placement of soils into families when laboratory analysis are not available.

Mineralogy: No major changes were proposed for the mineralogy subsection. Some suggestions were included to improve on the wording and clarification of the section. It was also suggested that the "ashy" mineralogy may be more appropriate at the Subgroup within various Great Groups, and that the 'sulfureous' mineralogy be retained. Where contrasting particle-size class is used, mineralogy class be applied to both particle-size classes unless mineralogy is similar.

Depth Classes: It was suggested that the depth classes as presently described could possibly be considered as series criteria rather than family separations. For depths on soils with cryic contacts, it was suggested that the depth be considered to 1 meter or to a lithic or paralithic contact if shallower; this would be consistent with recent changes in the control section for cryic subgroups.

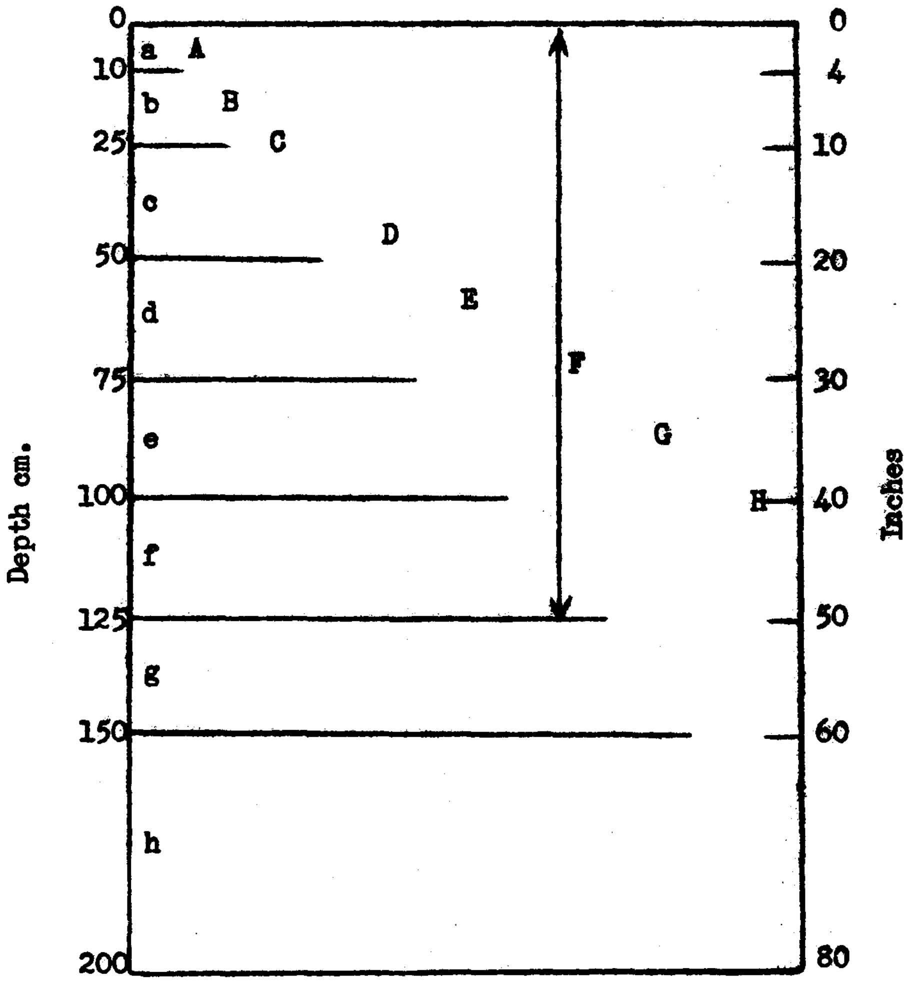
Since present depth classes are related to lithic contacts, some ideas were presented on a zonation of the control section that would be more informative on both shallow and deep mineral soils. These could be useful to indicate depth of solum, depth to lithic or paralithic contact within or below the control section, depth to fragipans, other diagnostic horizons, and thickness of various horizons. The zones could be designated by letters of the alphabet, upper case letters would be used for indicating depth of solum, depth to fragipan or depth to lithic or paralithic contacts. Lower case symbols would indicate the depth zone at which a particular horizon or soil layer occurred; if a thickness designation is desired, an arabic number can be used.

