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Expert Committee on Soil Survey

Comité d'experts sur la prospection pédologique

MINUTES SECOND ANNUAL MEETING

PROCÈS-VERBAUX DEUXIÈME RÉUNION ANNUELLE

March 18-21, 1980
Ottawa

18-21 mars 1980
Ottawa

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Minutes

Second Annual Meeting

Expert Committee on Soil Survey

Procès-verbal

la deuxième réunion annuelle

Comité d'experts sur la prospection pédologique

Editor J.H. Day Editeur

Ottawa
March 18-21, 1980

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le 18-21 mars, 1980

CONTENTS

Minutes of the Annual Meeting
of the Expert Commitee on Soil Survey

Chairman J.S. Clark welcomed the members of the committee as well as other participants attending the meeting.

Arising from the minutes of the previous meeting was the resolution prepared by W.W. Pettapiece concerning the retention of Canada Soil Survey Committee (CSSC) as the title of this body. The Chairman explained the role of ECSS in relationship to its parent body Canada Committee on Land Resource Services (CCLRS) and to the Canada Agricultural Service Coordinating Committee (CASCC) and stated that probably these committees could give no official recognition to CSSC. Clark also emphasized that wider representation on ECSS could best be fostered by the judicious use of travel funds provided by Canada Agriculture to CASCC for the participation by university representatives. There subsequently was not further demand by the attendees for continuance of CSSC.

The Chairman outlined the function of the committee as embodied in the terms of reference incorporated in the previous minutes. Following brief discussion the terms of reference were adopted.

Dr. Clark alluded to the process of integrating regional views on research and services required into a set of national recommendations. He recommended that for 1980-81 our recommendations should be formulated within the framework of "A strategy for agricultural land resource research for Canada".

The Chairman outlined the five-year program plan requested by the Research Branch on short notice in January.

1. Alternative soil and crop management practices in Ontario; special attention to be directed to the effects of monoculture, soil erosion and yield maintenance. 12 person years proposed.

2. Land programs. Acceleration of current programs by mainly contract funding.
   Soil Survey $2 million per year + 5py
   Information system $250 thousand per year
   Resource Protection definition of problem and inventory
   of occurrence $250 thousand per year
   Land Evaluation $600 thousand per year + 6py.

The Chairman then called upon the regional representatives for statements of regional need of research and services. The reader may find these statements in Appendix 1.

Following these presentations the chairman summarized several possible courses of action:

1. The ECSS should prepare a general statement in support of the strategy: this action is warranted by the regional representative's statements which have not changed in any material fashion during the last two years.

2. The ECSS recommendations for research and services in 1980-81 should refer back to those submitted to CCLRS in 1979-80 and upon which the strategy paper was based.

3. Regional statements that impinge on soil management should be redirected to the Expert Committee on Soil Management (ECSM) which committee is keenly concerned for soil quality.

4. Regional statements on need for agrometeorology research should be redirected to the Expert Committee on Agrometeorology (ECA).

5. The Chairman and secretary are to prepare a draft set of recommendations to go to regional representatives in June for comment and return in September. The revised recommendations would be forwarded to CCLRS in November.

Regional member nominees
Membres désignés sur les comités régionaux

		Term ends* Fin du mandat
BC - C. - B.	T.M. Lord	1982
AL	J.D. Lindsay	1983
SA	D.F. Acton	1982
MA	R.E. Smith	1983
ON	C.J. Acton	1982
QU	R. Baril	1983
NB	R.E. Wells	1982
NS - NE	K.T. Webb	1983
PE	A. Raad	1982
NF - TN	K. Guthrie	1983

Departmental representatives
Représentants des ministères fédéraux

Envir.	J. Thie	
INA - AIN	J.I. Sneddon	
EMR	R.J. Fulton	
Chairman - Président	J.S. Clark	1983
Secretary - Secrétaire	J.H. Day	1982

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* End of term occurs following the spring meeting of CASCC.
Le mandat prend fin à la réunion du printemps du CCSAC.

Nominations for representatives whose term ends in 1982 are not required this year.
Des nominations ne sont pas requises cette année pour les représentants dont les mandats prennent fin en 1982.

Minutes de l'assemblée annuelle du Comité Expert du relevé de sol

Le président, J.S. Clark, a souhaité la bienvenue aux membres du comité ainsi qu'aux autres participants qui assistaient à l'assemblée.

Relevant des minutes de l'assemblée précédente, il se trouvait la résolution préparée par W.W. Pettapiece concernant la rétention du nom de Comité Canadien du relevé de sol (CCRS) comme titre de cet organisme. Le président expliqua le rôle de CCRS en rapport avec son organisme parent, le Comité Canadien de Services de Recherches sur les Terres et le Comité Canadien de Coordonation des Services en Agriculture, et affirma que probablement ces comités ne pourront donner aucune reconnaissance officielle à CCRS. Clark souligna aussi qu'une plus grande représentation au CERS pourrait être plus favorable par un usage judicieux des fonds de déplacements fournis par Agriculture Canada à CCCSA pour la participation par des représentants des universités. Par conséquent, il n'y avait aucune demande ultérieure des participants pour la continuation de CCRS.

Le président souligna la fonction du comité telle que donnée dans les termes incorporés dans des minutes précédentes. A la suite de courte discussion, les termes ont été adoptés.

Dr. Clark se rapporta au procédé d'intégration des aperçus régionaux sur la recherche et les services dans un ensemble de recommendations nationales. Il recommenda que pour 1980-81, nos recommendations soient formulées dans le contexte du travail intitulé "A Strategy for Agricultural Land Resource Research for Canada".

Le président élabora sur le plan du programme de 5-ans demandé par la Direction de la Recherche avec peu d'avis en janvier.

1. Alternative des pratiques de gestion du sol et des récoltes en Ontario; un intérêt spécial devant porter sur les effets de la monoculture, de l'érosion du sol et du maintien du niveau de production. 12 personnes-année proposées.

2. Programmes des Terres. Accélération des programmes actuels surtout par voie de contrats.
   Relevé de sol: $2 million par an + 5 pa.
   Système d'information: $250,000 par an.
   Protection des resources: définition de problèmes et inventaire d'évènements: $250,000 par an.
   Evaluation des terres: $600,000 par an + 6 pa.

Ensuite, le président invita les représentants régionaux à fournir les rapports sur les besoins des régions en recherche et services. Le lecteur peut trouver ces rapports à l'annexe 1.

A la suite de ces présentations, le président a résumé plusieurs lignes de conduite possibles:

1. Le CERS devrait préparé un énoncé général en appui de la stratégie: cette action est justifiée par les rapports des représentants régionaux qui n'ont pas changés durant les deux dernières années.

2. Les recommendations du CERS en recherche et services en 1980-81 devraient se reporter à celles présentées au CCSRT en 1979-80 et sur lesquelles le document de la stratégie a été basé.

3. Les rapports régionaux qui empiètent sur la gestion du sol devraient être redirigés au Comité Expert sur la gestion du sol (CEGS) le dit comité étant extrêmement interessé à la qualité du sol.

4. Les rapports régionaux traitant des besoins de recherche en agrométéorologie devraient être redirigés au Comité Expert en Agrométéorologie. (CEA)

5. Le président et le secrétaire doivent préparer au brouillon un ensemble de recommendations pour remettre aux représentants régionaux en juin pour qu'ils émettent leurs commentaires et qu'ils retournent le tout en septembre. Les recommendations revisées devraient être envoyées à CCSRT en novembre.

Appendix 1. REPORTS BY REGIONAL REPRESENTATIVES

British Columbia

T.M. Lord

One year ago, Dr. Charlie Rowles, chairman of the Soils Department, University of B.C. prepared a statement on the British Columbia position for the first meeting of this expert committee. As chairman of the Soil Science Lead Committee, one of six lead committees under the B.C. Agricultural Services Coordinating Committee, he most ably summed up the main problems and priority needs for land resources research in the province.

During 1979, Mr. Norm Sprout of the B.C. Ministry of Environment and the B.C. member of the Canada Committee on Land Resource Services (CCLRS) consulted with resource specialists to prepare a detailed position paper identifying land resource research priorities in B.C. The broad framework had been provided by the CARC report on resources prepared by Mr. Maury King and the follow-up report by Drs. Halstead and Clark.

As current chairman of the subcommittee on soil survey under the Soil Science Land Committee, I was asked to prepare the 1980 statement for B.C. My report will follow closely the recommendations set out in the Sprout report of November 1979 to the Canada Committee, with an update on the present situation. In essence, "the British Columbia position on needed land resource research is to give priority to those activities which will help preserve and make agricultural lands more viable".

Under the Land Commission Act of 1973, some 4.6 M hectares of land (of which about half are Agricultural Capability Classes 1 to 4) were placed in Agricultural Land Reserves (ALR). Since implementation of the Reserves, pressures to remove land from the ALR have come from a number of sources including developers, speculators, government agencies, and sometimes the farmer himself. Although the Land Commission has withstood the siege very well on the whole, the province has recognized the need to "fine tune" certain aspects of ALRs in areas where numerous appeals for exclusion occur.

The term "fine tuning" means different things to different people. Most of us think in terms of more detailed inventories to provide better physical data. But it also deals with suitability and productivity of crops, more detailed climatic data, knowledge of sources for irrigation water, land tenure and economics.

The report to the Canada Committee identified three priority areas as: Southwestern British Columbia, the Rangelands, and Interior Wetlands. The program needs in each area are described under the subheadings - Inventory and Correlation, Agroclimatology and Water, and Land Evaluation and Land Use.

The following is a summary of land resource research needs in agricultural and adjoining lands of Southwestern British Columbia. The east coast of Vancouver Island and the Lower Fraser Valley is a high priority area containing three quarters of the population of the province, prime farm land, and an important agricultural industry. Competition to divert agricultural land to other uses is intense.

The Sprout report gave first priority to the need for a 1:20,000 scale detailed soil survey of the east coast of Vancouver Island, under a four year program. Word received only last week indicated that provincial funding has been provided to re-survey about 40,500 ha this year in the Duncan area of the Island. The detailed soil survey will attempt to sort out an extremely complicated pattern of water-worked till complexed with marine, fluvial, and glaciofluvial materials. The survey is expected to provide a review of agricultural capability ratings and to redefine Agricultural Land Reserve boundaries. The province is considering some contracting out on the survey. The federal soil survey unit has committed 0.5 professional man years for 4 years to soil correlation.

An important aspect of land use planning on Vancouver Island and in the Lower Fraser Valley is climate-soil moisture relationships. The proposed program has three components:

(1.) A 2-year study on energy balance on irrigated land to check PET equations and to establish climate-crop relationships.
(2.) A 2-year study on frost risk mapping
(3.) A 4-year study to investigate the application of the new moisture classification system (Climate Moisture Index) at a detailed soil survey level under a climate that is very wet in winter and very dry in summer.

An additional hydrology component will determine the availability of surface water and groundwater, and the extent of user competition for water.

Under land evaluation, there are needs dealing with agronomic productivity and management systems, and feasibility of irrigation and drainage.

A land use component would consider resource uses or practices that affect agriculture or form an alternate or complementary use to agriculture. Examples are problems on the urban-rural fringe in the Lower Fraser Valley and the relationships of forestry and farm woodlots on Vancouver Island.

Although some obvious items requiring research - waste application to soils, improved methods of analysing land suitability and land productivity - may be readily identified, the report recommends a contingency research fund be available to meet presently unidentified problems.

Norm Sprout further proposed that concurrent studies on information systems in the province be carried out. Programs to integrate the various provincial data files (soils, climate and aquatic systems) and meld these to the provincial interactive graphic display system (IGDS) with a capacity for autocartographic methods, should be developed.

Events appear to be moving swiftly in the field of information systems. The Resource Analysis Branch of the Ministry of the Environment has since hired a systems analyst (a soils graduate) to sort out such things; CanSIS is producing derived and interpretive maps; and the last day of our present meetings will deal with numerous aspects of the subject.

Although the Rangelands, which include grasslands, forested ranges, and interior wetlands, are ranked below the Southwestern area in priority, the rangelands comprise an important land resource within the province. Managers of the estimated 9.3 M ha of dryland ranges are the Range Division of the Ministry of Forests, and individual ranchers. The role of range manager is becoming increasingly oriented to integration rather than to single purpose uses for domestic livestock, silviculture, wildlife, etc. Primary needs are identified as vegetation studies and the gathering of more extensive climate data. A climate research program is required to develop an understanding of the relation of evapotranspiration and soil moisture to rangeland productivity.

The Interior Wetlands are an integral part of the ranching industry in that portion of the Interior Plateau known as the Cariboo and Chilcotin. But wetlands are also valuable for wildlife, waterfowl and water storage. In the past these complex ecosystems have suffered from lack of interest by both soil and vegetation mappers and researchers. A comprehensive program to study, characterize and classify wetlands is needed to provide management guidelines.

During the past two years a pilot research study by the federal soil survey unit has gathered soil and vegetation data along selected transects. This information will provide some of the basic material for developing a classification system. Complementary studies on hydrology, vegetation communities, and productivity of wetlands were done by provincial, federal, and university staffs. It is hoped to extend a small piezometer-vegetation project to a study of water table characteristics as related to soil, vegetation and climate. In addition, a program to evaluate remote sensing techniques over wetland transects has been proposed. In 1979 a start was made on the compilation of a field manual (or users guide) as part of the land use component of wetlands. Projected needs over the next three to four year period for land evaluation would involve contract funding to collate research data and practical experience.

The Sprout position paper concludes with a statement of Suggestions for Research by the Land Resource Research Institute:

Suggestions for Research by the Land Resource Research Institute

CanSIS - Federal/Provincial requirements

The CanSIS program has obvious applicability in total to the responsibilities of the Institute on federal lands. The staff of the Institute must remember however that the province has even more users for soil data in the fields of management, planning and design and that these users are interrelated in this province. Further, recourse management agencies have large computer requirements and in British Columbia such computer systems are interrelated. These facts precict a role for the Institute and the province particularly since the staff positions are limited in both cases.

The Institute should define standards; develop methods and principles for parameters and characteristics required for interpretive and derivative maps; and do the required research to better define parameters and characteristics. It should also hold in its data banks all soil data necessary for correlation, taxonomic research, etc. The Institute and its staff should not involve itself in operations and applications beyond federal requirements.

To sum up, CanSIS should do all things with respect to developing interpretations and derivations short of handing the material to a programmer. At this point the province should take over and program to fit its software and hardware systems. We would like the Institute to spend its time and limited personnel in research and development of methods and principles. We will spend our time on applied analysis and operations.

At the March 1979 meeting for the Expert Committee on Soil Survey, the procedures for nominating the single provincial representative were established. In British Columbia, BCASCC approved the recommendation of the Soil Science Lead Committee that the Chairman of the Subcommittee on Soil Survey represent the province for the 1980-81 period.

The Soil Science Lead Committee, in its annual report, December 1979, agreed to limit its submission to BCASCC to four of provincial concern and one of national concern from each of the three subcommittees (climatology, soil fertility and soil survey).

Soil Survey Subcommittee recommendations of provincial concern are:

i. A pilot study should be undertaken on the intensive management of the soils of a selected watershed. The study to involve a detailed soil survey and examination of interpretations with respect to the level of information needed, scale, costs and the relationships to past and current investigations and practices.

ii. Soil surveys should be conducted at different intensity levels in unsurveyed areas of the coastal mainland from Powell River northward.

iii. Soil degradation problems should be given special attention and research, particularly in the Lower Fraser Valley, including water erosion on bare sloping soils, wind erosion on winter bare fallow soils, subsidence of organic soils, soil compaction, soil removal during turf farming and the effects of the use of municipal sludges on heavy metal concentrations in soils.

The Committee noted that there are a number of soil problems of particular concern in the Peace River area of the province including (i) Soil erosion, (ii) low soil temperatures and their effects, (iii) soil acidity and lime availability and distribution, (iv) loss of organic matter due to cultivation, (v) potential agricultural development such as in the Fort Nelson area.

In view of these problems, and the limited personnel available in the area to address them, the committee recommends that a high priority be given to assigning a soil specialist to the area to deal with them.

In regard to problems of national concern the committee recommended that BCASCC support the position paper and recommendations pertaining to Land Resource Research prepared by Mr. P.N. Sprout for the Canada Committee on Land Resource Services.

Alberta

J.D. Lindsay

The information to be presented is a summary of a document compiled in Alberta for the Canada Committee on Land Resource Service (CCLRS). The report was prepared by representatives of Agriculture Canada, Alberta Agriculture, the University of Alberta, Alberta Environment, and the Alberta Research Council.

The format adopted follows that suggested by Halstead et al. and includes five main program components, namely, Inventory and Correlation, Climate and Water, Land Evaluation and Land Use (Interpretations), Information Systems, and Soil Quality and Degradation Problems.

Inventory and Correlation

The objective of Inventory and Correlation in Alberta is to up-date the reconnaissance soil survey of approximately 8 million hectares in central and southeastern Alberta. Priority areas identified for this work include the Calgary-Edmonton corridor, potentially irrigable areas and urban areas. The suggested map scale is 1:50,000 requiring about 200 person years over a ten year period. The present effort amounts to about 8 to 10 person years annually.

At the same time it is recognized that increased attention in the future is required in such areas as soil correlation, development of soil mapping systems, and the monitoring of mapping confidence limits.

Climate and Water

The objective of this component is to provide information for new land development and land evaluation interpretations. At the present the effort in the acquisition of soil climate data is modest but it is expanding. Monitoring of soil temperature and soil moisture is now carried out in conjunction with survey activities in the County of Beaver and Warner, Calgary and Drumheller areas, and in the Rocky Mountains. Hopefully, the monitoring of soil temperature and moisture and water regions will become an integral part of any new survey projects.

Land Evaluation (Interpretation)

The objective of this component is to develop and test a new productivity land rating system. It would identify both the cereal- oil seed and forage production systems. It is felt by some workers in Alberta that the present CLI system favors cereal-oil seeds at the expense of forage.

The present effort in developing a new system of relating yields to the CLI classification system amounts to about 1.5 person years. It is suggested that the input should be 4 person years for a period of three to five years.

In addition, consideration should be given in the near future to the development of interpretative criteria for non-agronomic uses of soils. These include the suitability of soils for specific tank operation, building sites, concrete corrosion, recreational developments etc.

At the present time in Alberta, soil interpretations for these uses are included in soil survey reports but they are for the most part subjective in nature and generally based on criteria established elsewhere.

It has been suggested by some workers in Alberta that an examination of laboratory operations should be considered with a view to placing more emphasis on determinations related to the physical properties of soils. It would seem that in many instances the physical properties are the most important in terms of developing interpretative criteria for nonagronomic uses of soils.

In 1979, about one person year was devoted to acquiring data in the field and in the laboratory relative to some of the physical properties of the soils in the Edmonton area. A summer Job Core program has also provided considerable data along these lines.

Information Systems

The main objective of this component is to publish soil survey reports and maps of the up-dated surveys. New methods of report compilation and publication are being investigated including the computerized Textform format. At the same time it is realized that data management systems are required for the storage and manipulation of survey information.

Soil Quality and Degradation Problems

The objective of this component is to develop soil quality criteria for disturbed and undistrubed soils. Consideration is being given to the study of natural and man-make degradation processes such as soil salinity, soil acidity from fertilizer use or SO_2 impingement, fly ash disposal, soil erosion, and soil nutrient and organic matter loss.

The extraction of fossil fuels using surface mining methods is a major industry in Alberta. Such developments result in a significant disturbance of land which hopefully will be returned to at least its original level of production. Reclamation of disturbed land therefore has reached a point of some concern.

Within the soil survey grant about 2 person years are presently developed to this type of research. However, other agencies including the Universities of Alberta and Calgary, a number of government departments, and organizations in the private sector also participate in studies associated with disturbed land reclamation. Coordination of the efforts of the various agencies is obviously of major importance at the present time.

Summary

1. The resurvey of out of date map areas in central and southeastern Alberta is a first priority. Concurrent with the surveys will be the correlation function, mapping system development and an assessment of mapping levels of confidence. At the same time data management (information systems) will be employed and an extension of data acquisition in soil climate will be a part of the program.

2. Land Evaluation programs for both agronomic and nonagronomic uses of soils is recognized as a second order priority. Investigation into those soil properties that significantly affect the suitability of soils for various uses should be expanded.

3. As a third order priority studies of soil quality and soil degradation problems will be continued but the extent to which it will be expanded is difficult to foresee at the present time.

Saskatchewan

D.F. Acton

The 1979 report to this committee made reference to the fact that a strategy paper on land resource research needs was being prepared for the province. As a consequence, it was only possible to briefly itemize some of the priority areas foreseen at that time. Since then, a Land Resource Strategy Paper for Saskatchewan, a statement developed jointly by the Saskatchewan Department of Agriculture and the Saskatchewan Institute of Pedology, has been prepared and presented to the Canada Committee on Land Resource Services. It seems appropriate to prepare a general outline of this strategy paper and present, in considerable detail, the components of this paper that have particular relevance to soil survey.