These zonations can also be applied at the Subgroup or Series level if desired.

The zonation of the control section is presented in Figure 2.

The main use presently foreseen for this zonation is informative, but may be used in the future to formulate depth classes for mineral soils. An example of its use is provided.

Figure 2


Depth cm.
0
10
25
50
75
100
125
150
200
a
b
c
d
e
f
g
h
A
B
C
D
E
F
G
H
0
4
10
20
30
40
50
60
80
Inches

e.g. in a descriptive legend a table showing the subgroup, family and series are usually given.

Subgroup	Family	Series
a) Orthic Gray Luvisol	D - fine-loamy, mixed	Waitville
b) Gleyed Rego Black	C-c clayey/loamy skeletal, montmorillonitic/mixed	Marquette

In (a) the D indicates that the depth of solum extends to a depth of 75 cm for the series; in (b), C indicates that the solum extends to an approximate depth of 50 cm; the c indicates the zone in which the clayey sediments occur.

If these designations are to be used for depths to lithic or paralithic contacts that are deeper than 50 cm (lithic subgroup) then a "rock" term would have to be introduced as part of the particle-size section. Since the control section is terminated at a lithic or paralithic contact, it would be advantageous to have some term to indicate presence of rock at the family level.

Soil Climate: There has been a recent change in the temperature classes and regimes used for the soil climate map of North America. It was proposed that the new classes and regimes be accepted.

Reaction Classes: The general consensus of the Western Canada pedologists is that the Subgroup and Great Group criteria provide information on reaction within the solum and should not be considered at the family level. It was suggested that reaction classes be applied to the control segment below the solum of mineral soils.

Calcareous Classes: The present calcareous classes are satisfactory. It was proposed that the calcareous classes be applied to the control segment below the solum of mineral soils.

Special Horizons: Special horizons such as fragipan, duripan and orstein should be considered at a higher category similar to placic horizons. These horizons are often discontinuous in the soil profile, but two forms could be defined, e.g. the orthofragipan   o - fragi (subgroup)

parafragipan p - fragi (subgroup)

It is suggested that:

o - fragi ---- could be used to describe the soils that have a fragipan present in 75% or more of each pedon and occurs within a depth of 40 inches.

p - fragi ---- could be used to describe soils that have a fragipan present in 35 to 75% of each pedon.

Recommendations

1. The soil family committee be responsible to review and evaluate the proposals, recommendations and suggestions from the regional reports and prepare a preliminary draft of the Soil Family.

2. The soil family committee should review the U.S. Soil Family criteria and evaluate the implications that may result from the use of their terminology within the Canadian Soil Family.

3. The preliminary draft should be circulated to pedologists so that the criteria could be tested on established series. Anomalies or inconsistencies with other sections of the S.S.C.C. should be noted and forwarded to the committee for further evaluation.

4. The soil family committee evaluate the properties of VFS fraction, its use in other textural classifications, and establish guidelines for its use in the particle-size class.

The following section is a discussion of Soil Family with the discussion led by Michalyna.

Cann: presented the eastern point of view of soil family. I think you could gather from the remarks through Mitch's paper that I lean quite strongly towards the U.S. system. There are a number of reasons for this. Some of you know that the family has been developed over a long period of time. The present American document is a result of a large amount of discussion by a number of very competent people. Certainly they have had all the problems that we are now faced with in making these decisions. There are probably just as many people in the States who do not like ti as do like it. Nevertheless, it is the concensus of opinion that is much larger than ours. Evidently, a number of people think that this U.S. system will not apply to Canadian conditions. It is a system that requires careful reading. We must realize at the beginning that the soil families is a taxonomic category and as such should be worked into the system on the basis of a classification category using parameters which will group soils between the subgroup and the series and which will also act as a kind of control where we separate our soil series. Mitch has come up with some good suggestions and new ideas which we must examine and discuss. In the U.S. system we are separating a subgroup of soils on the basis of a set of characteristics and they start first with soil texture. One of the main areas of contention in all of these discussions is whether we should recognize a Bt or a Bn or whether this textural designation should apply to the weighted average of the whole section or profile. One of the things we are trying to do is group soils that have more or less similar moisture regines because these are the kinds of things that we are looking for. Now one may say that we want to know something else, for example, engineering properties, about our soils. So we do want to know engineering properties at' the series level, but we do not make any distinction in our soils series on the basis of engineering properties, rather we make our distinctions on the basis of morphological features and then we interpret these features for various purposes. And so in the family level we are concerned with what kind of moisture and nutrient movement we have through the control section, therefore it seems to me essential that we recognize different pans and Bt's and so on because often the Bt's determine the moisture characteristics of the whole control section and in the same way a pan will do the same thing. Therefore, if you accept this U.S. system you must accept also all of these built-in criteria because they are specifically designed for the system. Other characteristics than the ones mentioned are used to differentiate soils at the series level. There has been some mention about parent materials but here again we may have a number of parent materials that are more oe less similar and that texturally may come out in the same family, but you could have several series on these similar parent materials. Incidentially, if you have read the SSCC you will have noticed that we do not have a control section for the soil family. That control section mentioned in the SSCC is the section for the soil series and so we are perhaps a little off the mark.