1. Inventory of the Agriculturally Developed Region of the Province.

The basic resurvey of the agriculturally settled region of the province was initiated in the late 1950's. This survey is intended to provide more detailed and current soil information than that available from the early, broad reconnaissance surveys. Reports for 4 NTS sheets have been published. Three more sheets have been mapped, with reports in varying stages of completion. This represents approximately one-half of the survey area. It is anticipated that it will be well beyond the turn of the century before the remainder of the area will be covered, at the current rate of progress. Concerns about deteriorating land quality and soil management to curtail soil degradation have greatly increased the need for an earlier completion of this program. This need was met, in part, in the early 1970's by increases in the provincial soil survey staff and later by an increase (one) in federal technical support, but subsequent budget restrictions, especially on the provincial side and increased responsibilities by the survey staff to conduct other programs have sharply curtailed the rate of completion of the basic survey. To compound matters, there is an apparent need in the agricultural region to increase the detail of mapping and the kind of information collected to meet the specific needs of the producer and various government agencies.

The action required is to accelerate the provision of the basic inventory and maps of the soil resources of the agricultural region of the province to ensure that 1) inventory is complete within the next 20 years, and 2) the kind of information collected is adequate for on-farm decision making.

The needs, to accomplish this objective is to increase the survey staff by five person-years, suggesting two federal and three provincially supported appointments. Considering the present compliment of experienced staff on the survey, this added staff could be at a training or recruiting level.

2. Northern Saskatchewan Inventory Program

Industrial and mining development, and proposed hydroelectric projects in northern Saskatchewan, have underscored the need for more finite information on soil, climate, vegetation and water.

The action desired is to collaborate with scientists from various renewable resource sectors in preparing a reconnaissance biophysical inventory for the area north of 55^o in the province, utilizing the surficial geology framework presented in recently completed surveys by the Saskatchewan Research Council.

The need is for two pedologists, over an initial 5 year period, to collaborate with these other scientists in preparing a reconnaissance biophysical survey of the region.

3. Interpretation of Soil Inventory Information

The need for efficient food production can be met and maintained only if land is wisely used, and if the optimum use results in economically viable farm units. Soil inventory interpretations, particularly the prediction of yield potentials, are fundamental to the wise use of land and the selection of cropping alternatives. Such information would lead to the development of sound agricultural policies which will recognize the close relationship between a permanent and economically viable farming industry and the soil resources of the province. In response to such concerns, Agriculture Canada through the LRRI has initiated a national land evaluation program. This strategy paper recognizes the need for a strong provincial input into this program.

The action required involves developing a soil interpretations group that is fully integrated with the basic soil inventories. In so doing we hope, as an immediate objective, to rapidly produce a more readable and more highly interpreted soil survey publication. Longer range objectives will focus on the prediction of relative productivity of soils under a range of farming systems. Interpretations will also be developed to meet agricultural policy requirements as well as for renewable resource management, urban and rural planning, transportation, etc.

The needs to carry out the evaluation or interpretation components of this program are relatively minor, two professional person-years is suggested, but the success of this program is perceived to be closely related to the capability of land quality, water cycle, nitrogen, the basic inventory and other rpograms to deliver the information required.

4. Provincial Soil Information System

The Institute of Pedology initiated the development of a modest soil data bank some years ago, primarily in support of the Soil Testing Laboratory operation. In recent years, with funding from federal sources, two of the files in this data bank, the Soil Data File and Soil Performance Management File have been gradually developed and updated. A number of other provincial agencies, in particular the Municipal Assessment Branch, Land Bank, and Crop Insurance, are in the process of developing soil data banks to meet their specific objectives. The strategy paper recognizes the need to integrate these data banks to provide a soil storage and retrieval system for all provincial users. The desirability of structuring the integrated provincial data banks to ensure compatability with CanSIS is underscored.

The action desired is to establish a provincial soil information system that integrates but does not consolidate the individual data banks presently in operation or in the process of being initiated.

A major requirement is the development of a provincial capability to input cartographic information to facilitate the development of interpretation and evaluation programs. What is needed, at least initially, is the provision of one additional professional to spearhead the development of this local capability. For the most effective development of the soil information system there is need for early action to ensure that existing data are structured such that ready access to all banks by authorized provincial users is possible. There is an urgant need also to integrate the provincial soil data bank with CanSIS.

5. Land Quality

Concerns have been expressed by farmers, scientists and extension workers about the rapid spread of soil salinity, on the 50% or greater decrease in soil humus, and the significantly reduced ability of the soils of the province to meet nitrogen and other plant requirements. Projects in farm production systems, water research, nitrogen research, and micronutrients have been designed to further substantiate the presently documented evidence of soil quality deterioration, and to develop remedial measures. These projects collectively will provide the majority of the land based information required by the soil interpretation and land evaluation group and like this latter project, these land quality projects will make extensive use of the provincial soil information system.

The action required is to develop a series of field investigation sites where an integrated approach to the evaluation of changes in soils as a result of man's activities and the extent to which rain and snow precipitation can be economically cycled through crops will be developed. An accelerated research program, aimed at establishing guidelines for rebuilding the active soil organic matter, evaluating the role of symbiotic and asymbiotic nitrogen fixation, and the initiation of a program involving the survey of the micronutrient content of major soil types and developing techniques for diagnosing micronutrient deficiencies, will complete this four part soil quality study.

Analysis of the Need

Our recognized requirements for an acceleration of the basic soil survey program in the province has been stated to various committees, management groups and others so many times that one eventually gets the impression that our perceived needs are completely unrealistic; that they cannot be justified. Let's examine the facts!

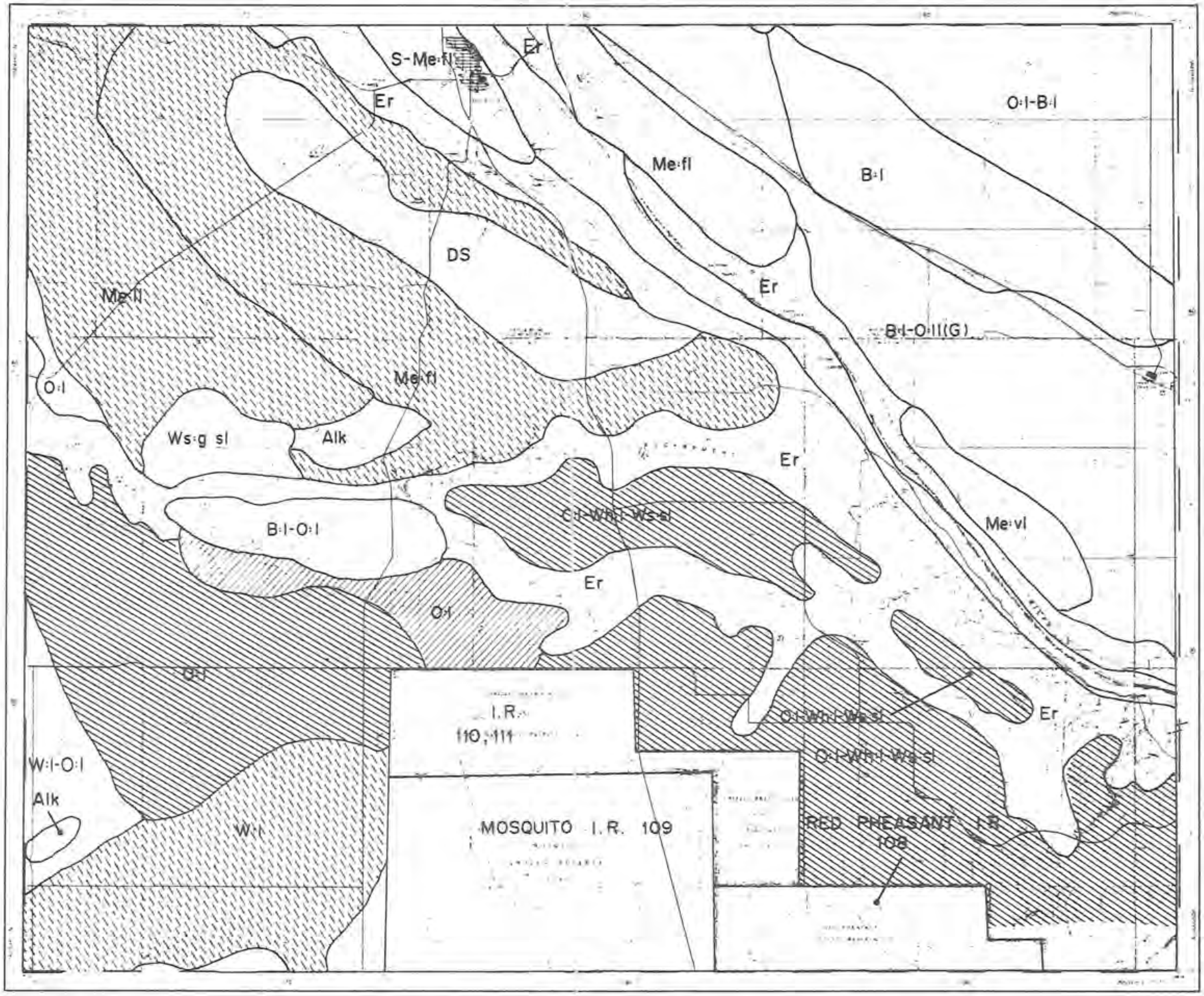

Figure 1. Soil information from broad reconnaissance surveys (Soil Survey Report No. 12) for an area near North Battleford, Saskatchewan.

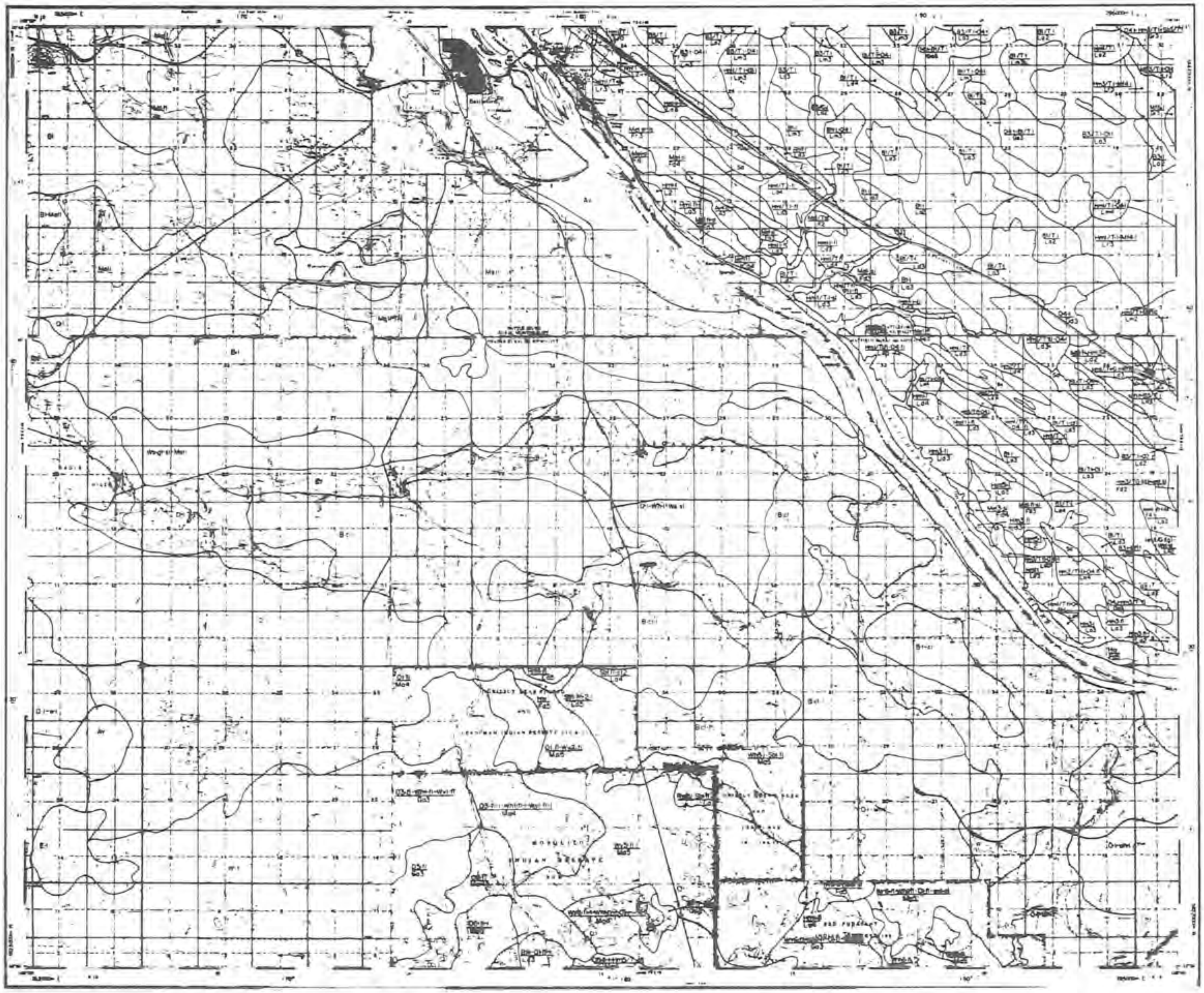

Figure 2. Detailed soil information from the Basic Soil Survey and Indian Reserve Survey and soil information derived from rural land assessment data for CLI agricultural capability maps.

Figure 1 presents an overlay of the map from soil survey report No. 12 on a contour map for the area. It is apparent, already, that soil boundaries such as those along the Eagle Hill Escarpment lack precision; that the survey certainly lives up to its definition of broad reconnaissance. Figure 2 shows, in the area north of the North Saskatchewan River and in the Indian Reserves, the information contained in the detailed soil surveys conducted as part of the basic soil survey and of the special surveys of Indian Reserves. The soil information for the remaining area is taken from the R.M. Brochure map series which represents assessment - derived soils information for areas not covered by basic surveys. The additional information portrayed on the basic soil survey maps compared to the broad reconnaissance map may be grouped into three kinds:

1. Description of the soils. The basic soil survey, through the concept of the map unit, indicates the kind and relative extent of the kinds of soils, or series, in that map unit. In other words, different kinds and extents of series of the same Association can be indicated in different map delineations on the basic survey whereas in the old, broad reconnaissance survey there was no clear way to establish the kinds and extent of series contained in a map delineation of an association.

2. Landform information - the basic survey has, most significantly, added information on the kind of topography or pattern of slopes and, in addition, provides a greater number of slope classes than was contained in the broad reconnaissance surveys.

3. Mapping accuracy. While the mapping accuracy of the basic soil survey maps may not be any greater than that on the broad reconnaissance map, the increase in the survey intensity has markedly increased the capability to make more kinds of statements of greater accuracy for a small land area such as a section or quarter section than was possible on the broad reconnaissance surveys. One could develop a defence to an argument that the mapping inaccuracies that do exist in our basic surveys are mostly academic; that they are of little consequence to the producer considering the kind of agricultural practices in vogue today. A close examination of Figure 2 indicates that this is clearly not so with information on the map from Soil Survey Report No. 12. The area bordering the west side of the Indian Reserves is a case in point. The basic soil survey in the Indian Reserve indicates these soils to be dominantly Black Chernozemic soils (Oxbow Association) with very significant inclusions of Dark Gray Chernozemic (Whitewood Association) and Gray Luvisolic soils of the Waitville Association. The adjoining areas, as mapped on the broad reconnaissance survey indicates these soils to be Dark Brown Chernozemic (Weyburn Association). The argument has often been placed before us that the user of the information can recognize the inadequacy of the survey and correct for it. Such was not the case, in this instance, where the soils mapped as Weyburn on the early reconnaissance survey have continued to be called Weyburn by Land Assessors, and by Pedologists creating soil and agriculture capability maps from this assessment survey.

Inadequate inventories have serious repercussions throughout the production system. In the case cited, the repercussion to the producer, in terms of assessment, land value, crop insurance premiums, management practices, etc., should be fairly obvious. The impact on broader agricultural issues such as quotas, transportation, etc., will depend on the gross inadequacies of the survey and the use that is made of land information such as in agricultural policy development.

Summary

Professional and technical support for research by specialty area and resource requirements are summarized in Table 1. Of particular note, from the standpoint of this committee, is the requirement to markedly increase the field component of the soil surveys by virtually doubling this staff and to develop an ongoing capability to manage and interpret this and other information through the addition of at least two man-years professional staff. In addition to this large requirement of professional staff, are requirements for technical support for the analytical laboratory, computer programing and drafting, totaling 3 person-years to support the soil inventory and interpretive programs. This, in turn, must be augmented with at least 3 person-years of temporary technical support.

Concluding Recommendation

Soil inventories for much of agricultural Saskatchewan are inadequate for use at the producer level. For the area that is covered by adequate inventories the information lacks interpretation and adequate presentation for the producer. In that this situation is common across Canada, it is hereby recommended that the CCLRS place the strengthening of federal and provincial support for soil surveys, in the regions, as its first priority. Further, that this recommendation be fully supported with documentation, province by province or region by region, on the status of inventories and their interpretations and the impact improved information would have on agricultural production in the region.

Table 1. THE SASKATCHEWAN INSTITUTE OF PEDOLOGY - Professional Man Years in Research, by Speciality Areas[5]

	Speciality Area	Professional Man Years - Research			
		Current: 1978			Needed[4]
		University[1]	Federal[2], Provincial	Other[3]	
I	Field Survey	-	8	-	7
II	Land Evaluation; Interp. Pedology; Soil Info. Systems	0.5	1.0	3.0	2.5
III	Genesis, Classification, Mineralogy, Chemistry	1.0	2.0	0.5	0.5
IV	Productivity - nutrition	1.0	1.0	-	1.5
V	Water - irrigation	0.5	-	-	2.5
VI	Microbiology - O.M.	0.5	-	-	1.5
VII	Agronomy, Soil Management	-	-	-	2.0
	TOTAL	3.5	12	3.5	17.5

[1]Nine faculty members contribute 25% of their time to research, plus Dept. Assistant post.

[2]Eight Federal plus five Provincial scientists minus 1 M yr for administration and teaching.

[3]Not included are Hanm, Ho, Johns and four P.D.

[4]Does not include P.D. Permanent staff are a) Univ.: 4 professors; b) S.D.A.: 2 pedologists; c) C.D.A.: 1 pedologist; d) northern Sask.: 2 pedologists; e) plus computer programmer and draftsperson; f) 6 1/2 temporary research scientists.

[5]Data taken from documents titled:
a) Personnel Requirements in the College of Agriculture in 1978-1990, Table 5, p. 53 (1979), and
b) Land Resource Strategy Paper for Saskatchewan, Table 1, p. 15 (1979).

Prepared December 7, 1979.

Manitoba

R.E. Smith

This report briefly outlines a research plan designed to find solutions to land resource use planning and management problems important to Manitoba. It is the result of recommendations put forward by the Manitoba Soil Science Lead Committee. This committee is comprised of representatives from various subcommittees such as the Soil Survey Advisory Subcommittee, the Soil Fertility Advisory Subcommittee, the Manitoba Agrometeorology Subcommittee, and the Pesticides Subcommittee. These subcommittees make annual reviews of relevant research requirements in their specific areas of concern, establish scientific criteria and make recommendations for the maintenance and protection of soil environmental quality, establish priorities in research to obtain solutions to problems in soil management and land use planning and participate in the extension of information to extension personnel and the general public.

The Soil Science Lead Committee, in cooperation with other appropriate lead committees, makes recommendations to the Manitoba Agricultural Services Coordinating Committee (M.A.S.C.C.) and provides representation on appropriate Canada Committees such as the Canada Committee on Land Resource Services (C.C.R.S.). This committee, comprised of representatives within the research community, various federal and provincial government agencies and the private sector, provides a well balanced forum for the development of soils orientated research strategies for Manitoba.

Present research strategy, as it has for many years, reflects the need to continue a strong program of inventory to assess deteriorating agricultural land quality; to resolve rural-urban land use allocation problems; to identify climatic requirements of important value-added crops; to study the impact of soil losses by water erosion, the extent of organic matter decline in soils and changing salinization as a result of cultivation; to develop computer-based systems of land evaluation; and to continue a research program to improve fertilizer recommendations for the economically important crops in the province. Large mining and hydroelectric development projects in northern Manitoba suffer from inadequate soil resource data for assessing environmental impact of such developments, to provide base line data for community planning and to develop natural resource based economic opportunities.

Specific program components include:

1. Inventory

Basic resurvey of approximately 4 million acres at 1:20,000 scale and 11 million acres at 1:40,000 scale in selected areas of the Red, Assiniboine, Pembina, Souris, Swan, Saskatchewan and Winnipeg river basins has been identified. It is estimated that it will take approximately 35 to 40 years to complete this project with available resources.

Giant hydroelectric and large mining projects in northern Manitoba have provided the stimulus for needed basic soil resource data for environmental impact studies, monitoring environmental degradation related to such activities, community development planning, delineating areas for local food production, identifying natural resource based development such as forestry and tourism. Priority areas include the Thompson, Nelson House, Flin Flon, Kississing Lake, Granville Lake, Uhlman and Reindeer Lake N.T.S. map sheet areas.

An acceleration of the resurvey and northern Manitoba projects would greatly increase the need for enhanced soil correlation and quality control procedures as well.

Effective program development in inventory and correlation requires additional staff from:

CDA 1 Professional person-year at BI-3 level
1 Soil Surveyor Assistant at EG-ESS-5 level
3 x 4 person-months or one person-year casual support at EG-1 level

MDA 1 Professional Agrologist at AG-3 level
1 Resource Technician at Tech. 3 level
1 Laboratory Technician at Tech. 3 level

2. Agrometeorological Studies

Agrometeorological studies and enhanced agriculturally oriented, weather and climate forecasting services have been identified as high priority provincial concerns.

Quantitative climatic data requirements for the economically important regionally adapted crops and for such value-added crops as corn, sunflowers, soybeans, fababeans, rapeseed, buckwheat and mustard are required for crop and land management planning.

There is also a need to review the number and location of existing weather stations and a need to enhance weather and climate forecasting to better serve the farming community in Manitoba. This latter concern would involve the Agrometeorology Section of the Land Resource Research Institute and the Atmospheric Environment Service of Environment Canada.

One professional person-year on a continuing basis, is required to adequately undertake the climatic data requirements of crop research in the province.

3. Land Degradation Studies

Studies to inventory, assess and monitor the kind, degree and location of various kinds of land degradation in the province is a third area of concern. An assessment of the extent of soil loss and susceptibility to water erosion is required on different soil types under different systems of soils and crop management. The extent of organic matter decline in soils and the impact of reduced levels of organic matter on the ability of soils to supply nitrogen must be determined. Changes in soil salinity and other water borne pollutants as plant nutrients and pesticide residues must be assessed and research on management practices to develop remedial measures is required.

At least 3 professional person-years, a soil physicist, a soil microbiologist and a hydrology oriented pedologist on a continuing basis, are required to adequately develop and support this program in Manitoba.

4. Agricultural Land Evaluations Research

A fourth area of research concern is accelerated activity in agricultural land evaluation research for land use planning and policy development. It currently requires the integration of soil inventory, agronomic and climatic data to establish production potentials on the basis of established soil units. There is an urgent current need to develop the operational capability of the Soil Performance/Management file of CanSIS to support this project.

An additional one professional person-year on a continuing basis, is required to develop and carry out an effective program of land evaluation in the province.

5. CanSIS

Development of an effective computer aided data management system is essential to the land evaluation project, the land inventory and the development of methods to effectively communicate with users of soil survey information. Increased programming support is needed to accelerate the operational capability of CanSIS. Specific requirements include the purchase of a flathead plotter by the provincial government and software development by CDA to provide massive symbol update, partial symbol retrieval, point-in-polygon, windowing, merging of maps, accessing and analyzing hard data from various CanSIS files employing standard analytical packages as SPSS.

6. Soil Fertility Research

Increased funding and professional person-years are required to continue research aimed at developing improved fertilizer recommendations for all crops are both agronomically and environmentally sound. Specific requirements include investigating more efficient use of all available nitrogen; more effective methods of applying phosphorus to annual crops and perennial forages; determine the extent to which Manitoba soils are deficient in potassium for cereal crop production; determine the extent of sulphur deficient soils and determine sulphur requirements for annual crop and perennial forage crop production; and the micronutrient requirement of all crops but with particular emphasis on perennial forages and annual legumes.

An additional professional person-year in soil fertility research is required to adequately develop this program, in particular the micronutrient studies.

Development of most of the above research programs has, to varying degrees, been initiated as a result of the integrated action of the federal and provincial governments and the University of Manitoba. It reaffirms Manitoba's desire to accelerate present projects and to initiate new programs by continuing the historical cost-sharing arrangements by these agencies. Of the above projects, the land degradation project, the climatic data requirements of crops and the land evaluation projects enjoy highest priority, since it is these that have as yet to be established on a sound footing in the province.

Ontario

C.J. Acton

Status with Respect to 1979 OSSLURC Recommendationa

1. Support for land evaluation research has continued with Agriculture Canada/DSS contract funding to the University of Guelph, Centre for Resources Development for the amount of $247,000 for the 1979-81 period. A NSERC Strategic Grant of $30,000 is supporting development and validation of land productivity models for Ontario. The OMAF contract at the University of Guelph is providing about 1 m. y. of support.

2. Further support for soil erosion research is forthcoming for the period 1980-82 through IJC contract funding to the University of Guelph; approximate total = $50,000.

3. There has been no increase in funding for research in support of the soil survey program in Ontario.

4. No increased funding has been made available to conduct research to operationalize CanSIS retrieval systems. The province, through a Ministry of Natural Resources contract to University of Guelph, Department of Information & Computer Science, is attempting to integrate the many land-based information systems presently in existence into one provincial system. For efficiencies in accessibility and use of land resource data this subcommittee expresses concern that the proposed provincial system should be completely compatible with CanSIS.

Underlying Assumption Relating to 1980 O.S.S.L.U.R.C. Recommendations

No recommendations are forthcoming relating to the need for continued support for the soil inventory program in Ontario. It is assumed that it will continue at least at its present level of support. It should not be construed that the recommendations which follow are of higher priority than the on-going inventory program. Because there is a continuing demand for more soil inventory data to serve increasingly specific uses, the needs for supporting research to provide an improved soil data base in Ontario is apparent. Most of the research priorities which follow have been identified with this objective in mind.

Recommendations

Priority 1

To: Agriculture Research Institute of Ontario

Proposal

To increase funding for research in support of the soil survey program in Ontario.

Details

Increased funding is required in Ontario Ministry of Agriculture and Food Program 39, University of Guelph to provide support for 1 Research Assistant, 1 Technician, 3 part-time summer support staff and operating funds. Total direct costs are estimated at approximately $60,000/yr.

Background

With the expanded soil inventory program and demands for more accurate and specific information on soil resources as a basis for land use decision-making, the need for support research studies in this area is becoming increasingly important. The scope of the research projects is very broad, but they are all related to improving the quality, usefulness, and rate of production of soil survey information. They include projects such as the following:

1. Studies on soil variability to establish statistically sound estimates of the range of soil characteristics to be encountered in natually occurring soil groups delineated on the soils map.
2. Studies to improve the predictive capability in soils mapping. This involves establishing improved soil-geologic-vegetation relationships to more effectively utilize existing resource information in the preparation of soil maps. Also, transect or grid-sampling procedures, together with application of statistical techniques, should be evaluated on a pilot scale for expediting soil inventories.
3. Quantification of soil survey information. Provision of quantitative data on such things as soil physical properties, erodibility, productivity, drainage, etc. is required. In some cases much greater characterization of soil properties are needed; in others, methodology research for quantification is required. This type of data provides a more objective basis for interpretations in terms of capability, suitability or limitations for a given use. Information interpreted in this manner is more easily utilized by planners, land managers, etc.

Priority 2

To: Agriculture Canada, Central Region and Agriculture Research Institute of Ontario.

Proposal

To develop further (operationalize) CanSIS for ease of accessibility particularly in those aspects related to soil interpretations for potential users in Ontario.

Details

Funding is required for one graduate research assistant for 2 years ($12,500), to develop software needed to improve accessibility ($10,000), and to obtain copies of data tapes (minimal cost).

Background

Soils data has been put into the CanSIS data bank over a period of several years. Included is morphological, physical and chemical data on a soil series basis; soils, management and yield data for a range of crops from various research plots; and soil map information on a county basis. The amount of information being stored is increasing yearly as the practice becomes routine. There is a need to improve the accessibility of this information to Ontario users, through research to determine the type of output which best serves user needs, to prepare software packages for manipulation and retrieval of stored data, and to establish a user policy with regard to data retrieval.

Priority 3

To: Agriculture Canada and Agriculture Research Institute of Ontario.

Proposal

To develop a land evaluation system useful for land use planning and policy development in Ontario.

Details

A federal-provincial cost-sharing program is needed to further develop the land evaluation system and obtain the required information over the next decade. A major program similar to the CLI should be initiated to provide continuity of support over a number of years.

Background

There is growing uncertainty about the ability of the Canadian land resource to meet future societal demands for goods, services and amenities because of conversion of agricultural land to alternative uses, increasing food imports, and the vulnerability of high-energy agricultural technology. Planners and other decision-makers are faced with competing demands for land without adequate knowledge of how possible changes in population, trade, climate, energy availability and other factors might affect the future land needs for future food and fibre.

The land evaluation system, currently under development by a multidisciplinary team at the University of Guelph under the sponsorship of Agriculture Canada and O.M.A.F., is designed to address this problem. Land evaluation can be regarded as a synthesizing technique which takes what is known about the capability of land for certain uses, about the availability of land and non-land resources, and about the goals or needs the use of land must meet, and indicates the relative importance of each area for agriculture nd other uses under alternative future scenarios.

The work in 1979-1981 has the following objectives:

a) refine the prototype model,
b) demonstrate and explain its application to a variety of analytical problems,
c) improve output formats for use by policy makers and planners,
d) estimate revised data for current and projected land productivity, demands and land constraints,
e) demonstrate application of the system at the provincial and subregional levels,
f) improve crop productivity models.

Having operationalized the system on a demonstration basis, and looking toward a program similar to the C.L.I., the team will proceed beyond 1981 to refine the system's capabilities and convenience in a variety of analyses, especially improving the accuracy of data and realism of assumptions with respect to:

a) delineating areas of homogenous soils, climate, urban proximity
b) estimation of yield of each crop on each kind of land, and fuel and nitrogen required for that yield, with average and recommended management,
c) feed requirements for each kind of livestock (roughage, protein, TDN)
d) outputs, demand for consumption and trade
e) land available for agriculture
f) land for urban, forestry and other competing uses
g) constraints on land use allocation, such as
-rotations to control soil erosion
-mixtures of crops
-urban influence on choice of crop, and yields
-energy available
-nitrogen available

The funding and manpower requirements are substantial. Three research assistants, two research associates and faculty time are required for data compilation and validation, model development, and computer programming. To retain the specialized skills currently available longer-term fund commitments on the order of $120,000 per year are required.

Priority 4

To: Agriculture Canada and Agriculture Research Institute of Ontario.

Proposal

To continue support for soil erosion and sedimentation research in Ontario.

Details

Funds are required for continued support of two research assistants and operating costs beyond 1982, situated at the University of Guelph. The approximate cost is $50,000/yr.

Background

Recent PLUARG studies illustrated that much of the sediment delivered from agricultural lands was contributed by particular soils and land use within "hydrologically active" areas. These sediment contributing areas varied in size seasonally but did reach maximum values during and immediately following snowmelt events. Under Canadian climatic conditions it also became apparent that the most active period of erosion and sediment transport was during and immediately following the snowmelt period. Research has been initiated to establish erodibility of soils during this period of active erosion as well as determining the significance of freeze-thaw cycles on soil aggregation. Also, research to establish cost effective methodologies for identifying sediment contributing areas of the province is underway. Further support is needed to continue these projects over a period of years.

Québec

R.W. Baril

Les équipes pédologiques des gouvernements fédéral et provincial poursuivent l'inventaire fondamental des sols du Québec en tant que ressource en vue d'établir leur valeur agrologique. L'équipe provinciale procède à des études de reconnaissance à l'échelle du 1:50,000; l'équipe fédérale reprend à une échelle détaillée soit le 1:20,000, la couverture des comtés les plus productifs du Québec et enfin, l'université même, quelques projets à une échelle détaillée de quelques secteurs pilotes pour la formatin d'étudiants gradués.

L'état d'avancement des travaux en cartographie est le suivant:

1. Equipe provinciale - Les études pédologiques des comtés de Rivière-du-Loup et l'Islet sont arrivées au stade d'impression et les cartes des Iles d'Orléans et aux Coudres viennent de sortir des presses. Les rapports et les cartes des comtés de Témiscouata et Charlevoix seront prêts pour l'impression à la fin de l'année 80 ou au début de 81. L'étude pédologique du comté d'Arthabaska sera complétée vers la fin de 1981 ou au début de 82. Présentement, l'équipe provinciale travaille dans le comté de Mégantic. La couverture du comté de Mégantic a débuté en 79 et se poursuivra quelques années.

2. Equipe fédérale - Actuellement, la cartographie pédologique effectuée couvre 75% du comté de St-Hyacinthe, soit 140,000 acres. Les directeurs de l'Institut de Recherches Pédologiques du Québec auront une décision à prendre sur la forme que prendra la publication. La saison prochaine, trois équipes finiront la cartogrpahie du comté de St-Hyacinthe. Une autre équipe procèdera dans le comté de Richelieu à la confection d'une carte pédo-géomorphologique.

3. Université - Dans le cadre d'un projet de recherche, on finalisera la cartographie détaillée de deux secteurs du comté de Lotbinière.

Paralellement aux travaux de cartographie, le programme de recherche de l'I.R.P.Q. se complète de travaux spéciaux en géomorphologie, en minéralogie, en micromorphologie et caractérisation des sols. Ces travaux visent à résoudre des problèmes particuliers concernant la caractérisation des matériaux originels, la genèse, la classification et la cartographie des sols.

Les principaux objectifs de recherches des membres de l'IRPQ sont les suivants:

- poursuivre les levées pédologiques par les équipes provinciale et fédérale.
- réaliser une cartographie pédo-géomorphologique des terrains en vue de la prospection pédologique.
- appliquer des techniques microscopiques, minéralogiques et chimiques afin d'approfondir la connaissance des podzols boréaux humides.
- analyser minéralogiquement plusieurs séries de sols du comté d'Arthabaska.
- caractériser différentes séries de sols ayant des horizons à caractères particuliers; horizons cimentés et horizons à fragipan.

- mettre sur pied une banque québécoise de données de sols.
- interpréter les unités cartographiques dans le but d'en arriver aux unités d'aménagement comme le font les américains. Priorité, cartographie détaillée.
- caractériser quelques séries du point de vue de leurs propriétés physiques et hydrodynamiques.
- étudier l'effet d'injections de lisier de porc sur l'amélioration des propriétés physico-chimiques et mécaniques du sous-sol.
- installer des puits d'observation afin de mesurer la hauteur de la nappe d'eau des principaux dépôts des sols du comté de St-Hyacinthe.

Nous nous permettons de proposer que le gouvernement fédéral consente à l'engagement de personnel supplémentaire tel que décrit dans l'entente de l'IRPQ, c'est-à-dire de combler les postes vacants laissés par le départ de 2 pédologues seniors. En second lieu, que les textes provenant d'Ottawa nous soient communiqués en français, ce qui nous faciliterait leur comérphension et leur étude.

New Brunswick

R.E. Wells

A. On-going New Brunswick priorities with regard to soil survey and soil interpretations focus on two general areas. The first of these concerns the lack of utilization of existing soil survey information for improvement of crop yields and management practices. Toward remedying this deficiency in the agricultural areas the Province has evolved a three phase strategy:

1. The first phase involves completion of present 1:10,000 and 1:20,000 scale soil surveys, namely the Gloucester Peninsula and Havelock areas. These surveys, now nearing completion, will provide detailed and semi-detailed information for a major attempt to make on-farm use of this type of soil resource data.

2. Second major approach to increase use of existing soil survey information has been to expand the site selection program started for apples to include blueberries and vegetable crops. New Brunswick policy now requires farmer applicants to have on-farm soil inspections prior to approval of assistance for development.

3. Pending successful development of methodology to utilize results of the before-mentioned detailed and semi-detailed soil surveys, the third phase will involve operational soil survey of production record farms as a basic first step in developing a comprehensive agricultural land management program.

The second major focus is that of forest site evaluation and classification for reforestation and other management measures. This program is based **upon:** a) Climatic zones b) Soil-geologic units c) Forest growth data.

The subdivision of New Brunswick into climatic zones has been carried out by H. van Groenewoud (Maritimes Forest Research Centre) and should shortly be available in published form. The site classification program also calls for delineation of broad soil-geologic units based on textural and mineralogical characteristics of surficial materials and subdivision of these units as needed on the basis of drainage, compact layers and other soil characteristics. Initially most of the forest growth data to be utilized in the program will come from plantations. The growth data will be compared with the climatic zones and soil-geologic units (land sub-units) and expectations are that this synthesis should provide an accurate basis for selection of optimum sites for the planting of various tree species. Emphasis of the program to data has been on parts of the province with established plantations.

B. Overall research needs and priorities associated with soil survey and soil interpretations in New Brunswick can be listed as follows:
- Need to define and quantify soil degradation as a result of continuous potato production in terms of soil structure, organic matter content, soil fertility levels, biological activity, erodibility, etc., and to design suitable remedial measures;
- Need to quantify soil erodibility as a factor of major soil types, climatic factors, tillage and cropping practices;
- Need to define and quantify soil moisture status of major New Brunswick soils in terms of their moisture excess, deficit and regime as a basis for establishing model management and improvement practices for soils with limiting moisture regimes.
- Need to define and quantify the extent and significance of various compacted and cemented layers occurring in New Brunswick soils, and to design model improvement practices and evaluate their lasting effects;
- There is a need to establish a project leading toward land suitability classification of major New Brunswick lands to various adapted crops (i.e. soil x climate x crop suitability)
- There is a need to initiate a systematic approach to furnish detailed soil data for projects designed to collect yield data.
- There is a need to evaluate the variability of soil characteristics within mapping units for existing soil survey information with the overall aim of designing soil survey methodology suitable for soil management, crop specialization and planning at the farm level.
- There is a need to establish benchmark sites to monitor soil climate in relation to atmospheric climate for important major New Brunswick soils. There is a lack of sufficiently detailed soil climate information with which to tie together climate, soil and biological production.
- There is a particular need to develop interpretive criteria for silviculture especially as they relate to plantation establishment and detailed forest land management practices.

Finally there is a continuing agreement on the priority for L.R.R.I. to complete soil survey at an exploratory level for the remaining one-third of the Province before going on to same kind of an operational program to provide more detailed information for on-farm application.

Nova Scotia

K.T. Webb

I. Needed services and research requirements for soil survey are:
   (a) A compatible correlation procedure which can be applied throughout the Atlantic region.
   (b) The quantitative evaluation and identification of soil interpretation criteria would be helpful. Methods of applying interpretations at different survey intensity levels and to varying kinds of mapping units require development. A mutually acceptable system for determining CLI ratings for Agriculture appears desirable for the Atlantic region.
   (c) Marketing research should be initiated to determine who the users of soil survey information are in the province and what information to specific soil survey field problems.
   (d) Adequate soil laboratory back up is needed to provide prompt information to specific soil survey field problems.
   (e) Standardized methods for, and evaluation of the nature and composition of the organic matter component in soil may enable further refinement in soil taxonomy and provide guidelines for soil management.
   (f) Continued research for the SWIG, Soil Water Regime Classification is required. Further investigations are necessary to correlate soil morphology and site features to moisture regime criteria. To better understand these relationships, data must continue to be generated in the following areas:
      (1) Water table information should be collected from more soils.
      (2) Hydraulic conductivity measurements of restricting soil horizons should be taken more frequently.
      (3) Relationships between water retention and soil morphology require investigation.
      (4) Better understanding of soil structure as it affects hydraulic conductivity and water retention is needed.

      Correlating the SWIG approach to taxonomy, soil mapping, correlation procedures and soil interpretations will require investigation.
   (g) Soil Physical Problems

      In Nova Scotia, crop yields over extensive areas are adversely affected by shallow rooting depths caused by perched water tables, ortsteins, plow pans, fragipans and dense basal tills. At this time, little information exists as to the best methods of alleviating these rooting restrictions. It is now apparent that further improvements in crop production may best be achieved through research efforts directed toward understanding the nature, extent and effect of compact subsurface layers and their amelioration.

To assist in the achievement of these goals, soil survey requires quantitative criteria to classify and differentiate the limits and characteristics of restrictive soil layers. With refinements in the limits of these layers, research results on soil physical problems can be more accurately extended.

(h) Soil Degradation
 (1) Soil Erosion - Measurements of soil loss in Nova Scotia have ranged from 40 tonnes/ha from a 10% field in silage corn to 230 tonnes/ha from residential construction sites on drumlin terrain. Many more sites are needed to provide soil loss data on the more important soils in the Province. Erosion plots on agricultural land are required to validate the losses of such vital soil components as organic matter, soil structure, tilth, water holding capacity and nutrients, Evidence of these losses are needed to provide convincing arguments for the implementation of soil conservation practices.
 (2) Acid Precipitation - The impact on soils of long range transportation of air pollutants is not as well understood or documented as the case of aquatic ecosystems. Forest soils are not as well buffered as agricultural soils and may suffer degradation over time due to the effects of acidic precipitation. Baseline data on forest soil chemistry need to be established for representative soils throughout the Province.
 (3) The loss of soil organic matter due to various management practices requires investigation.
 (4) The development and extent of acid sulphate soils in dykeland areas need to be examined.
 (5) Monitoring and testing the impact of pipeline construction on the soil resource should receive high priority.

II. Needed services and research requirements for land evaluation are:
 (a) A climatic zonation mapping program which concentrates on the agricultural areas of the Province.
 (b) Greater input of reliable production data acquired from modern management systems.
 (c) Improved data credibility collected from more sites.
 (d) Data input documenting horticultural crops, their management and yields.
 (e) Information on the socio-economic factors affecting land use decisions and the value and use of land as a production base.
 (f) An integrated information system that has the capability of handling different data bases.