Clark: There were no specific recommendations at the end. I have talked to Drs. Cann and Michalyna and they feel that there are four topics to be considered. We should keep our discussion quite precisely to these topics. We feel that the order of discussion should go:

1) Do we take the U.S. approach or do we take the Canadian approach to classification at families?

2) Establish the concept of a soil family.

3) Definition of the control section.

4) Textural groupings in soil family.

Michalyna: With regard to the first point we have to consider what the U.S. textural grouping involves. There is one suggestion that we accept the U.S. scheme as such. I have tried to outline some of the implications in accepting this scheme.

Coen: I would like to suggest that before you can make any decisions on whether you want to accept the U.S. or the Canadian scheme you have to know what your concept is. Therefore, until we have settled number 2 it will be impossible to settle number 1.

Clark: I hate to disagree with you Gerry. If you say that you can accept the U.S. scheme you accept the definitions concept holus bolus, and then you are done. On the other hand the decision could be to develop a Canadian concept.

Michalyna: I think what we are after here is the use of their limits within the section on particle class modifier, the names attached to those and if you adopt the names it implies the adoption of certain control sections. We have to accept this implication that if we use Orthic Grey Luvisol, fine loam, that we are applying it the same way the U.S. is, namely the textural class name applies to the Bt horizon.

Clark: Those in favour of going the independent Canadian way, that is to say not accepting the total package as implied by the U.S. classification, put up their hand.

Day: I think this is an oversimplication because the family criteria that we use are tailored to our classification system. The U.S. system differed in degree because their classification system is different.

Clark: Are you prepared to vote on the question that we not adopt the U.S. system? Would that make you happy?

Day: It would because I do not think we can adopt it.

Clark: Those in favour of not adopting the U.S. system, raise their hands. Agreement to this motion.

Cann: Perhaps I could backtrack here for a moment. I may have given you the impression that I was in favour of the U.S. system but I feel somewhat like John does. I do not accept it wholesale, as a complete thing. I think we have already written into some of our criteria, the principles of separating family groupings on the basis of their textural classes. I think this is the point of contention as to whether or not we should use their textural designations to separate our family groupings. I think this is where the contention arises, not that we should blindly accept their system but that we are using the parts of their system that we can apply to adequately separate our own soils.

Michalyna: We have to make a decision here, whether we are going to apply it to the Bt horizon of Gray Luvisols and thereby restrict the information given about the whole profile.

Lavkulich: I think one of the things you have to consider here is correlation. You made a statement a few minutes ago that we correlate with the Americans but if you have different criteria I do not see how we can correlate our soils with theirs at the family level.

Clark: I think we can take those aspects of the system and the general concepts and let some of the detailed definitions vary. I gather that in essence we have to do this because our classification system is different.

Day: I move that we accept the terminology and particle size classes used in the U.S. soil family. I suggest this because I think it is an advantage to us as well as to the Americans to be talking the same textural terminology of the whole soil with terms like coarse loamy, fine loamy, coarse silty, fine silty, moderately fine, fine, skeletal. We have used some of these terms in our book. I think it would be an advantage to use the class coarse loamy, fine loamy, coarse silty, fine silty. At one of the work planning conferences that I attended, the basis for the choice of those splits was stated to have engineering implications as to how moisture moves in the profile, moisture holding capacity and plasticity. The motion was seconded by Farstad and carried by a show of hands based on a small number of votes.