Prince Edward Island

F. Wilson

Last year Dr. Raad addressed the first annual meeting of the Expert Committee on Soil Survey, and expressed thereto the provinces position. I would like to reaffirm that position taken, to elaborate somewhat, and, in general, bring you up to date on our situation. The latter first. The inclusion of the Soil Survey Unit in the Technical Services Branch of the Department of Agriculture and Forestry, has come to pass, making the complement now, in addition to the Soil Survey Unit, a soil chemist, a soil physicist, a drainage engineer, an agroclimatologist, a weed and pest control specialist, and a farm machinery engineer. I mention this here not only because it reflects our philosophy of providing an integrated approach to land management problems but also reflects on our perceived data handling needs which I will deal with later.

We still believe that the need to establish practical solutions to the problems of compact subsurface layers, soil compaction and degradation, drainage classification and its effects, and data handling as expressed by Dr. Raad, exists. Some progress has been made in this regard. Some time will be spent in the next few days discussing drainage proposals first promoted in the Atlantic region, and moe specifically, by our Federal colleagure Conrad Veer. Our Federal colleagues have also established a series of ground-water wells throughout the province and are monitoring them. The Technical Services Branch is providing information on soil moisture status and permeabilities.

We have the end of the map making phase of the soil survey in sight. About 60% of the 100 1:10,000 maps have been forwarded to LRRI, about 25% have been returned completed, and 15% are ready to go and about 25% are yet to be done. We have been negotiating with our Federal colleagues to identify each of our roles more clearly and to coordinate our efforts so that the remainder of the maps will be ready for digitizing by April 1981 if at all possible. It seems in order to mention that the Provincial involvement with Soil Survey has never been less than two persons and at times has been as high as 5 of the 7 people mapping during the summers, drafting services are provided, as has been some secretarial help. The Technical Services Branch has also provided detailed (data and written) information to LRRI, Atlantic, and local people relating to our proposed integrated land management service. We expect the cooperative spirit to continue, and if we are able to meet the April 1981 goal mentioned above it leads to some urgency in putting in place our data handling needs.

Dr. Raad, last year, introduced his "Land Resources Record Book" and has made available to many his integrated approach to land management and conservation. He also mentioned that there was strongly expressed interest by farmers in overcoming their land management problems. Since then the National Farmers Union and the Federation of Agriculture have recommended to the Minister implementation of the proposed system.

It has been given added support by Dr. Ian MacQuarrie's report to Executive Council on Soil Erosion on Prince Edward Island. Circulars have come from the Premiers Office asking all concerned departments to be ready to implement most if not all of Dr. MacQuarrie's recommendations. And what are they? Those recommendations of interest here are

(1) that financing for land management programs should increase at least ten fold during the next phase of the Development Plan,
(2) that the work of the Technical Services Branch of the Department of Agriculture should be supported strongly,
(3) and that with the cooperation of farmers and groups such as the Federation of Agriculture and the National Farmers Union demonstration projects on erosion abatement should be established on a province wide basis.

Some funds have been provided to start the latter this summer and we're not into Phase III yet! Thus there is very strong support for Dr. Raad's proposals and funds are beginning, to see that it is put in place.

Our soil information is being put on the CanSIS computer, and for this we are indeed thankful. Not only will we be getting information to deal with problems at the provincial level, but also at the map sheet leval and we are provided with a clear acetate soil map which we overlay on our 1:10,000 photo base to get a reproducible map available to those who wish to use them in this form. But we would like to get down to a finer level - to the watershed to do erosion control planning, to the Community Improvement Committee level to do municipal planning, and to the farm and field level for it is he who owns the land who decides generally what is done with it. The Land Resources Record Book would include information on land owners fields and acreages, soil maps, drainage maps, erosion potential map, frost risk map and yearly soil tests. The data handling system would also include information on his forested land, on his hedgerows, as it relates to wind velocities and wildlife uses, land use for water management, and in fact would include any pertinent data that would bear the decision making level in the management of farms, forests, and other resouces. It is of importance to the land owner to know the possible carry over effect of sprays on subsequent crops, know what the beneficial effects and costs are to draining a certain parcel of this land, and know the consequences of planting a potato variety requiring 140 days to maturity in areas where the probability of having a shorter growing season is high. It has been estimated that 2 to 4 thousand acres of potatoes are lost per year simply by planting in the wrong areas and this is of consequence not only to the grower, but to the crop insurance agency and the general economy as well.

If we are going to serve a significant number of land owners we want to have our soil information as good and accurate as possible so that we can integrate it with other information as or more important in providing an integrated service. We are presently exploring with other organizations who have expressed a willingness to cooperate with us the setting up of the desired automated data handling system to deliver this integrated package. We look forward to participation of CanSIS in this endeavour.

Newfoundland

K. Guthrie

The Newfoundland government does not carry out any agricultural research and therefore the province depends upon Agriculture Canada for this service. The Agriculture Canada Research Station in St. John's provides good service to the province; however, much of the land resource research is carried out for the Maritime region and is often not applicable to Newfoundland. Also, there are no colleges or universities conducting agricultural research, and the agriculture industry is too small at present to undertake research on a contractual basis.

Major emphasis has been placed on expansion and development of agriculture by a 5 year DREE Agriculture Subsidiary Agreement which will be in effect for another 3 years. This agreement, together with the discovery of oil off the coast and increasing optimism for the future has increased the pressures on land. With increasing pressures, increased research services are required.

The priorities for agricultural research and data collection in Newfoundland are:

<u>Agrometeorology</u>

- Information on localized climate
- Frost probability data and maps
- Growing degree data and maps
- Soil temperature - crop growth studies

<u>Land Evaluation and Land Use</u>

- Land Registration
- Determination of land values according to productive potential and market proximity
- Comparative values for alternate uses of agricultural land
- Costs and benefits to society of preserving agricultural land

<u>Soils</u>

- Water regimes - water table fluctuations
  - soil water regime classification and interpretation.
- Land clearing - improved methods and cost-benefits of clearing land of various agriculture capability or performance classes
- Feasibility of draining mineral soils
- Effects of compacted and cemented layers on agricultural use
- Productivity/performance trials of soils
- Correlation between soil mapping, soil testing and productivity/performance trials
- Management, nutrition, carrying capacity and improvement of heathlands (barrens) for livestock grazing.

APPENDIX 2. WORKSHOP SESSIONS ON CLASSIFICATION AND INTERPRETATIONS

Soil Water Regime Classification 1980

J.L. Nowland

Purpose

SWIG contends that the soil water regime is one of the most important attributes of soils, not only from the standpoint of its role in soil genesis, but also its pivotal significance to those making use of soils information to practical ends. Its significance to users was corroborated in the "market analysis" done by Valentine and the Vancouver Job Corps in 1979.[1]

The deficiencies in the current approach to "drainage" were discussed in previous reports of the CSSC Subcommittee on Soil Water.[2,3,4] The particular blend of parameters embodied in the new proposal is arbitrary in the sense that certain facets of the soil water regime such as water table are given more emphasis than others, such as surface infiltration capacity, and pore volume. This was a deliberate simplification in the belief that the properties chosen capture the essence of what is required for interpretations and are within the expertise of most mappers.

The purpose of the classification, then, is to characterize the soil water regime in a manner that will be practical for mapping purposes, that covers the most important parameters needed in interpretations, and that can be applied consistently on a national basis. It is to be sufficiently simple for inexperienced mappers to apply. It is to be sufficiently flexible that regional needs can be accommodated by subdividing the class limits on the one hand, or generalizing them or omitting optional criteria on the other. It must facilitate both interregional comparisons at the general level, and useful site comparisons at the local level.

The classification is for sites not areas, and has to be incorporated in map unit definitions in the same way as other site-specific properties. Its practical usefulness depends to a large extent upon:

i) Development of local field clues in each project area that relate the classification criteria to observed soil morphology and site conditions;

ii) an expanded effort in field measurement of water table, hydraulic conductivity, and water content;

iii) adequate description of associated land use;

iv) critical review of the class limits in relation to interpretive requirements;

v) more precise and consistent characterization of soil structure as it affects hydraulic conductivity.

Progress

Progress was not as rapid as I would have hoped, but reasonably satisfactory. We are still at the stage of testing the proposal set forth a year ago for classifying soil water regimes in the course of soil surveys, which we regard as the immediate priority. Although some survey units are satisfied that we have an improvement over the old scheme, and that it works in the field, more time is required in 1980 for testing.

The main complaint is lack of data to support the classification, and it is interesting to note that more time for testing is needed as much in the province with most data as in those with least. In one or two provinces, the proposed scheme is already incorporated in their daily field sheets, and it could be used on a routine basis in 1980.

On data collection and the proposal, our philosophy is as follows:

1) The initial application of the new proposal with existing data involves as much guesswork as the old scheme, even more, but unlike the old scheme, it can be built upon.

2) The new scheme involves some reorientation of thinking, which in itself has been quite productive in field situations.

3) If the general approach is acceptable, then a reasonably practical framework of classification is required in order to provide a vehicle and a spur for a much expanded effort in data collection. Although some have said that we cannot classify until we have the data, we feel that having slots for soils being mapped motivates data collection at the survey level.

4) Data collection could be envisaged at three levels:

   i) by the soil surveyor as just one of the many tasks in routine mapping;

   ii) by the surveyor with a special interest in soil water doing a little research on the side;

   iii) by the full-time researcher, perhaps in cooperation with several surveyors.

   At this stage we are concentrating on the first two levels, because the quality of their inventory of the soil resource can be markedly improved by better characterization of soil water conditions. Practical support at the third level is growing visibly.

5) Soil survey will have to accept the notion that field measurements are a legitimate part of soil survey, unless the surveyor has extraordinary insight into soil morphological evidence. At the same time the basic mandatory laboratory analysis package will have to include some determinations not presently regarded everywhere as routine, such as desorption curves and bulk density.

6) Indirect field clues that relate soil morphology and site conditions to the measured data and classification criteria will have to be developed locally for each region and project.

7) There is some difficulty deciding what additional effort can reasonably be asked of the survey units, but recommendations to this end are attached. Once the most suitable data collection methods are established, a Methods Manual for field monitoring will be proposed.

SWIG - OUTLINE OF SOIL WATER REGIME CLASSIFICATION 1980

CLIMATIC ZONE

At the broadest level, there is a requirement to stratify water regimes by climatic zone. This requirement comes into sharp focus, for example, when attempting to define classes for the influence of lateral seepage, where the effects on plant growth vary greatly between climatic zones.

For the present, and until something better materializes, the Soil Climates of Canada provide a framework. USE IS OPTIONAL

I	Arctic	III	Cryoboreal	V	Mesic
II	Subarctic	IV	Boreal		

Soils without a Perennially Frozen Horizon

ARIDITY (A) CLASSES

Class	Aridity Index	Class	Aridity Index	Class	Aridity Index
1	<100 mm	5	250-299	9	450-499
2	100-149	6	300-349	10	500-549
3	150-199	7	350-399	11	550-600
4	200-249	8	400-449	12	>600

Aridity Index: the long term average of the supplemental water required to maintain plant available water equal to or greater than one-half of capacity throughout the growing season for a perennial crop.

USE OF ARIDITY CLASSES OPTIONAL IN SUBHUMID AND MOISTER SOIL CLIMATES (WATER DEFICITS <12.7 CM).

SOIL TRANSMISSIBILITY (K) CLASSES

Class Symbol and Name		Minimum control section transmissibility (cm/h) and depth of impedance (cm)	
A	High transmissibility	>10	throughout control section
B	Medium trans., deep impeded	2.5-10	at impedance below 50
C	Medium trans., shallow impeded	2.5-10	at impedance within 50
D	Uniform medium transmissibility	2.5-10	throughout control section
E	Slow trans., deep impeded	0.5-2.5	at impedance below 50
F	Slow trans., shallow impeded	0.5-2.5	at impedance within 50
G	Uniform slow transmissibility	0.5-2.5	throughout control section
H	Very slow trans., deep impeded	<0.5	at impedance below 50
J	Very slow trans., shallow impeded	<0.5	at impedance within 50
K	Uniform very slow transmissibility	<0.5	throughout control section

An impedance is an horizon having an average K sat. value <1/3 of the overlying 25 cm. of soil, and which restricts flow when saturated.

LATERAL SEEPAGE MODIFIER[1]

d Dystrophic: Soil supports plant growth equivalent to or less than associated non-seepage sites.

m Mesotrophic: Plant growth up to 25% greater than on non-seepage sites.

e Eutrophic: Plant growth more than 25% greater than on non-seepage sites.

USE OF LATERAL SEEPAGE MODIFIER IS OPTIONAL. Symbol is attached to K class symbol to indicate degree of biological impact of nutrients or oxygen or both in major flows of seepage water.

ZONE OF SATURATION (S) CLASSES (WATER TABLE)

Classes	1	2	3	4	5	6	7	8
Mean highest (MH) (cm depth)	>100	50-100	0-50	50-100	0-50	0-50	Surface	Ponding
Mean lowest (ML) (cm depth)	>150	>150	>150	100-150	50-150	<50	>50	<50
Class Names	deep	deep proximate	deep and shallow	proximate	proximate and shallow	shallow	proximate ponded	shallow ponded

MH is an estimate of the average annual highest zone of saturation maintained for a two day period or more. The zone of saturation must be 25 cm thick or greater. ML is an estimate of the average annual lowest zone of saturation. The zone of saturation must be 25 cm thick or greater.

SATURATION PERSISTENCE (P) CLASSES (WATER TABLE)

THIS IS AN OPTIONAL REFINEMENT OF THE S CLASSES in which the persistence of a zone of saturation within 50 cm of the surface is estimated for a summer period (April 15 to Oct. 31 - 200 days) and a winter period (Nov. 1 to April 14 - 165 days). The zone of saturation must >25 cm thick.

Summer Class	Symbol	Period	Winter Class	Symbol	Period
Ephemeral	e	0-2	Ephemeral	e	0-2
Very short	v	3-15	Short	s	3-60
Short	s	16-30	Long	l	61-165
Medium	m	31-60			
Long	l	61-120			
Prolonged	p	120-200			

The symbol is attached to the S class symbol, e.g. 5ml, and the summer estimate can be used without a winter estimate.

ɛfinitions apply only to East Coast humid maritime climates and require modification for other ːimates.

WATER REGIME MODIFIERS

These are an optional refinement of the basic classification, indicating two degrees of impact of long-term modification, minor and major.

D, DD	ditched (open, covered)	R, RR	ridged, listed, plancheron
T, TT	tube drained (tile, plastic)	I, II	irrigated
M, MM	mole drained (unlined)	X, XX	water table raised by dams, drainage scheme discharges etc.
S, SS	subsoiled		

THE OPTIONAL MODIFICATION NOTATION is attached to the basic symbol with a hyphen. The list is open-ended.

WATER REGIME CLASSES FOR CRYOSOLIC SOILS

The classes proposed for soils without a perennially frozen horizon require drastic modification for Cryosolic soils because of the over-riding influence of permafrost. At present, they are largely conceptual until field studies permit refinement.

1. Aridity (A) Classes. Inapplicable
2. Soil Transmissibility (K) Classes.

Textural and structural discontinuities in the soil profile assume less significance in relation to the influence of the permafrost table. Permafrost is not a static impeding layer in the sense defined for other soils. Therefore it may be necessary to use only the "uniform" K classes A, D, G and K.

Lateral seepage classes are of special importance in Cryosolic soils, but the class definitions would be different:

d Dystrophic: Soil supports plant growth less than 100% greater than an associated non-seepage sites.

m Mesotrophic: plant growth 100 to 250% greater than on non-seepage sites.

e Eutrophic: plant growth more than 250% greater than on non-seepage sites.

Further differentiation within class e might be necessary and good definitions of "plant growth" and "non-seepage sites" are required. These classes apply only to the Arctic and Subarctic Climates on the Soil Climate Map of Canada.

3. Zone of Saturation (ZS) Classes.

The depth criteria have been changed for Cryosolic soils.

Classes	1Z	2Z	3Z	4Z	5Z	6Z	7Z	8Z	9Z
Mean highest (MH) cm depth	>100	20-100	0-20	20-50	0-20	0-20	Surface ponding		
Mean lowest (ML) cm depth	>150	>100	>100	50-100	20-100	<20	>50	20-50	<20
Class names	deep	deep proximate	deep & shallow	proximate	prox. & shallow	shallow	deep ponded	proxi. ponded	shallow ponded

4. Saturation Persistence (P) Classes
   Optional use of summer classes. Winter classes inapplicable.

5. Ground Ice Classes
   Still to be developed

6. Water Regime Modifiers
   As for unfrozen soils: optional.

EXAMPLES OF CLASSIFICATION NOTATION AND DAILY FIELD SHEET RECORD

1. Basic classification notation (humid climate)

Notation	Water Regime Name
E3	Slow transmissibility, deep impeded; deep and shallow zone of saturation (or water table)
	Estimated minimum control section K sat. is in the range 0.5-2.5 cm/h, controlled by an impeding layer below 50 cm. Mean highest level of zone of saturation is between 0 and 50 cm, mean lowest is deeper than 150 cm.

2. Basic classification notation (semiarid climate)

Notation	Water Regime Name
4D1	Aridity Index 4; uniform medium transmissibility; deep zone of saturation.
	Texture and organic matter of the soil are such that 200-249 mm of supplemental water would be required to maintain plant available water at one-half of capacity throughout the growing season for a perennial crop. Estimated minimum control section K sat. is in the range 2.5-10 cm/h through most of the control section. Mean highest level of a zone of saturation is deeper than 1 m, mean lowest is deeper than 1.5m.

3. Complete national notation (and longest) for a hillside site in Newfoundland.

III1Ce5ml-DD (forested)	Cryoboreal climate. Less than 100 mm of supplemental water would be required to maintain one-half capacity throughout growing season; medium transmissibility (2.5-10 cm/h) controlled by impeding layer within 50 cm; lateral seepage causes forest growth >25% greater than on neighboring non-seepage sites; mean highest level of zone of saturation estimated at between 0 and 50 cm depth, mean lowest at 50-150 cm; medium period (31-60 days) of saturation within 50 cm during summer period; long period (61-165 days) of saturation within 50 cm during winter period, Nov. 1 to April 14.
	Major modification of water regime by ditching.

4. Daily field sheet record (Soil Water Regime Segment)

This is based on the 1979 layout for the "Atlantic Provinces Soil Survey Daily Field Sheet Record" and the Manitoba "Special Evaluation (1979), Soil Water Regime (Drainage) Classification". The codes for classes of AI, winter saturation persistence and modifiers are not finalized, but can be supplied on request.

Drainage (Old)

SOIL SITE DRAINAGE CLASSES

C601** Very rapidly drained
C602** Rapidly drained
C603** Well drained
C604** Moderately well drained
C605** Imperfectly drained
C606** Poorly drained
C607** Very poorly drained

Aridity Index

D301** <100 mm
D302** 100-149
D303** 150-199
D304** 200-249
D305** 250-259
D306** 300-349
D307** 350-399
D308** 400-449
D309** 450-499
D310** 500-549
D311** 550-600
D312** >600

SOIL TRANSMISSIBILITY (CM/HR)

E101**	High	>10
E102**	Med., Impedance >50 cm	2.5-10
E103**	Med., impedance <50 cm	2.5-10
E104**	Med., uniform	2.5-10
E105**	Slow, impedance >50 cm	0.5-2.5
E106**	Slow, impedance <50 cm	0.5-2.5
E107**	Slow, uniform	0.5-2.5
E108**	Very slow, impedance >50 cm	<0.5
E109**	Very slow, impedance <50 cm	<0.5
E110**	Very slow, uniform	<0.5

	ZONE OF SATURATION	Class
E201**	MH>100, ML>150	1
E202**	MH 50-100, ML>150	2
E203**	MH 0-50, ML>150	3
E204**	MH 50-100, ML 100-150	4
E205**	MH 0-50, ML 50-150	5
E206**	MH 0-50, ML<50	6
E207**	MH ponded, ML>50	7
E208**	MH ponded, ML<50	8

	SEEPAGE	Class
E251**	Dystrophic	d
E252**	Mesotrophic	m
E253**	Eutrophic	e

SATURATION PERSISTENCE <50 CM APRIL 15 TO OCTOBER 31

	DAYS	Symbol
E301**	0-2	e
E302**	3-15	v
E303**	16-30	s
E304**	31-60	m
E305**	61-120	l
E306**	121-200	p

SATURATION PERSISTENCE <50 CM, NOVEMBER 1 TO APRIL 14

	DAYS	Symbol
E310**	0-2	e
E311**	3-60	s
E312**	61-165	l

WATER REGIME MODIFIERS

E351**	Ditched, major influence
E352**	Ditched, minor influence
E353**	Tube drained, major
E354**	Tube drained, minor
E355**	Moled, major
E356**	Moled, minor
E357**	Subsoiled, minor
E358**	Subsoiled, major
E359**	Ridged, listed, major
E360**	Ridged, listed, minor
E361**	Irrigated, major
E362**	Irrigated, minor
E363**	Raised water table, major
E364**	Raised water table, minor

OBSERVED DEPTH TO WATER TABLE (M)

DEPTH TO IMPEDING LAYER (MM)

THE DIAGNOSTIC CRITERIA

1. Aridity (A) Classes

The Aridity Index is the long term average of the supplemental water required to maintain plant available water equal to or greater than one-half of capacity throughout the growing season. It is based on climatic data and soil waterholding capacity as they affect growth of perennial crops.[5]

It is proposed that Aridity Index be evaluated as the means of characterizing the drier soil water regimes, those for which zones of saturation criteria are inapplicable or ininformative. It is not a parameter to be measured or estimated in the field but would be used "off the shelf" in the form of tables for each province or region. An attractive feature is the combination of climatic water deficit and soil water retention into one index.