Cann: Having accepted that we can move on to the concept of the soil family. Having accepted the particle size classes and terminology we have pretty well committed ourselves to accepting the control section also.

Day: I do not see it quite that way Bruce. The U.S. system has fragic subgroups but we do not have fragic subgroups. Maybe we will in the future. With this in mind the characteristics that fragic imply are important in the way that moisture moves and in the ways that soil can be used, and I think it is appropriate that we recognize them at the soil family. As I understand the U.S. system fragic subgroups imply some information abouth the moisture relationships of that soil. We cannot do that because we do not have fragic subgroups so I think we should do that at soil family and this was the reason for putting in the little bit about special soil horizons, where the word fragic meant a fragic family. Because of the differences in our systems we cannot accept willy-nilly their definition of control section, rather we have tailor it to fit our classification and that is what we tried to do in our suggested guidelines. In these guidelines, distributed in 1971 to all units, Nowland and I dwelled very heavily on how to apply texture and what control section to apply to the soil texture. Perhaps we need to modify these guidelines. We did not specify in detail what portion of the profile we would apply such terms as pH, calcareousness, etc., we have not really covered that. I think we can make gains in this regard so that we will all know the rules by which we will apply these terms. In other words, do we have the right parameters in soil family? Do we need others in addition to the six or so that we mentioned?

Cann: For our own purpose we should determine where we are going to take out these fragic or ortstein occurrences. There will have to be a lot of work done between now and the next national meeting.

Editorial Comment: There followed a long discussion on the application and criteria for soil family. It is very difficult to select or to synthesize the feeling of the group on various topics such as the application of family particle-size classes and the control section, therefore I have passed over all of that and refer only to the following remarks of Clark towards the close of the session.

Clark: I have stayed out of all of this, but it seems to demonstrate the reasonableness of Pawluk's comments that nobody if really prepared to make an educated vote on this. I think we started off with the idea that like a lot of the other reports there should be some very firm recommendations come out of this. Here it seems the only thing that we can really recommend is for the committee to go back and incorporate the ideas that have been expressed here into their final report. Perhaps these sorts of discussion should be confined to study groups at the first day and bring them out on a second day.

Day: If now you do not feel that you can intelligently discuss this, to me it means only that one hasnot taken the time to think about it. We have been talking about soil families for nearly 6 years. Nowland and I sent out guidelines and we did not receive one bloody reply from anybody, not anybody, so people are not even thinking about it. To me it is mandatory that we make progress because of the pressure of northern surveys and other projects in which we may be able to use characteristics of elements of soil family in tailoring the soil map legend.

Pawluk: I would just like to make a comment on what John has said. The fact that people haven't looked at soil families is simply an indication that most of the soil survey people in the field are concerned with mapping and not with taxonomic units.

Clark: Conceptually, the federal element of the Soil Survey is supposed to be under centralized administration and I think there is a possibility now that we could take these problems and make them national programs in which regional people could be charged to formulate an answer within a time limit. It would be one way of moving these things along without gathering it all up in Ottawa. If there is a feeling that we need this type of operation let your opinions be known.

SOIL FAMILIES

C. Broersma

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The seeking for a better and more sophisticated soil classification continues, even though the use of the family and higher levels of the taxonomic classification as mapping units have been largely ignored. This can be seen by the fact that mapping has largely been centered around the series level. It is believed, by some, that a broader level of mapping and classifying is needed to bring together the many series into broader units for special uses or for use in exploratory and reconnaissance surveys.

Until now mapping at the reconnaissance level has been by use of soil series. This is accomplished by complexing the series. When looking closely at the criteria used for mapping the series in reconnaissance surveys it can be seen that the criteria used to define the series are really much broader than should be theoretically allowed and it is probable that really these series are much closer to being soil families. From personal experience in a pilot project to set up soil families for the Peace River Block, and using the present criteria for soil families, it seems that the soil series mapped equate very closely to that of the family. This shows that either mapping at the reconnaissance level has been at the soil family level, or something very close to is, or that the criteria for the family are not precisely defined, or perhaps both to some degree. This seems to raise the question, if in Canada on broad level mapping the soil series have been defined so widely that they are really soil families and also are the criteria for the soil family valid and usable?