The classification would be done by computer using the Agrometeorology Section's data bank in Ottawa, subject to appropriate arrangements being made if interest is demonstrated. The requester would supply only the location and available water capacity of the soils being characterized; and the name of the nearest weather station. Pilot runs have been successfully done in Saskatchewan, for which data are readily available, but the method has not been applied in humid climates. Although the methodology may be applicable in such climates, other models may be more appropriate. For example, a preference for the moisture subclasses of the Soil Climates of Canada was stated in British Columbia.

The methodology was initially developed as an Irrigation Scheduling Procedure[6]. The basic climatic data used in the calculations were daily maximum and minimum temperatures and daily precipitation for the period 1941-70. Soil data required are the available water capacity; the four classes used were ≤ 100, 150, 200, and >200 mm.

At the beginning of the growing season, one year before the period under study begins, the plant available water is assumed to be at 3/4 capacity. Beginning on this date, soil water is depleted at the rate of potential evapotranspiration and increased by precipitation. When available water is reduced to half of capacity, supplemental water is added. If rain continues after available water reaches capacity, the excess is assumed to be lost to deep percolation or runoff.

For perennial crops, the growing season starts when the 5 day running mean air temperature reaches and remains above 5.5°C and ends the day it becomes less. From the end of the growing season to the start of the following season, use is made of the Snow Budget described by Baier et al.[7] Use of the snow budgeting procedure permits the program to be run continuously for the number of years for which data are available.

2. Soil Transmissibility (K) Classes

No major changes from the first proposal have been made at this point in order to maintain continuity in testing. There was no consensus to change the class limits, but this could become necessary as data are accumulated to fill a very real gap. Difficulties were encountered with field estimates because of the lack of correlation between observations of soil structure and reliable measurements of K.

Some people wanted to make the symbolization more sequential so that slipping from medium to low rating of K means going from C to D, rather than C to, say, F. To do this and at the same time to handle the "depth to impeding layer" easily would require the use of a double character symbol such as B2 for medium with an impeding layer below 50 cm, and B3 for medium with an impeding layer within 50 cm. I would prefer a single character symbol in the interest of conciseness, and found as many in favour as against the idea.

The definition of an impeding layer as having a K saturation <1/5 of that of the overlying horizon turned out to be too restrictive for most people, including me, and it has been changed to <1/3. The impeding layer criterion is applied for saturated conditions only, since unsaturated flow is impeded by properties not intended to be flagged, such as a layer of coarse sand impeding movement from overlying finer textured soil.

Several people questioned the choice of class limits and it is clear that changes are needed to subdivide the lowest class, and perhaps adjust the other classes. One possibility is to adopt the 8 class US scheme, but the current treatment of impeding layers would then become very unwieldy. Another suggestion was to base the classification of transmissibility on the C horizon, with modifiers for any overlying contrasting conditions. There was some consensus that five classes of transmissibility are about the human limit of discrimination in field observations.

For conformity's sake, units of measurement should be converted to metres/sec.

3. Lateral seepage modifiers

A few correspondents expressed a need for more detailed breakdown of classes of lateral seepage on the basis of oxygen and nutrient status, but I have nothing to go on unless a concrete proposal is submitted.

It was pointed out that the names dystrophic, mesotrophic and eutrophic should be replaced because of their connotations for aquatic environments. Furthermore, the scheme does not cater to depressed productivity resulting from saline seepage, and a class should be added for this condition.

There were questions about identifying lateral seepage wherever there was a marked component of lateral movement created by slowly permeable subsoil horizons. The initial intent of this criterion was to flag massive seepage effects where the soils are dominated by seepage. However, if there is a general desire to flag the less obvious but important seepage influences, I would invite proposals on how to handle it. There is a possibility of confusion where a landscape attribute is being incorporated in a soil classification.

4. Zone of saturation (S) Classes

There was no general desire for changes here, but I had the feeling that class 3 was overworked and might be split. One suggestion worth considering was to separate the classification into classes of high and low water tables, coding each separately rather than combining in one term.

"Mean highest zone of saturation" and " Mean lowest" require definition, and in the case of "highest" it seems reasonable to exclude the ephemeral extreme high resulting from a 10 year extreme spring event. So I suggest these definitions:

"Mean highest zone of saturation is an estimate of the average annual highest zone of saturation maintained for a two day period or greater. The zone of saturation must be 25 cm thick or greater".

"Mean lowest zone of saturation is an estimate of the average of the annual lowest zone of saturation. The zone of saturation must be 25 cm thick or greater".

Suggestions for improvement gratefully accepted, and we can even define "saturation" if we have to.

5. Saturation persistence (P) Classes

The only change has been in the heading where wetness persistence was an obvious misnomer. It should also be clearly stated that this component of the scheme is optional, for use where the S Classes require refinement, such as in the case of some perched water gleyed soils.

The winter classes are inadequate for B.C. and they suggested the following changes:

Short	0-20 days total duration	S
Medium	21-60 days total duration	M
Long	>60 days total duration	L

An e (ephemeral) modifier is added for continuous saturation of 1 to 10 day periods within these total duration classes. Thus Me indicates that duration of saturation of 21 to 60 days but made up of periods of 1 to 10 days continuous saturation.

There was also a suggestion that the zone of saturation be considered at a depth of 100 cm from the surface.

6. Water regime modifiers

No comment, other than the addition of classes for regimes which have deteriorated. Beaver dams and increased discharge resulting from drainage or irrigation of adjacent areas were cited as situations requiring a modification term.

SOME PHILOSOPHICAL CONSIDERATIONS

1. There seems to have been some erosion of the attitude that "we cannot do it without the data". It helps to keep in mind that we are in the very early stages of a new game.

There has been an upsurge in dipwell installation in a few areas. The practicality of Clarke Topp's TDR water content measuring probes[8] was well demonstrated in Ontario, and anticipated refinements should make it a most useful field tool. I could envisage its use to monitor water redistribution in different landform segments and soils following individual rainfall events, and to alert us to factors not being adequately considered in water regime classification.

2. Relating the classification criteria to soil morphology and vegetation indicators is clearly a local activity. The local field clues should be documented quite systematically for each survey project to facilitate correlation between individual mappers. (See my Memo of April 30, 1979 for some examples).

3. It seems that we should retain the old drainage classes, at least for a while, because of widespread support for their time - honoured connotations. They are easier to communicate than symbols for each water regime factor (probably because the user is absolved from saying anything definite, and has plenty of scope for his own biasses). To circumvent the communication difficulty I propose names for the proposed classes (see the outline of the scheme).

RECOMMENDATIONS OF SWIG

1. Evaluation of the proposal. All soil survey units, federal and provincial, thoroughly evaluate the proposed classification of soil water regime during 1980 and send a report to John Nowland by Dec. 31, 1980. This should include an evaluation of:

i) the general principles of the approach.

ii) the individual criteria and class limits.

iii) the feasibility of identifying field clues to aid placement of soils in the classes.

iv) the research needs to make the scheme work, or supply the data base for a modified scheme.

2. Data collection. As a first step towards a national field monitoring program for soil water, benchmark sites should be established in each province. These are envisaged as supplying comprehensive high quality data, and are to be distinguished from simple dipwell sites that lack supporting data. Each benchmark site should consist of three or more subsites laid out to encompass related representative landscape segments preferably on the same material and covering a wide range of drainage conditions that we now recognize.

Other site selection criteria are:

i) soils and landforms of broad local significance

ii) important problem soils

iii) accessibility for servicing

iv) coordination with other provinces to increase the scope and reduce possible duplication in similar soils and climates.

Instrumentation and determinations should include:

i) groups of shallow (<6m) observation wells and piezometers strategically located across the site, with optional deeper (>6m) wells where necessary; readings at about two week intervals, with some monitoring of response to individual rainfalls where necessary.

ii) water content monitoring equipment, such as neutron probes, TDR equipment or equivalent.

iii) recording rain gauge.

iv) thermocouples or thermistors at various depths conforming to AES practice.

v) detailed characterization of soil morphology to relate field assessment guidelines to the measurements, and recognizing seasonal changes.

vi) determinations of in situ hydraulic conductivity, if possible, and water desorption curves in addition to usual laboratory analyses.

One member of the soil survey staff, federal or provincial, should be assigned overall responsibility for the monitoring project in each province, and for supervising one technician to service the sites. Participation of other agencies, such as AES, should be sought at the outset, and the sites should be used to capture data on other aspects of soil and climate in order to increase the returns on the investment.

Project proposals should be elaborated at the local level with the participation of agroclimatologists, soil physicists and hydrologists, and might differ in emphasis between provinces. The projects could be conducted through universities. They should continue for three to five years. Because of the time, effort and expense involved in such studies, it is likely that each province might have no more than two or three sites initially.

Individual project proposals should clearly specify plans for data handling and storage, and projected mode of publication, papers, monographs or soil reports. Project proposals should be submitted to SWIG for review and liaison with other interested groups.

3. Data collection. Soil survey units are encouraged to establish dipwell sites on a more modest scale than the benchmark sites in Recommendation 2, with the objective of improved estimation of water table level and persistence in the main map units of current survey areas. While the data are expected to be of value in augmenting mental models of water regime and can be used in the characterization of soils in published reports, the

limitations of using precipitation data from AES stations and water table data from single sites in complex landscapes must be acknowledged.

4. Data collection. Adequate characterization of soil water regime for Canadian soil survey reports requires that determinations of bulk density, water retention at different suctions and volume of coarse fragments be done on a routine basis. Field determination of saturated hydraulic conductivity using recommended methods should also be conducted when and wherever possible. At present most favoured methods are the air entry permeameter (Topp)[9] and the borehole method of Coté[10]. We are unable to recommend a reliable laboratory method.

References

1. Naughton, W.C., Navai, M. and Valentine, K.W.G. 1979. British Columbia Soil Maps and Reports: How well are they serving their purpose. Rept. of Youth Summer Job Corps.

2. Mackintosh, E.E. 1976. Dept. of Subcommittee on soil water regimes, CSSC.

3. Nowland, J.L. 1979. Progress Report - Soil Water Working Group (SWIG); in Minutes First Annual Meeting, Expert Committee on Soil Survey, Ottawa. pp. 125-162.

4. McKeague, J.A. 1970. Report of the Subcommittee on Soil Moisture Regimes. Proc. 8th Meeting, Canada Soil Survey Committee, Ottawa. pp. 9-20.

5. Shields, J.A. and Sly, W.R. 1980. Aridity Indices Derived from Soil and Climatic Parameters I. Perennial Crops. 13 pp. (in press).

6. Wilcox, J.C. and Sly, W.K. 1974. A weather based irrigation scheduling procedure. Tech. Bull. 83. Agrometeorology Research and Service, C.B.R.I., Res. Branch, Agric. Can. 23 pp.

7. Baier, W., Dyer, J.A. and Sharp, W.R. 1979. The versatile soil moisture budget. Tech. Bull 87, Agrometeorology Section, L.R.R.I., Res. Branch, Agric. Can. 52 pp.

8. Topp, G.C., Davis, J.L. and Annan, A.P. 1980. Electromagnetic determination of soil water content; measurement in coaxial transmission lines. Water Resources Research, Vol. 16. (in press).

9. Topp, G.C. and Binns, M.R. 1976. Field measurement of hydraulic conductivity with a modified air entry permeameter. Can. J. Soil Sci. 56, 139-147.

10. Coté, D. 1977. Description et performances d'un prototype d'infiltrometre à charge constante. Génie-Rural Laval, Vol. 9, no. 3, pp. 20-30.

APPENDIX 1

OUTLINE OF FIRST REACTIONS TO THE PROPOSAL

General

- identify long-term research needs
- document the field clues used at the project level to relate the criteria and class limits to soil morphology and site features.

Regional Comments

Newfoundland (federal staff only)

- no great difficulty in application
- need to get a handle on variability of snow accumulation and melt
- some impeding layers (eg. silty BC) difficult to recognize from morphology but greatly affect K sat., whereas well developed ortstein may not have much effect.

Nova Scotia

- need to retain old drainage classes
- new classification has been incorporated in Atlantic Provinces Daily Field Sheet
- individual site classification was usually within one adjacent class of agreement
- difficult to identify threshold at which seepage should be recognized; seasonal variability a problem, duration term needed
- wells installed in current survey areas
- important to record land use corresponding to identified regime; rejected idea of adjusting to a stated assumed land use
- morphological clues on grey materials very different to those on red materials
- even if diagnosis is one class out, the classification is better than the old drainage classes for interpretation purposes
- one suggestion for a zone of saturation class MH 0-50, ML 50-100
- some evidence that grouping of soils by new classes is better for interpretations than drainage classes (see Tables 1 and 2).

New Brunswick

- new scheme usable and an improvement
- wells established in one current survey project
- define terms "annual mean highest," "lowest," "zone of saturation," its minimum thickness, continuity and duration
- is frozen soil to be treated like any other impeding layer?

P.E.I.

- should adopt the proposal for Atlantic Provinces regardless of its reception elsewhere
- need more precise observations of soil structure and porosity as they affect transmissibility

- retain old drainage classes
- establish a minimum acceptable data package for soil reports to include more physical data, but with regional flexibility.

Quebec

- big improvement on the old drainage classes.
- approximately 40 dipwells to be installed in two current survey areas in 1980
- suggested revision of K classes to concentrate on C horizon, with modifiers for overlying contrasting conditions.
- unhappy with AI parameter for Quebec soils

Ontario

- general consensus that scheme is workable and an improvement
- less individual divergence of field assessments with proposed scheme than with drainage classes
- problem of assessing K sat. in structured clays, compact fine sands and soils with silty layers
- definition of impeding layer should be reduced from 1/5 to 1/3 transmissibility of overlying layers
- minority opinion to recognize impeding layers in class of high transmissibility
- define impeding layers only for saturated state
- separate zone of saturation into two groups of high and low rather than integrate into 1 combined class
- need to cross-reference K sat. values measured by different methods
- convincing demonstrations of air entry permeameter and TDR (moisture content) probe as useful tools in soil characterization
- suggestion for blitz on water table measurements on the important soils of a project area at the wettest and driest peak periods
- does the system adequately identify excessively drained situations? (Answer: let's apply Aridity Index in the East).

Manitoba

- general agreement on concepts and class limits, but some think the limits too narrow for Manitoba
- no consensus on usefulness of the new approach, and those who favoured it think it should be used to quantify the existing drainage classes
- resultant reorientation of field diagnoses was beneficial but time-consuming
- measured field data essential, but of limited use without complementary laboratory studies
- include modifiers for deteriorated water regimes, created by beaver dams, drainage discharge areas.
- relating morphological data at 200 existing and former dipwell sites to water table data is a herculean task.
- need to establish well-instrumented benchmark monitoring sites in all provinces, in cooperation with other agencies.
- need to revise lateral seepage classes and their names.
- need to standardize units for K sat at metres/sec.
- Aridity Index favoured, but some preference for using stubble as the starting point and using the regression method for determining AWC.

Saskatchewan

- limited feedback except for Aridity Index
- Aridity Index developed in pilot area of Saskatchewan has excellent promise for characterizing drier regimes, with the advantage of combining water retention and climatic deficiency parameters

Alberta

- in semi-arid areas, the proposed scheme did not work any better than drainage classes; most soils fell into same class, D-1
- probably works well in humid areas
- K sat. classes OK when more data available
- does the identification of an impeding layer mean anything in soils that are never saturated?
- concepts of normal, shedding, receiving, presence or absence of external drainage, obvious recharge and discharge situations are worth looking at for possible incorporation.

British Columbia

- incorporate an infiltration capacity parameter
- more quantification of lateral seepage called for
- need classes of runoff
- simplify by not recognizing impeding layers for class of medium transmissibility
- include aspect in the site characterization of water regime
- allow flexibility in the "stretched 200 day growing season" on a regional basis within the province
- difficult to estimate K saturation class on dry clays and fissured soils
- individual vegetation indicator species not useful, but community type provides useful field clues to water regime in limited areas
- in humid climates, organic matter masks colors that might be useful to infer depth and persistence classes
- mottles fade in summer in some soils, or never appear in oxygenated saturated soils
- much support for USDA concept of tabulating soil water states by seasons; it's simple, and requires no equipment (See Appendix 3).
- favoured Aridity Index approach in principle but question the methodology for B.C. conditions - prefer a model based on incident solar radiation. Prefer measured AWC to regression approach
- suggested revisions of winter persistence classes.

Ottawa

- need to define the purpose of the exercise
- need to incorporate other components, such as amount and variability of storage capacity; type and rate of water redistribution, proportion of landscape gaining and losing water, or showing little redistribution; oxygen status of 0-50 cm layer.
- need to get the data before formulating a classification
- need to proceed with classification to motivate data collection.

APPENDIX 2

CORRELATION OF SWIG AND OLD DRAINAGE CLASSES

The following is taken from a report from Con Veer on a field trip in Pictou Co. N.S. on behalf of SWIG.

"To give you an idea of the variability in moisture regimes that occurs in Pictou County I will summarize most of the observations made on the 3rd and 4th of July 1979, and tabulate them so that comparison between the drainage classes and the proposed moisture regime classification is possible. These observations, obviously (to me at least) come from an area that, if it had to be mapped in detail, would be a surveyor's nightmare, i.e., significant and short interval variability in topography, drainage and parent material."

Table 1. C.S.S.C. drainage classes versus proposed moisture regime classification. (Information from Ken Webb's field notes, Pictou Co., N.S.)

CSSC			
Well	Mod. well	Imperfect	Poor
A1 e	B2 v	C3 s	G3 m
	B3 s	E3 s	J3 s
	D e 4 s	F3 x	J3 m
	E2 m	F3 s	J e 6 p
		F5 m	J8 p
		G3 m	
		H3 s	
		J3 x	
		J3 s	
		J3 m	

Interesting differences in support of the proposed classification might easily be gleaned from the tabulation. Assuming, e.g., that saturation class and persistence gives a good first approach to soil "workability" date and for convenience we don't consider consistence, the following tabulation reveals that in the C.S.S.C. drainage classification moderately well, imperfect and poor soil drainage all might occur in 3s and imperfect and poor in 3 m. The implications speak for themselves.

Table 2. C.S.S.C. soil drainage classes versus proposed moisture regime classification. (Saturation and persistence classes only) (Information from K. Webb's field notes, 3 & 4 July 1979. Pictou County N.S.)

Saturation/Persistence	C.S.S.C.			
	Well	Mod. well	Imperfect	Poor
1 e	1			
2 v		1		
2 m		1		
3 x			2	
3 s		2	5	1
3 m			2	4
4 s		1		
5 m			1	
6 p				1
8 p				1

Table #2 also shows the wide range of saturation and persistence of saturation that might occur under well to poorly drained C.S.S.C. classes.

APPENDIX 3

ANNUAL WATER-STATE REGIME (USDA)

The annual waterstate regime is a continuous record of the water state. The water state of the soil above bedrock is evaluated for designated layers, specifically the layers used in defining wetness classes. A moisture regime for a hypothetical soil is shown in table 3.

Table 3 Annual Soil-Water Regime

Depth (cm)	J	F	M	A	M	J	J	A	S	O	N	D
0-25	f	f	m	m	m	m	d	d	d	m	m	f
25-50	f	f	f	w	m	m	m	d	d	d	m	w
50-100	w	w	w	w	m	m	m	d	d	d	m	m
100-150	w	w	w	w	w	m	m	m	d	d	d	m

f - frozen more than half of the month
w - wet more than half of the month
m - moist more than half of the month
d - dry more than half of the month

A more detailed approach can be used. The moist state can be divided into slightly moist and very moist. The presence of free water in the wet state can be indicated. Free water may not be evident where there are no noncapillary pores.

(Taken from Report of Committee 6, Soil-water Relations, National Work Planning Conference of the Cooperative Soil Survey, San Antonio, Texas, 1979. (ch. M. Stout Jr.))

COMMENT (J.L.N.)

This is not part of the SWIG proposal but is included for information since one or two people have expressed interest in its application in Canada.

The neat matrix is appealing. Perhaps SWIG should be the last to criticize the scheme on the grounds of the guesswork involved! But doesn't much of the appeal arise from a false suggestion of precise knowledge? I mean, does the table supply enough reliable information to be worth preparing? Do we have adequate definitions of wet, moist, dry?

On the other hand, the table would probably enjoy good reception by users. And it might be quite informative if Aridity Classes were differentiated for each of the four depth increments (instead of the soil as a whole).

Taxonomic Family Climate

G.F. Mills
Canada-Manitoba Soil Survey

Membership of working group

An "ad hoc" working group was established in February, 1980, to provide representation from the various soil survey units in Canada. Regional input to the working group was by correspondence and was received from T. Vold, G. Still and R. Trowbridge (British Columbia), T. Macyk and R.A. MacMillan (Alberta), G.A. Padbury (Saskatchewan), C.J. Acton (Ontario), R.W. Baril (Quebec), G.J. Beke (Nova Scotia), R. Wells (New Brunswick), K. Guthrie and P. Heringa (Newfoundland), J.H. Day, J.L. Nowland, A. McKeague and R.B. Stewart (Ottawa).

Objectives

The terms of reference suggested for the working group are as follows:

1. To promote discussion on the role of Climatic Criteria in the Canadian System of Soil Classification, and

2. to examine more effective ways of understanding relationships between biologic production and soil and climate.

The short term objective of the working group is to define the current role of climate in soil classification and if warranted recommend increased input of climatic criteria. In particular, we should examine the role of climate in the Soil Family and its use as a more integral part of soil survey, mapping methodology and correlation procedures.

Background

Climate is recognized as the major driving force in soil formation. Climatic parameters play an important role in soil classification in Canada, because of the influence on the soil properties forming the basis for classification. Decisions were taken early in the development of soil classification in Canada to retain some measure of climate at the higher levels of the classification. However, climatic criteria are not applied uniformly in all of the soil orders of our taxonomy. Major climatic differences are reflected at the Order level in the Cryosols, the Order and Great Group level in the Chernozemic, Luvisolic and Podzolic soils and, at the Great Group level in the Brunisolic and Solonetzic soils. Three Orders, Gleysolic, Organic and Regosolic soils occur over such a range of environmental conditions that climate criteria are not differentiating at the higher categories of classification.

The magnitude of climatic differences recognized at the Order and Great Group categories in the Canadian System of Soil Classification exert a fairly strong influence on major land use activities such as agriculture and forestry. However, this level of climatic differentiation is not suffieiently detailed to provide an adequate base for local planning and management decision making.

Recognition of this deficiency in our data base has resulted in the inclusion of climatic criteria in the Family level of classification. Early approaches simply considered aerial climatic parameters such as moisture, temperature and growing season relationships (NSSC 1965). More recently soil climate (soil temperature, soil moisture and related calculated parameters) has been built into the soil family (CSSC, 1970, CSSC (eastern) 1971, CSSC (western) 1972, CSSC, 1973.

Soil climate studies have progressed to the point where we now have a first approximation of the Soil Climate Map of Canada (Clayton et al., 1971), many criteria of which apply to the Soil Family category as well. The framework of this classification and the combinations of parameters were intended to be provisional. As such they are subject to modification that might become available. In addition, there are relationships between soil climate properites and properties of the prevailing aerial climate which are not fully understood or well defined as yet.

Climatological research in Canada continues to refine our estimates of climatic variability. Some of this work is directly related to the response to climate of imprtant crops such as corn (Major et al 1976). Computer modelling techniques permit estimation of agroclimatic data for geographic points over extensive areas such as the Great Plains (Williams/Hopkins, 1968). Evaluation of this data for large areas of agricultural production is ongoing and was utilized to help define Agroclimatic Areas of Alberta (Bowser, 1969). Computer modelling also has been undertaken for the forested area of the Prairie Provinces (Powell et al., 1977, 1978). Other research keys on the derivation of additional climatic parameters from existing data. Climatic moisture indices were calculated from available data (Sly, 1970) and utilized in the compilation of the Soil Climate of Canada. Single factor maps derived from available climatic data (Chapman and Brown, 1966, Shaykewich, 1974) assist in characterizing agroclimatic zones. Soil capability and soil types within agroclimatic zones have been related to yield data in Alberta (Peters, 1977). Although much as been accomplished, the current emphasis on land evaluation provides impetus for accelerating the study of soil - climate - yield relations.

Extensive areas of northern Canada lack adequate climatic characterization. In such areas, the distribution of regional climatic conditions is often shown by inference from natural indicators in the environment such as permafrost characteristics and distribution (Brown, 1967) or the distribution of prevailing forest vegetation across Canada (Rowe, 1972). Currently, an ecoregion working group of the Canada Committee on Ecological (Biophysical) Land Classification is attempting to bring together environmental factors such as climate, vegetation and soil in a generalized map (1:5,000,000 scale) and descriptive format (CCELC, 198_). Soil survey is represented on this working group.

The Role of Climate in Soil Classification

There are well established relationships between soil distribution and climatic parameters particularly at the higher categories of soil classification. Similar relationships at lower levels of classification are rather imperfectly defined as yet. The role that climate might play in soil classification can have two emphasis:

1. Land Evaluation and Soil Interpretation: More precise definition of soil-climate relationships is necessary if we are to be more quantitative about soil properties in the context of land evaluation programs related to biologic production.

2. Soil Correlation: Soil-climate relations at the Soil Family and Series level provide a useful correlation tool for soil classification and soil surveys.

Current trends in soil science emphasize increasingly quantitative evaluation and interpretation of soil data. It is reasonable that such trends would also apply in the area of soil-climate relations pertaining to biologic production. The demand for more precise statements concerning soil-climate-crop yield relations is created to a large extent by current land evaluation projects. Land evaluation programs supported by the Land Resource Research Institute and projects such as the F.A.O. Agro-ecological Zonation study depend in part on better definition of soil-climate relationships (ECSS, 1979).

Considering future needs for more precisely defined soil-climate relationships, particularly in the context of the short-term objective of the working group, an increased role for climate in soil classification might develop in two ways or some combination thereof:

1. Provision for more climatic detail, either aerial climate, soil climate or both in the Canadian System of Soil Classification. Much of the increase in detail would evolve at the Soil Family level and could include:

   (a) measurement of soil climate on benchmark soils

   (b) evaluation of measured data relative to the existing soil climate classification, followed by adjustment or modification to the classification where required.

   (c) development of more precise relations between aerial climate, soil climate and soil classification.

2. Cooperative effort between climatologists and pedologists towards more definitive local and regional characterization of aerial climate. The results of such study could stand on their own merits or be superimposed or appended to the soil classification from outside.

Summary of Regional Viewpoints

A questionnaire was circulated to members of the working group to initiate discussion and to facilitate regional input regarding the status and current usage of climate relationships in the Canadian System of Soil Classification. The excellent response obtained from the questionnaire is summarized in the following section. The viewpoints expressed through the questionnaire helped formulate the recommendations of the "ad hoc" working group and should serve as background material for future work.

1. Are the present soil climate criteria used in your region either for (1) soil correlation purposes (series establishment and establishing relationships between existing series) or (2) interpretive purposes related to soil productivity?

Response

(1) Soil correlation purposes

Most regional groups do not use soil climate for correlation. Quebec and Manitoba use soil climate to qualify soil series and Newfoundland use it to correlate between soil associations. The B.C. Forest Service is attempting to use the Soil Family (and soil climate) in some regions to define ecosystem types in their ecological classification system. Alberta is delineating physiogrphic-climatic-vegetative regions which provide guidelines for restricting the distribution of soil series to regions having similar climatic-landscape characteristics. Ontario classifies soil series in all current surveys at the Soil Family level, using soil climate criteria from the Soil Climate Map of Canada and modified according to local conditions.

(2) Interpretive purposes related to soil productivity

Some application of soil climate criteria for interpretation of soil productivity has developed in Quebec and Manitoba. P.E.I. also relates productivity to soil climate. Aridity indexing in Saskatchewan may help relate soil climate to productivity. Forest productivity in B.C. is related through climax vegetation to soil climate and thence to soil type. Difficulty in applying the present soil climate criteria result from the great complexity of climatic and terrain features in B.C. Alberta does not yet have sufficient soil climatic data to relate to yields and productivity. To date they rely most on aerial climatic data incorporated into Agroclimatic areas.

(2) If soil temperature and moisture criteria are applied in your region, are they based on the Soil Climate Map of Canada or on actual data measured from benchmark sites?

Response

Several groups, B.C., Quebec, and Manitoba, Ontario, and Newfoundland have attempted to apply soil climate criteria from the Soil Climate Map of Canada, B.C., Manitoba and Nova Scotia are using a limited amount of measured data where available.

(3) If soil climate measurements are being undertaken in your region, could you provide a listing of sites being monitored for both soil temperature and soil moisture with a brief description of the range of soil conditions encountered on the sites?

Response

Number of Active Monitoring Sites

Region	Soil Temperature			Soil Moisture		
	Soil Survey	AES	CDA	Soil Survey	AES	CDA
N.W.T. & Y.T.	8	7				
B.C.	15 (forest service)	3		15(Thermistor)		
Alta.	16	11		16(neutron probe)		
Sask.		15				
Man.	75	6		83(Wells)		
Ont.		9	2			1
Que.		11		30(Wells)		
Maritimes		4		? (Wells)		
Nfld.		2				

(4) Is there any attempt to map soil climate in your region beyond the first approximation portrayed on the Soil Climate Map of Canada?

Response

For most regions there is not sufficient data to modify the soil climate classification or the soil climate map. Some modification has been attempted in southern Manitoba. The very broadly defined Arctic temperature regime has been tentatively modified in the N.W.T..

(5) Are there any studies of aerial climate in your region designed to relate climate to a geographic land base such as soil? Could you provide examples or a brief description?

Response

Activity in this area varies across the country. Computer modelling and mapping exists for the agricultural areas of the Great Plains, also a few map sheets in Ontario, a statistical map of aerial climate in New Brunswick, Frost Hazard map for P.E.I., a corn heat unit map for the Maritimes, single factor agro-climatic maps for Manitoba, a few such studies in Quebec, corn heat unit map for the Prairies.

Much of this data stands by itself, some has been applied to the characterization of Agro-climatic zones (Alberta) and Land Resource Regions and Areas (Manitoba), very little has been used to characterize soil units

(6) Could more specifically defined climatic criteria (soil or aerial climate) within the Canadian System of Soil Classification aid in soil correlation or be applied to soil interpretations for biologic productivity in your region?

Response

Several regions recognized a need for better definition of taxonomic categories in terms of climate. Feelings were mixed about the utility of climate for correlation purposes; some regions believe that such definition would in fact make correlation more difficult (partly due to inadequate data). Quebec felt that climatic criteria should be built into the Classification at a very high level by establishing a Suborder. Ohters stated the climate can be accomodated taxonomically by sharpening up parameters at the Soil Family level. B.C. has attempted to describe a "Soil-Water" system similar to that proposed by the U.S.D.A. as an aid for soil correlation.

For interpretations most groups favoured superimposing climatic parameters on top of soil properties (parameters will vary with the use in question). Alberta sees a need for climatic criteria as well as data to either develop yield predictions or else to measure yields and then relate them to narrowly defined soil series which have been mapped in a restricted climatic region.

(7) What is the place of more specific climatic definition in soil classification? Do we continue to build it into the system at Order, Great Group and Family categories or should the climatic characteristics stand on their own and be superimposed on the soil classification from outside?

Response

Opinions varied from unqualified Yes, unqualified No to a few qualified Yes's (Yes but don't clutter up taxonomy, Yes, but at higher levels only). Quebec feel that adoption of a suborder level in our classification could give climatic criteria the high priority they deserve. This is a major change and if contemplated we might as well adopt U.S. Soil Taxonomy?

Increased usage at soil Family level and sharpening up parameters for soil climate and confirm relationships between soil moisture and soil and air temperature can be done within the context of our present classification (B.C. at the Family level, Alberta suggests stratifying the climatic data starting with the Order and becoming increasingly specific down to the series level, also Manitoba).

If the emphasis should remain on characterization of aerial climate, these parameters will likely continue to be superimposed on soil properties from outside (Saskatchewan).

One person feared integration of climate with taxonomy is difficult and requires much work. Prefers to keep the two separate and overlay the climate.

Newfoundland had one opinion that climatic criteria should be utilized in the taxonomy only at the Order and Great Group level while a second opinion was that climatic criteria should stand on their own and be superimposed on the taxonomy from outside.

(8) Can more specific climatic parameters built into soil classification assist in the stratification process alluded to in the Proposed Soil Mapping System for Canada.
(PSMSC, 1979, Pt3.5, Stratification of Mapping Units P17)?

Response

Many regions thought that climatic parameters built into soil classification could assist in stratification of map areas. One group wished to characterize the climate of large regional separations as precisely as possible, but not sure how climatic parameters built into soil classification would do this any better than if superimposed from without.

Climate, within the classification at high levels (Gt. Group, Family or Suborder) will naturally apply to soils at lower levels. In this sense, more data used at the Family level would provide groupings of soils with restricted ranges in temperature and moisture. Quebec advocates a new suborder level to accomplish stratification for mapping purposes. Alberta and Manitoba are attempting to stratify soils by climate for mapping purposes. B.C. sees merit in such stratification, but feel that the successful application of soil climate differences will depend on the development of soil climate-climax vegetation-soil development relationships. Ontario agreed that incorporation of climatic parameters into soil classifications could assist with the stratification process, Newfoundland have concern about regional parent material differences overriding the effects of climatic parameters. Stratification for mapping purposes could become more applicable in the future. Ottawa (Nowland) recognizes a need for stratification in the soil mapping process but states that such climatic zonation should be capable of going to a meso level and lower. At the lowest levels, it should be able to differentiate map units in the Niagara Peninsula from those in the Annapolis Valley or the Montreal Plain.

(9) What experience has your region had in relating agriculture and forest productivity to climatic parameters? Is there a role for more precisely defined soil-climate relations in this evaluation process?

Response

Most regions have used aerial climate to aid in the characterization of zones or regions of uniform agricultural or forest productivity.

In recent years work is accelerating on productivity modelling related to various crops. Ontario is becoming quite quantitative about crop productivity across various climatic regions. Manitoba has worked on the relations between yield, fertility and moisture availability. This work and more like it is basic to many land evaluation programs in progress across Canada.

Relationships between productivity and soil climate have not been studied extensively. There are relationships between aerial climate and soil climate and the two data sets can be complementary. Some work on developing these kinds of relationships has taken place in most regions and there seems to be a need for continuing work in this area. In this respect, more precisely defined soil climate relations, either incorporated within the taxonomy or superimposed on the soil classification would be very helpful for evaluating soil-land-Productivity relations.

One view expressed in Ontario is that ecologically significant soil regions (similar to Site Regions of Ontario or the current Ecoregion concept) can be useful for soil correlation and definitions of regions of relatively uniform macroclimate and biologic productivity. Manitoba is following this approach for soil correlation purposes and has attempted to fit such regions as closely as possible to areas of uniform potential in so far as climatic parameters affect agricultural or forestry productivity. Nfld. has some experiments relating agricultural and forestry yields to climatic parameters and feel there is a future role for more precisely defined soil climate relations. B.C. attempt to relate forest productivity to both aerial climate and edaphic factors. They feel there is a definite need for more precisely defined soil-climate relations.

Recommendations of Working Group on Taxonomic Family Climate

Regional response to the questionnaire indicates that additional study is required to adequately define the role of climatic data in the Canadian System of Soil Classification. While assessing the role of climate, consideration should be given to its use for soil correlation and for making soil interpretations and land evaluations for various purposes.

Many data gaps are evident in terms of characterizing soil climate. Similarly, for many parts of Canada, there is requirement for more dense aerial climate measuring networks. The continued development of climatic modelling techniques is required to provide more adequate climatic characterization for agriculture and forestry. Research is required into the relationships between soil climate and aerial climate. It is necessary to evaluate these relationships in terms of soils and crop adaption, crop yields and productivity.

To adequately deal with these data and research needs, involvement and input from many personnel working on an organized and coordinated program are required over several years. Such study of soil-plant-climate relations is actually a major part of recently established land evaluation programs. The data and research needs most appropriate for consideration by soil survey personnel at this time are the relationships between soil climate and aerial climate. The emphasis should remain on soil climate with adequate provision for liaison and cooperation between workers in meteorology, climatology, agronomy and forestry.

When the Soil Climate Map of Canada was published in 1973 the Soil Climate Subcommittee recommended that the soil climate classification should be continuously tested, evaluated and if necessary, modified. At the present time all aspects of soil moisture are being studied by a working group on Soil Moisture established under the auspices of the Expert Committee on Soil Survey. However, thermal aspects of the soil climate classification have not been studied by a working group on a formal basis since 1973. In order to initiate such formal study, the "ad hoc" working group wishes to make only one recommendation.

Recommendation: That a national working group with regional representation be established to study relationships between soil, soil temperature and aerial temperature. The purpose of such study is to better define the role of soil temperature in the System of Soil Classification for Canada, and in particular, the function it may serve for soil correlation, soil interpretations and land evaluation.

Based on regional viewpoints expressed in replies to the questionnaire, the initial terms of reference suggested for the working group are to:

1. assess the current system of soil temperature classification and identify data gaps and any shortcomings in the system,

2. actively promote and coordinate a national monitoring program of soil temperature studies designed to provide basic data for testing and evaluating the current system of characterizing soil temperature,

3. suggest modification to the soil temperature classification as indicated by data derived from the monitoring program and recommend suitable ways to relate soil thermal properties to the taxonomy,

4. seek cooperation with Working Group on Soil Water with respect to development of the national monitoring program and the relationship of soil climate to the taxonomy,

5. maintain liaison with the Expert Committee on Agrometeorology regarding climatic data needs.

Bibliography

Bowser W.E. 1969 Agroclimatic Areas of Alberta, Surveys and Mapping Branch, Dept. of Energy Mines and Resources, Ottawa

Brown, R.J.E., 1967 Permafrost in Canada, Map 1246A Geological Survey of Canada, Dept. of Energy Mines and Resources

CCELC 198_, Ecoregion project of the Canada Committee on Ecological (Biophysical) Land Classification (in preparation)

Clayton, J.S., W.A. Ehrlich, D.B. Cann, J. H. Day and I.B. Marshall, 1977. Soils of Canada, Research Branch Canada Department of Agriculture Vol. 1 pp 73-80 and accompanying map "Soil Climates of Canada."

Chapman, L. J. and D. M. Brown 1966. The Climates of Canada for Agriculture, The Canada Land Inventory Report No. 3 Dept of Forestry and Rural Development Canada.

CSSC 1970. Proceedings of the Eighth Meeting of the Canada Soil Survey Committee, Ottawa, Ont.

CSSC 1971 (eastern) Report on the Second Meeting of the Eastern Section of the Canada Soil Survey Committee Fredericton, New Brunswick.

CSSC 1972 (western) Report on the Second Meeting of the Western Section of the Canada Soil Survey committee, Kelowna, British Columbia.

CSSC 1973 Proceedings of the Ninth Meeting of the Canada Soil Survey committee, Saskatoon, Saskatchewan

ECSS 1979 Minutes First Annual Meeting of the Expert Committee on Soil Survey, Ottawa, Ont.

Hare, F.K. and M.K. Thomas 1974 Climate Canada, Wiley Toronto, Ont. p256

Major D.J. and C.F. Shaykewich, J. R. Rogolsky, D.G. Green, W.L. Pelton and J.A. Buchan, 2nd Edition 1979. Corn Heat Units on the Praires. Published by the Alberta Corn Committee, Manitoba Corn Committee and Saskatchewan Corn Committee

NSSC 1965. Report on the Sixth Meeting of the National Soil Survey Committee of Canada, Quebec City, Quebec

NSSC. 1968. Proceedings of the Seventh Meeting of the National Soil Survey Committee of Canada, Edmonto, Alberta

Peters, T.W. 1977. Relationships of Yield Data to Agroclimatic Soil Capability Classification and Soils of Alberta. Can. J. Soil Science 57:341-347

Powell, J. M. and D.C. MacIvor 1977. A summer climate classification for the forested area of the Prairie Provinces using factor analysis. Information Report NOR-X-177 Northern Forest Research Center Canadian Forestry Service, Fisheries and Environment Canada, Edmonton, Alta.

Powell J.M. and D.C. MacIvor, 1978. Maps of selected climatic parameters for the Prairie Provices May to September, 1961-1970. Information Report NOR-X-206 Northern Forest Research Center, Canadian Forestry Service, Fisheries and Environment Canada, Edmonton, Alta.

PSMSC, 1979. Mapping Systems Working Group. A proposed Soil Mapping System for Canada. Rept submitted to Canada Expert Committee on Soil Survey Land Resource Research Institute Agriculture Canada Ottawa, p 60

Rowe, J. S. 1972, Forest Regions of Canada. Can. Dept. Environment For. Serv. Publ. No. 1300 172pp.

Shaykewich, C.F. 1974 Climate of Southern Manitoba As it Relates to Agriculture Publ. No. 546 Manitoba Dept. of Agriculture

Sly W.K., 1970 A climatic moisture index for land and soil classification in Canada. Can T. Soil Sec. 50: 291-301

Williams/Hopkins, 1968. Agroclimatic Estimates for 1180 points on Canadian Great Plains, Agrometeorology Section, Plant Research Inst. Res. Branch Can. Agr. Ottawa

Soil Classification

Charles Tarnocai

Introduction

Since the 1979 meeting of the ECSS Alex McKeague has resigned as chairman and I have been asked to chair this subcommittee.