The soil series is defined by limits (polypedon) wide enough to allow reasonable uniformity over a practical sized area. The limits must be narrow enough to keep the series as taxonomically homogenous as possible, and at the same time, wide enough to create bodies of a size that can be readily identified and delineated on the landscape. The soil series is defined as follows:

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

As has been stated no characteristic can be allowed a range that would alter significantly the morphology, genesis, or use capability of the series from place to place. Thus the soil series as a taxonomic unit is taken from the continum of soil and represented by a frequency distribution:

A B

-2σ $-\sigma$ $+\sigma$ $+2\sigma$

<u>model for soil A</u>

-2σ $-\sigma$ σ 2σ

<u>model for soil B</u>

A soil series thus has to fall within those conditions set up by the limits of e.g. σm 2σ depending on which criteria.

The soil family on the other hand has a much wider or broader criteria. The limits set up under the frequency distribution for the soil family are such that they are still part of the continum but at a higher level. This can be seen in that the soil family is defined as:

"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 the uniformity is at a broader degree than in the soil series".

Thus only diagnostic criteria should be considered that are significant at this broader level of classification. The soil family is still a frequency distribution, in that it still represents a part of the continum and therefore can be better visualized as being made up of a number of smaller, better defined frequency distributions, e.g. series.

If the soil family is to become a more used level of our classification system, it is advisable that first the criteria used to define the family should be checked and critically evaluated. Although the criteria appear precise and useful in the classification manual, application of the criteria would show otherwise. The following are some suggestions for soil family criteria based on a pilot project carried out in the Peace River Area of British Columbia. In making these suggestions, it is assumed that the soil family is taxonomic and should reflect environmentally significant separations of subgroups or grouping of soil series.

Criteria:

Texture -

Propose the use of only fo-- levels of texture - divide the textural triangle into three groups: coarse, medium and fine, with an extra criteria for defining coarse material.

Strongly contrasting layers -

This section of the classification appears to be satisfactory.

Mineralogy -

These were taken from the U.S.D.A. without considerations of how useful they really are and from the available data if it can be predicted what mineralogy is important for the family level.

Taking the example of the Peace River, the only available data is from J.S. Clark, Brydon and Hortie.

The clay minerals of some B.C. subsoils by extrapolating this data into the surficial glacial geology of the area.

Depth Classes -

Depth classes are distinguished to determine variations in the total depth of the soil profile, including the C if present, which are significant to soil use and management, over bedrock, other strongly contrasting nonconforming rock material, or even pans, or other diagnostic horizons.

It is suggested that it would be more meaningful if the depth classes were defined not only in relation to bedrock or cryic layers but also into other restricting layers, for both plant growth and engineering, such as fragipans, ortsteins, duripans, $CaCO_3$ layers, salic layers, etc.

Thus it is recommended that the following classes be recognized:

Micro -	less than 20 cm
Shallow -	20 - 50 cm
Moderately Deep -	50 - 100 cm
Deep (or Normal) -	100 cm or greater

The criteria for the depth classes for the family should be such that they portray the information of depth as well as to why or what causes it to be of a certain depth. Thus it is important to soil use and management to know the approximate depth of the soil, including the C if present, to such special horizons as lithic or cryic contacts as well as fragipans, ortstein, cemented, compacted, salt and calcium carbonate horizons. These horizons all impose severe limitations to the solum above and are thus of outmost importance taxonomically as well as for interpretative classifications.

It is suggested that the depth of the soil be regulated by such special diagnostic horizons as mentioned above. These, therefore, will affect the control section in that they separate what is above this horizon from what is below.

Example:

Alcan - has a Ck at 72-74 in = 185 cm
Cs at 74+ in = 188 cm

these can be ignored since they are outside of the normal depth of influence.

Moberly - has a Ck at 24+ inches = 61 cm

this could be mentioned by calling this horizon a moderately deep calcium carbonate substratum.

This would show that the soil has a restricted layer of $CaCO_3$ between 50-100 cm.

Landry - has a Ck at 19-23 in approximately 48-58 cm.

this would be a moderately deep soil

Reaction Classes -

Should be related to depth classes.

Acid	Neutral	Alkaline
<5.0	5.0-7.5	>7.5

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