The revised soil classification system was published in 1978. This soil classification will not be changed before 1983 when a further revision of this classification system is scheduled to be published. Problems relating to the current soil classification arose shortly after the "Canadian System of Soil Classification" was published. Work on these problems should begin now so that by 1983 some of the problems will be solved and the proposed changes will have been documented and tested.

Recent Activities

Work has already begun on some of the classification problems raised in the past. Work on the Bt horizon has been completed by the LRRI Soil Classification Section and the data, along with the recommendations, was presented at the ECSS meeting and is included in the ECSS proceedings.

Work on problems relating to organic horizons, Folisols and humus form classification began last fall with the formation of a working group in British Columbia. The urgent need to focus on this problem reflects the importance of organic horizons and Folisols in forest and watershed management and environmental protection. The information required by these disciplines indicated the deficiencies in both our soil classification and our handling of the organic materials and Folisols. This deficiency was especially noticeable in British Columbia although the same concern was raised in the Maritimes and in Ontario. The objective of the Working Group on Organic Horizons, Folisols, and Humus Form Classification is to study the problems and formulate proposals to improve the definitions and classifications. The working group prepared its first report, which suggested alternate proposals and recommendations, for presentation at the ECSS meeting. The proposals and recommendations are included in the ECSS proceedings. In the near future, this report will be reviewed by the subcommittee members and other interested people. Based on the comments resulting from this review, the working group will prepare a second report which will include the final proposals. It is planned that these final proposals be field tested for a few years.

Other soil classification problems have been submitted by subcommittee representatives from various regions. These problems were reviewed by the subcommittee during the meeting held on March 20, 1980. A list of these soil classification problems, according to their priority ratings, are given in the following section.

New Soil Classification Problems

A. High priority problems

1. The classification of Gleysols requires basic work.

   a. The presently insufficient color criteria should be replaced and field measurement methods should be developed to assist in the classification of Gleysols.
   b. Research is required on the longevity of mottles after natural or artificial improvement of soil water conditions.
   c. Separation of Gleysolic and Gleysol subgroups of other Orders requires improvement. The separation would become clearer if the Gleysolic Order were more precisely defined.

2. Better definitions of placic, ortstein and fragic horizons are needed in terms of minimum strength of development in order to separate them more clearly.

3. The mineralogy classes (borrowed intact from the U.S. Soil Taxonomy) need to be modified for Canadian conditions where, because of glaciation, our chances of finding soils with predominant mineralogy are unlikely.

B. Medium priority problems

4. Despite years of work there are deficiencies in our knowledge of organic matter in soil from the point of view of land use. Research is required to determine not only the nature of organic matter in different soils under different climates but also how this is changed by fertilization and cultural practices.

C. Low priority problems

5. Some research is required to support the proposition that the Podzolic Luvisol/Luvisolic Podzol separation should be relegated to the family level.

6. A diagnostic Luvisolic B horizon should be included in the Canadian System of Soil Classification.

7. There is a problem relating to the use of the modifier "j". The limit between Bf and Bfj is well defined but when is Bn really Bnj?

8. Solonetzic Dark Gray Luvisol and Gleyed Solonetzic Dark Gray Luvisol subgroups should be established.

9. Climatic criteria should be used at a very high level in our Soil Classification System. This can be done by creating a suborder which would encompass the temperature and moisture characteristics of the soil.

List Of Errors And Ambiguities In The 1978 Publication

Page 23. Definition of "f" should be modified. Second sentence should read "It must have a hue of 7.5YR ...".

Page 25. The Bfj definition should be modified as follows: It is a horizon with some accumulation of pyrophosphate extractable Al and Fe but not enough to meet the limits of Bf. In addition, the color of this horizon does not meet the color criteria set for Bf.

Page 25. In the definition of "m", criterion 2 should be changed as follows:
2. Very little or no evidence of eluviation.

Page 26-27. The term cementation implies cemented when wet.

Page 27. Podzolic B horizon. Delete point 4 since some podzolic B's in Newfoundland have >40% clay.

Page 28. Gleyed Eluviated Melanic Brunisol. The lower case suffixes for the B horizon should be changed to Btjgj.

Page 83. The definition of the Organic Order should be changed. As it now stands there is a bias towards wet organic soils.

Page 93. Depth criteria for acidity of Podzolic soils should be included. For example:

Humo-Ferric Podzol		Eutric Brunisol	
Ae	0-2 cm	Ae	0-2 cm
Bf	2-12 cm	Bm	2-12 cm
BC	12-17 cm	BC	12-17 cm
Ck	17+ cm	Ck	17+ cm

For Brunisols, if the pH is 5.5 or greater in the uppermost 25 cm then the soil is classified as Eutric Brunisol; if it is below pH 5.5 then the soil is classified as Dystric Brunisol. Should a Podzolic soil be acid at least in the uppermost 25 cm?

Page 129. Definitions for cryic, lithic, turbic and cryoturbic phases should be included.

Pages 141-144. Landform classification.

1. p. 144 "loamy" reads same as "clayey".
2. definition for loamy should be taken from the family particle-size classes, page 117.

3. symbols for surface expression of both organic and mineral landforms should be integrated to eliminate duplication
   h - hummocky, h - horizontal
   s - sloping, s - steep
   f - floating, f - fan
   r - ribbed, r - ridged
   For example, "l" - level, could apply to horizontal organic forms; "i" - inclined, could replace sloping; "r" could be ridged in both cases; and floating could become "fl", "w" or some other symbol.

Page 146. Terminology for slope classes 8, 9 and 10 should be changed to:

Slope Class	Percent Slope	Terminology
8	46-70	steep slopes
9	71-100	very steep slopes
10	>100	extreme slopes

Luvisolic Soils

The horizon sequence given for the Brunisolic Gray Luvisol and the Gleyed Brunisolic Gray Luvisol, respectively, are as follows:

LFH, Bm or Bf, Ae, Bt, BC, C or Ck
LFH, Bm or Bf, Aegj, Btgj, BCgj, Cg

In over 90% of these soils in Saskatchewan the Ae horizon occurs above the Bm rather than below it as indicated in the Canadian System of Soil Classification.

Systematics of the Classification

There is a need to examine the major places in the system containing "except for" statements and recommendations for the appropriateness of this kind of systematics. In reviewing a paper where non-pedologists were trying to prepare a dichotomous key for the Canadian System of Soil Taxonomy it became apparent that this key procedure is not possible down to the subgroup level, due to systematics, or lack thereof. An example of this occurs in the Dark Gray Luvisol where no single criterion can be used to separate this subgroup from Dark Gray Chernozemsics in that they may have, but do not have to have, a Chernozemic A horizon. A second occurrence pertains to Calcareous Chernozemic soils. Once again, there is no single criterion upon which a Calcareous Black, for instance, can be separated from a carbonated Orthic Black using a key procedure. Since the classification criteria used in separations such as these are inconsistent with those in the remainder of the system, the apparent aberrations in the system should be re-examined.

Slope Classes

There appears to be a general feeling that the descriptive terms for slope classes should be deleted. This still would retain the slope classes to be used on a national basis but would allow use of appropriate terms on a local basis, eg. "moderate slopes" may have a different meaning to Saskatchewan pedologists than to B.C. pedologists.

Recommendations

1. The report of the Working Group on Organic Horizons, Folisols and Humus Form Classification should be reviewed by the members of the subcommittee. Based on the comments and suggestions derived from this review the working group should prepare a report including the final proposals for changes in the classification system.

2. Work on the new soil classification problems should be carried out as follows:

   a. Work should begin immediately on high priority problems (items 1-3).
   b. Work should begin in two years on medium priority problems (item 4).
   c. Work should begin in approximately four years on low priority problems unless the region in which these problems arose wishes to carry out the work and submit a proposal to the subcommittee.

3. The Landform Subcommittee should be revitalized. During the last two years a number of questions have arisen which indicate that it is necessary to firm up and elaborate some of the definitions and terminology.

Bt Horizon Criteria

J.A. McKeague

Bt Criteria

According to present criteria a Bt horizon must have:

- more clay, by specified amounts, than an overlying eluvial horizon, and
- evidence of illuvial clay in the form of clay skins on ped surface, or oriented, apparently illuvial clay occupying at least 1% of the area of thin sections of the horizon.

Study of thin sections of soils sampled for the ISSS tours in 1978 showed that illuviation argillans were absent or very scarce in about 1/3 of the horizons designated Bt. With the cooperation of many pedologists, I started a study in 1977 to attempt to de-determine:

- what clues were used by groups of pedologists in deciding whether a horizon should be designated Bt.
- what degree of uniformity there was in field estimates of Bt's.
- whether a stereomicroscope would be useful for detecting clay skins.
- the degree of agreement between macro- and micromorphological estimates of illuvial clay
- the reliability of quantitative estimates of illuvial clay by micromorphology.

A total of 72 pedons, from Nova Scotia to B.C. were sampled; I was present at 39 of the sites with pedologists from the province concerned. Each of us estimated independently whether the pedon had a Bt horizon. Samples were taken for particle size analysis (if data were not available) and for micromorphological study. Results will be published in Soil Science and Geoderma in 1980. They are summarized under several headings.

Clues used in detecting Bt.

Some pedologists focus on texture and structure and do not look for clay skins, others look for clay skins using a hand lens.

Uniformity of field estimates of Bt.

Pedologists of a given area generally come to the same conclusion. Of the 39 pedons I saw, I agreed with the experts in 23 cases and disagreed in 16. Pedologists from different regions would probably have different opinions on Bt development.

Stereomicroscope.

Clay skins can be seen more easily under a stereomicroscope at magnifications of 10 to 30 under good light than in the field with a hand lens. Experience would be required, however, to judge the occurrence of clay skins equivalent to about 1% of the area.

Agreement among various estimates of Bt.

Field estimates by pedologists of the area (macro) indicated more pedons with Bt horizons than were estimated by stereomicroscopic observations or by point counting (Table 1). Only 4 of 11 Chernozemic pedons and 1 of 5 Solonetzic pedons thought to have a Bt horizon met the micromorphological criterion; 24 of 34 Luvisolic pedons did.

Reliability of micromorphological estimates of illuvial clay

Ten operators estimated illuvial clay in six thin sections. For a section in which illuvial clay was clearly distinct from the matrix, values ranged from 1.1 to 4.6%, mean 3.2% and CV 39%. For the most difficult section, estimates ranged from 1.7 to 17.8%, mean 5.4% and C.V. 64%.

Operators who worked in association, however, obtained similar results. For example: 3.7, 4.6; 1.4, 1.8; 0.7, 0.6; 4.3, 4.6. Obviously, work is required to develop guidelines for recognizing illuvial clay in thin section. Even with the problem of lack of uniformity of estimates, however, micromorphology is a useful tool for checking Bt development. Many horizons thought to be Bt horizons on the basis of texture have less than 0.1% illuvial clay as judged by point counting of thin sections.

Conclusions

1. Some Chernozemic and Solonetzic soils, especially from the Brown and Dark Brown zones, that seem to have Bt horizons on the basis of texture have little or no oriented, illuvial clay in thin sections. Other reasons for the change in texture from A to B should be considered.

2. Recognition of Bt horizons in the field is improved by checking for clay skins with a hand lens as well as by looking for a change in texture. Structure is not a good general clue in assessing Bt development.

3. Standardization of counting techniques and concepts of illuvial clay is essential for those who use micromorphology to estimate illuvial clay. Until some degree of standardization is achieved, the 1% illuvial clay criterion should not be applied rigorously.

4. Regular comparisons of field and laboratory estimates of illuvial clay could lead to greatly improved consistency in recognition of Bt horizons in the field. A stereomicroscope might be a useful tool in the field.

References Samples

During the last 2 years few data has been received on the CSSC refence samples. We would like to update the compilation of results so please send your data. Also I wonder if the Canada Soil Survey collectively is satisfied with the quality control of soil data from the laboratories. Is some system of quality control necessary? Undoubtedly, the answer is "yes" for point counting of illuvial clay. How about mineralogy? particle-size? exchangeable cations? Atterberg limits?

Structure

In the Classification section of LRRI we have a project "Soil Water-Structure" in which part of the aim is to relate macromorphology to soil water transmission and retention. Chang and I are trying to improve descriptions of macrostructure. We are interested in input from anyone who has ideas on this subject.

Clay Mineralogy

Clay fractions of ISSS tour soil samples were found to have low amounts of identifiable crystalline clay. Subsequent research has shown that much of the apparent amorphous clay was due to poor orientation of phyllosilicates. Pretreatment with tiron is much more effective than citrate-dithionite for preparing podzolic B samples for X-ray diffraction analysis. This work is a joint project of Miles and Kodoma, Soils Section C.B.R.I. and Chang Wang.

Table 1. Pedons with Bt by:

Order	Macro	Stereo	Point Count	Total Pedons
BR.	0	0	0	4
CH.	11	6	4	19
GL.	5	3	3	7
LU.	34	26	24	34
SZ.	5	2	1	6

Organic Horizons, Folisols and Humus Forms

R. Trowbridge

Early soil classification studies and soil research concentrated on the mineral soils. This was partly because they represent a dominant soil type and partly because of their importance for land use and crop production. Work relating to organic soils only began in the 1960's. Until now the work has mainly been concentrated on those organic soils which have developed in peat materials. Research relating to upland (freely-drained) organic materials and soils (Folisols) developed on these materials has been greatly neglected.

In recent years the importance of organic materials associated with mineral soils and organic soils (Folisols) has been recognized. This has been mainly due to the importance of the organic horizons and Folisols in forest and watershed management and environmental protection. The type of data these disciplines required indicated the deficiencies in our knowledge of the organic materials and Folisols.

This deficiency was especially noticeable in British Columbia, although the same concern was raised in the Maritimes and in Ontario. In the fall of 1979 a Working Group was formed in B.C. to study the problems relating to organic horizons, Folisols, and humus form classification and to formulate proposals to improve the definitions and classifications. The definitions and alternative proposals presented in this paper are tentative. A great deal of work must be done to gather the necessary data and to document the various situations. It is also hoped that the suggestions and alternative proposals will generate interest relating to these problems in other parts of Canada.

ORGANIC HORIZONS

The characterization of a soil profile consists of descriptions of its organic and mineral horizons (and layers). Pedologists working in the field of forest soils have found organic horizons to be a most important part of the soil pedon. A mantel of organic soil horizons covers virtually all of the forested land in Canada. In order to study, classify, interpret, and manage forest environments, organic horizons are given as close attention as are other (mineral) soil horizons. Just as certain mineral horizons are diagnostic criteria for mineral soil classification, so too are certain organic horizons diagnostic for classification of organic soils and humus forms.

There is an urgent need to improve upon present definitions, criteria, and conventions pertaining to organic horizons. Designation of organic horizons is at times unclear and confusing. This is most striking at two levels:

1. distinguishing the L, F, and H horizons from the O horizons, and
2. distinguishing among the L, F, and H horizons (in particular between L and F and between F and H horizons)

There is also a need to improve conventions governing the use of symbols (ie. lowercase suffixes and horizon combinations).

The Canadian System of Soil Classification (CSSC 1978) recognizes two groups of organic horizons: the L, F, and H horizons and the O horizon. The separation of these groups is based on the origin of the materials and on saturation or lack of saturation for prolonged periods. It is difficult at times to assign an organic horizon to one or the other of these two groups, given present definitions and criteria. This is especially the case in areas transitional to traditional concepts of upland and wetland environments. Pedologists generally use a combination of several criteria to judge whether the organic horizon belongs to the L,F, and H group or to the O group. Table 1 is an attempt to state the criteria commonly employed as guidelines in making that judgement.

Chemical criteria for distinguishing between these two groups must be developed. Pedologists are generally able to assign horizons consistently to the two groups in characteristic situations. In non-characteristic situations, however, chemical analysis could provide a clear determination for designations, as is done with mineral horizons.

The designation of horizons within the L, F, and H group can also be difficult. Definitions are presently based broadly on the ability of the pedologist to discern the original structures and the degree of decomposition. These definitions are inadequate if the horizon does not fit central concepts. This is the case for the L, F and H horizons where not only are horizon boundaries difficult to determine, but the horizons invariably also have a combination of characteristically vague properties relating to discernability and degree of decomposition. Therefore, common concerns are: 1) where does one horizon end and another begin, and 2) which designation should be applied.

Table 1. Guidelines pertaining to organic horizon differentiation in upland and wetland environments.

Criteria	Upland (L, F and H)	Wetland (O)
Horizon Drainage	Freely drained[1]	Not freely drained
Water Table	Absent in horizons (may fluctuate in response to water input)	At or near soil surface for significant duration during the frost-free period. (May decline during growing season due to evapotranspiration, not drainage.)
Dissolved O_2	Present	Present or absent
Site Position	Generally level to sloping	Generally depressional
Underlying Mineral Soil	Generally rapid to imperfectly drained, at times poorly to very poorly drained	Poorly to very poorly drained (strongly gleyed)
Vegetation	Non-hydrophytic	Hydrophytic
Biota	Predominantly aerobic. Fungal mycelia and/or actinomycetes commonly present; mites and springtails present at some time during year. (Other biota may also be present.)	Anaerobic (few flora or fauna observed beneath surface)

1 Freely drained horizons are those in which drainage is not seriously restricted. They occur on, but are not necessarily restricted to, soils with rapid to imperfect drainage.

The L,F,H and the O horizons should be redefined, and chemical and physical properties should be analyzed in order to propose differentiating criteria. In addition, a concise definition of an "organic horizon" should be adopted, parallel to the "mineral horizon" definition. To this end, this working group proposes the following definitions:

organic horizon - a horizon containing more than 17% organic C (approximately 30% organic matter) by weight in the soil fraction finer than 2mm.

L - A freely drained organic horizon consisting of relatively fresh plant litter residues in which virtually entire original vegetative structures are discernible. May be discolored and show some signs of faunal activity but is not substantially comminuted and does not show macroscopically obvious signs of decomposition.

F - A freely drained organic horizon characterized by obvious partial decomposition and dominated by partial (rather than entire) vegetative structures which are macroscopically discernible.

H - A freely drained organic horizon dominated by well humified organic matter with advanced decomposition in which the original structures are, upon rubbing, macroscopically indiscernible.

O - An organic horizon that is not freely drained.

There is frequent misuse of symbols in combination when designating freely drained organic horizons. It has become common practice to designate the horizons "LFH", or even "L-H". We recommend that rules governing horizon designations (CSSC 1978) be applied consistently to all horizons. Combinations of uppercase letters should only be used for transitional horizons having gradual boundaries. If it becomes necessary to refer to a combination of L, F, and H horizons on the ground surface, the term "ectorganic horizons" (Wilde 1958) rather than "LFH horizons" should be used.

In these ectorganic horizons, lowercase suffixes are not recognized by CSSC (1978) to indicate variations within the master horizon designations. Within the broad definitions of the organic horizons there are clear departures that become diagnostic in humus form classification, and would help to characterize organic soils (particularly the Folisols). The British Columbia Ministry of Forests has developed and is testing lowercase suffixes and criteria. For example, the letters "li" (ligneous) are applied to a horizon dominated (more than 50% by volume) by residues of decaying wood. Lowercase suffixes were also introduced by Bernier (1968) to show subordinate features of organic horizons. Development and use of lowercase suffixes for all organic master horizons should be encouraged and become mandatory.

The working group's organic horizon designations do have some inconsistencies when the L,F, and H and the O groups are compared. All organic horizons have parent materials which can be derived from different sources. They are often derived from litter materials which fall from above and form a layer called the L horizon. Parent material, however, may be derived from within a bryophyte vegetative layer having some fallen litter material resting on top of, and intermixed within it. In this case one cannot describe, in a profile description, the parent material. Forsslund (Wilde 1958) designated this Living Layer an "S layer". The two groups have been divided into levels of decomposition, but the three levels of freely drained (L,F, and H) horizons do not correspond to those represented by the other (Of, Om, and Oh) horizons. Also, the degree of decomposition criteria are symbolized with uppercase letters in the L,F, and H group but, in contrast, are symbolized with lowercase letters in the O group of horizons.

There are alernate approaches to organic horizon designations. For example, the FAO and the Soil Survey Staff (U.S.A. 1975) apply different organic master horizon designations than does the CSSC (1978). Figure 1 is a schematic representation of an idealized concept and approach to organic horizon designation. Other approaches should be studied and considered as possible alternatives that would provide a more systematic and consistent approach for designation, symbology, and criteria.

In conclusion, we would like to make the following recommendations concerning organic horizons for your consideration and adoption:

1) Guidelines be prepared for characterizing the two groups of organic horizons.
2) L,F,H, and O horizons be redefined.
3) The term <u>organic horizon</u> be defined briefly and concisely.
4) Physical and chemical properties be developed as differentiating criteria for distinguishing all organic horizons.

5) Conventions governing the use of symbols be improved.

6) Lowercase suffixes be developed to indicate departures subordinate to master horizons.

7) Alternate approaches be considered for organic horizon classification.

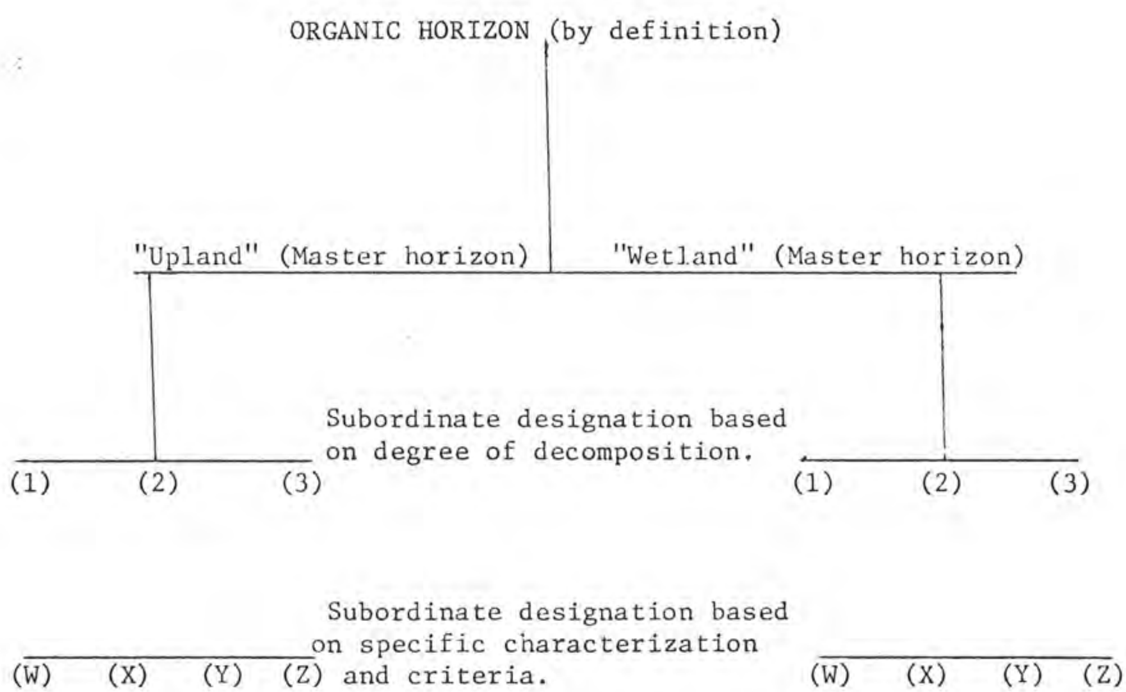

Figure 1. Idealized concept and approach to organic horizon designation.

Folisolic Soils - Proposals for Changes in Taxonomic Classification

The following discussion deals with Folisolic soils (soils with thick L, F, and H horizons)[1], their current classification, problems relating to the classification, and suggestions for classification improvement. The purpose is to identify the deficiencies of the present classification, to suggest improvements, and to solicit support for classification modification in the next version of the Canadian System of Soil Classification.

Folisolic soils were first identified in the Canadian soil classification about 10 years ago and reflected the state of knowledge at that time. They consisted mainly of thick forest floor organic accumulations over bedrock. Presently (1978 classification) they are generally defined as consisting of well to imperfectly drained organic forest floor accumulations (L, F, and H horizons) greater than 10 cm thick overlying either bedrock or fragmental rock material. They are classified as a Great Group of the Organic Soil Order. However, soils consisting of thick L,F, and H horizons (horizons similar to those presently classified as Folisols) but underlain by unconsolidated, non-fragmental mineral soil are classified on the basis of soil development in the mineral material, <u>regardless</u> of the thickness of the overlying organic horizons.

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1 L,F, and H horizons may be grouped and expressed as "freely drained ectorganic horizons".

This classification procedure provides for several inconsistencies. The first is that the thick organic surface horizons, if over bedrock, are diagnostic at the Soil Order level yet, if over unconsolidated material, are not diagnostic at any point in the classification system (except perhaps as soil series criteria). Another is that poorly drained organic soils (bogs and fens) are classified in the Organic Order when the depth of O horizons over mineral soil exceeds 40 cm; this parallelism does not exist when the organic material is of the well drained, folisolic type.

Another inconsistency in the present classification is that the Folisols in the Organic Order are an exception to the usual environmental conditions for that Order. They vary from the usual in that they are: 1) well to imperfectly drained versus poorly or very poorly drained; 2) rarely, if ever, saturated in the sense of being subject to high, permanent groundwater tables; 3) developed mainly in organic material of forest origin in contrast to hydrophytic vegetation; and 4) subject to "upland" accumulation and decomposition processes rather than to peat-forming processes associated with poorly drained conditions. These inconsistencies are somewhat analogous to having well drained soils in the Gleysolic Soil Order.

Soils with thick L,F, and H horizons seem to be mainly restricted to areas where the climate is cool and wet along the West Coast of Canada. These areas include the Queen Charlotte Islands, the western and northern parts of Vancouver Island, and the coastal areas of the mainland as well as some parts of inland B.C. The soils rarely freeze nor do they completely dry. The cool, moist conditions limit widespread forest fires to very rare occurrences. Under these conditions, the accumulation and decomposition of organic forest floor material can be considered as one of the dominant soil forming processes.

Soil surveys in these areas over the past few years have shown that there is a substantial acreage of soils with deep L,F, and H horizons, that the thickness of these horizons is at least 15 cm and often between 40 and 100 cm, and that the thick organic horizons overlie both bedrock and mineral soil material. The surveys have also indicated that, because of the thickness of the organic surface, the characteristics of the underlying mineral soil are of lesser or minor importance for tree growth or related silvicultural activities. Trees and undergrowth are dominantly rooted in the organic material, most biological activity seems to be centered there, and land management is related much more strongly to the organic surface horizons that to the underlying mineral soil.

Because of the importance of the organic surface material, it appears that this material should be identified as a diagnostic feature in the classification system. This already occurs for organic material over bedrock (Folisol Great Group) but not for deep L,F, and H accumulations over mineral soil.

There seems to be several methods to emphasize the thick L,F, and H horizons in the classification system, with each having attractive features as well as some limitations. Three methods are outlined in the following sections. Common to all of these options is the fact that unconsolidated mineral soils with less than 40 cm of L,F, and H materials on the surface would continue to be classified as at present (ie. Orthic Humo-Ferric Podzol, Orthic Dystric Brunisol, etc.). Those soils with 15 to 40 cm of L,F, and H materials should, however, be identified as "folisolic phases", similar to the "peaty phases" of Gleysolic soils (Figure 2A). Folisolic phases should be incorporated in the classification as an item that is to be applied consistently for identification of mineral soils which have relatively deep L,F, and H horizons. It would also provide a mechanism for a "continuum" between soils with thin L,F, and H horizons and those where these horizons are thick.

Option one is to expand the present Folisol Great Group of the Organic Soil Order to accomodate soils with thick L,F, and H horizons over unconsolidated mineral material (Figure 2B). A statement indicating that accumulations of L,F, and H materials thicker than 40 cm over mineral material also fall in this Great Group is required. Subgroups could be based on the kind of soil development in the underlying mineral soil (ie. Podzolic Folisol, Brunisolic Folisol).

This option makes the depth of L,F, and H horizons the main diagnostic feature with the soil development in the underlying mineral soil as a secondary differentiating criteria. It also provides a mechanism for indicating the concurrent operation of two soil-forming processes - L,F, and H material accumulation and decomposition and mineral soil development. This already occurs in most other Soil Orders (ie. Brunisolic Luvisol, Luvisolic Podzol).

An apparent limitation, however, is that this option requires redefinition of the Organic Order and makes the Order even more diverse than at present. Essentially the only commonality among the soils in the Order would be that they are developed mainly from organic material. There would be no consistency in soil drainage, type of organic material, or soil-forming process.

Option two consists of defining "Folisolic" Subgroups for the existing Great Groups or subgroups in the appropriate mineral soil orders (Figure 2C). The existing Folisol Great Group in the Organic Order would remain unchanged. This method probably requires the least modification of individual soil orders but does require the definition of several subgroups which have L,F, and H material accumulations greater than 40 cm.

A drawback is that the main differentiating criteria for classification still remain based on the soil development in the underlying soil and that the characteristics of the overlying L,F, and H horizons become secondary. Field observations indicate that the characteristics and depth of the organic surface horizons are more important for forest and related uses than are those of the underlying soil. This option, however, still retains the "integration" mentioned under Option 1.

Option three is to define a new soil order consisting of "Folisolic" Soils (Figure 3). Not only does this allow the present Organic Order to revert to its original concept (very poorly drained, high water tables, hydrophytic vegetation) but it also allows for definition of Great Groups and Subgroups based on the thickness of the L,F, and H layer as a whole, on the type of underlying mineral material, on the kind of soil development in the underlying mineral soil, and on the relative thickness of individual L,F, and H horizons, if required.

The following outline is intended only to show the rationale of the proposal and to identify important parts of the concept. Definitions are not necessarily complete nor are all subgroups identified. New names are suggestions only.

FOLISOLIC ORDER - These are organic soils composed mainly of well to imperfectly drained L,F, and H horizons thicker than 10 cm if over bedrock or fragmental material or thicker than 40 cm if over unconsolidated mineral soil. The underlying mineral soil may have soil developments defined for mineral soils.

GREAT SOIL GROUPS AND SUBGROUPS: three great groups are suggested as defined below along with attendant subgroups.

Lithic Folisol Great Group - these soils consist of more than 10 cm of L,F, and H material over either bedrock or fragmental rock material (similar to the presently defined Folisols). Two subgroups are proposed - Typic Lithic and Fragmental Lithic.

Typic Lithic Folisol Subgroup: these soils consist of more than 10 cm of L,F, and H material over bedrock. Further depth subdivisions can be made by using the presently defined lithic phase criteria.

Fragmental Lithic Folisol: these soils consist of more than 10 cm of L,F, and H material over or interspersed with fragmental rock material. For more specific depth divisions, depth criteria for phases can be developed.

Terric Folisol Great Group: these soils consist of more than 40 cm of L,F, and H material over unconsolidated, non-fragmental, mineral soil. Five subgroups are suggested for the present. These are:

Podzolic Terric Folisol - more than 40 cm of L,F, and H material over unconsolidated mineral soil with podzolic (by definition) soil development.

Brunisolic Terric Folisol - more than 40 cm of L,F, and H material over unconsolidated mineral soil with brunisolic soil development.

Luvisolic Terric Folisol - more than 40 cm of L,F, and H material over unconsolidated mineral soil with luvisolic soil development.

Regosolic Terric Folisol - more than 40 cm of L,F, and H material over unconsolidated mineral soil with regosolic soil development.

Gleysolic Terric Folisol - more than 40 cm of L,F, and H material over unconsolidated mineral soil with gleysolic soil development.

Histic Folisol Great Group: these soils consist of more than 40 cm of L,F, and H over O materials.

Fibric Histic Folisol: more than 40 cm of L,F, and H material over dominantly fibric peat (Of).

Mesic Histic Folisol: more than 40 cm of L,F, and H material over dominantly mesic peat (Om).

Humic Histic Folisol: more than 40 cm of L,F, and H material over dominantly humic peat (Oh).

In the previous subgroups, more specific depth classes can be developed through phasing.

Chernozemic, Solonetzic and Cryosolic Terric Folisols are not expected to occur. If they are identified in the future, they can be added.

Subgroups based on the degree of decomposition of the organic material are not presently proposed in any of the new great groups. Current experience and data indicate that all of the proposed subgroups consist dominantly of mor-type H material.

General Considerations for Separating Folisolic Soils from Organic Soils with O horizons.

Folisolic soils usually:[1]

1) have developed under and are supporting a "forested ecosystem"
2) consist of organic material derived from leaves, twigs, needles and similar plant remains
3) are underlain, where unconsolidated mineral soil exists, by well to imperfectly drained soil profiles
4) occur on slopes and tops of ridges and in similar landscape positions
5) are freely-draining soils, ie. do not have high groundwater tables.

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1. Points 3) and 5) may not apply if underlain by Gleysolic Soils.

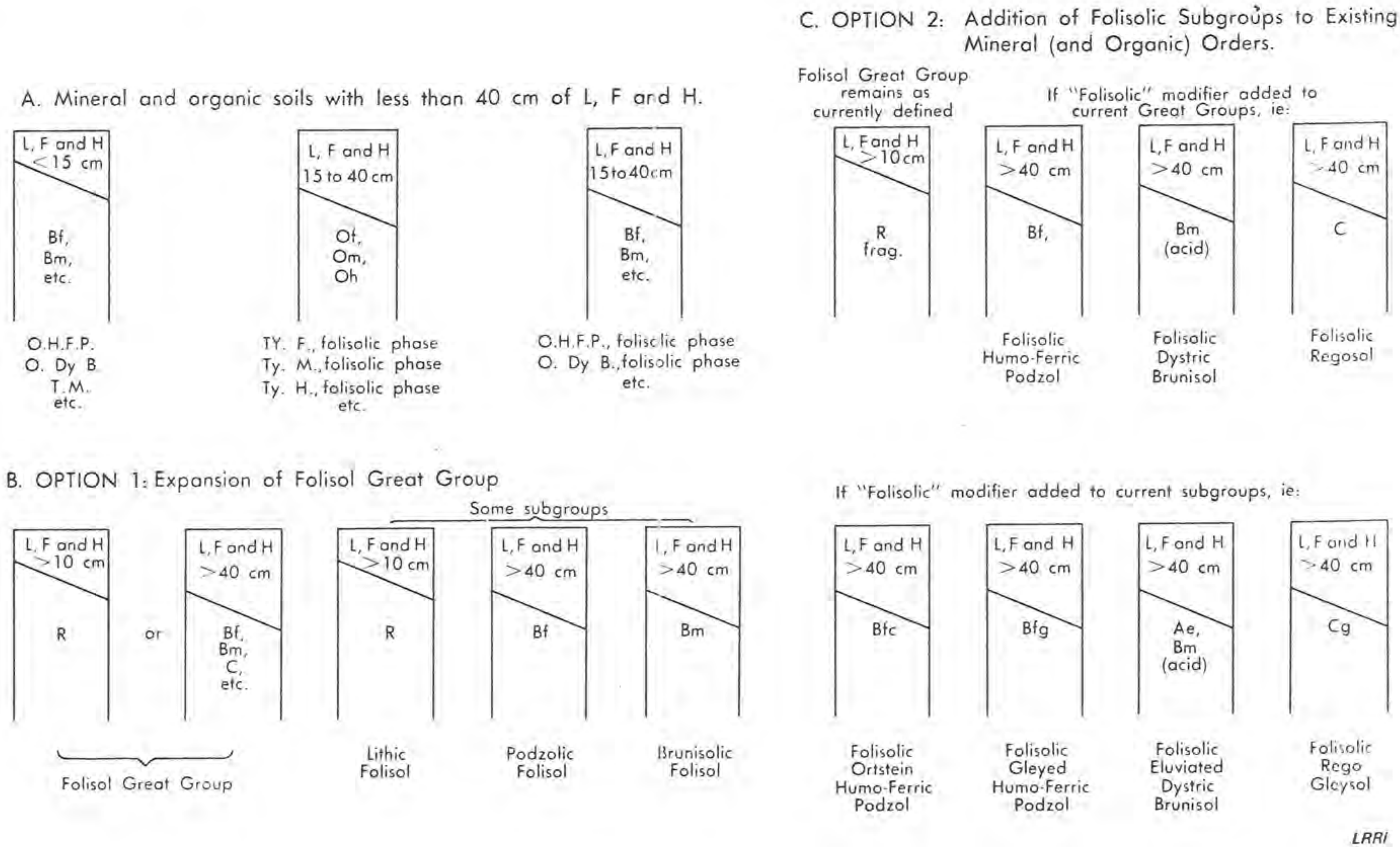

Figure 2. Schematic soil profile diagrams: A. Soils with less than 40 cm of L,F and H; B and C. Options 1 and 2, respectively.

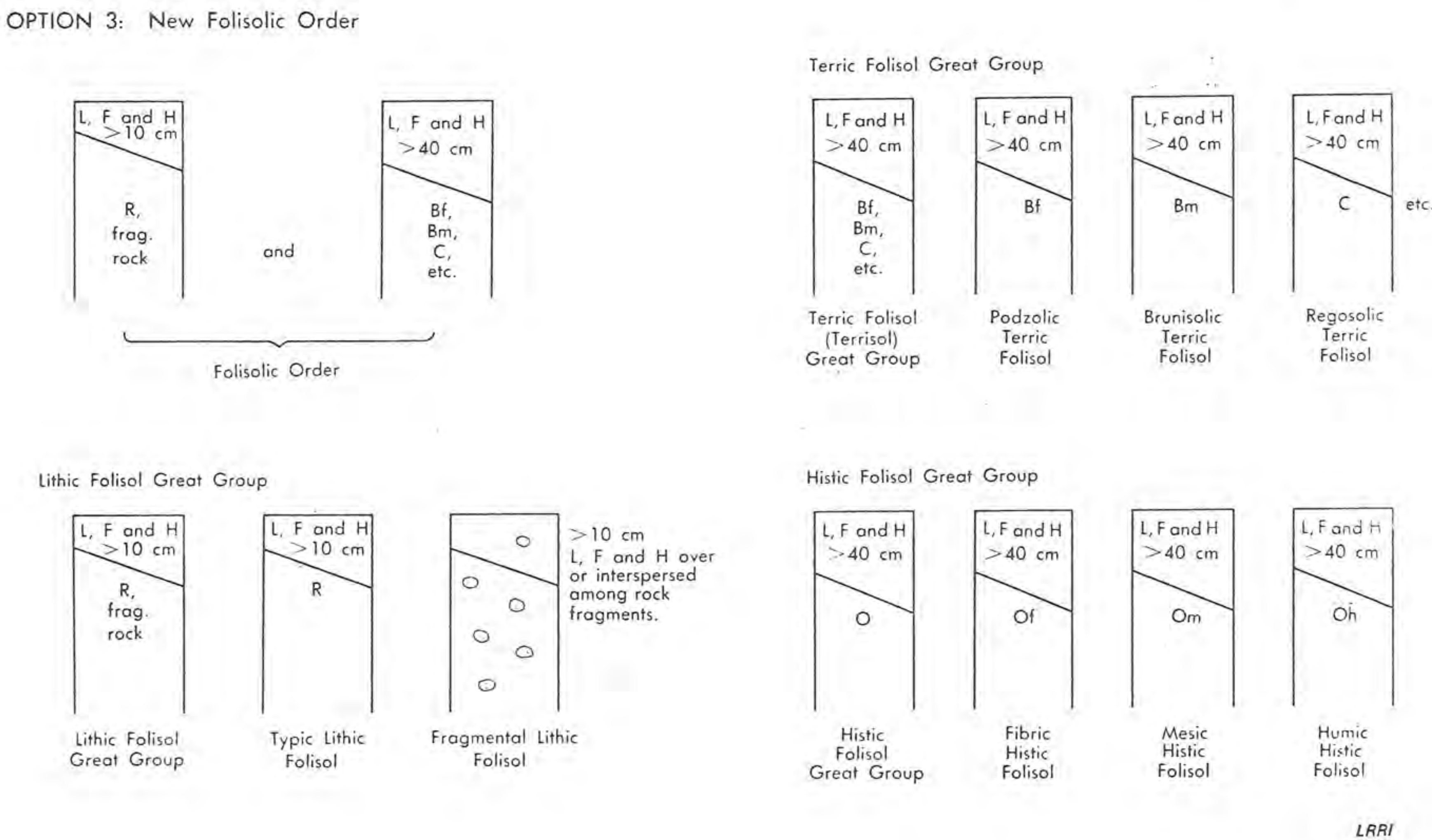

Figure 3. Schematic soil profile diagrams for option 3.

The previous discussion is based on perceived problems in British Columbia. Comments on similar conditions elsewhere or on alternate methods for resolution are welcomed.

A few schematic diagrams to indicate the various options described are attached.

HUMUS FORM CLASSIFICATION

The British Columbia Ministry of Forests' Research Branch initiated a great deal of interest in humus forms through their ecological classification program and subsequent proposal of a humus form classification to be used by the Ecological Program Staff.[1] The following discussion has been edited from "The First Approximation of Humus Form Classification in British Columbia" (Klinka et al.in print). It deals with the questions asked of the Working Group in terms of a review of humus form classification, terminology, and humus form significance. It discusses the ecological approach taken to classification; defines humus, humus form, and humus form profile; and provides for a control section. Lastly, the taxonomy of the classification is discussed.

Humus form classification to date has not been able to provide an adequate and consistent approach to humus studies. The Working Group recommends that the Expert Committee on Soil Survey (ECSS) consider and recognize the importance of and need for a hcmus form cla[illegible] that would provide a methodology for description of organic horizons and a meaningful classification and taxonomy and that the ECSS should also promote recognition of the very important role that humus studies have and require.

1 The Ecological Program Staff, in the context of this study, is a group of pedologists and ecologists responsible for an ecological classification program carried out by the Ministry.

Introduction

Bernier's (1968) descriptive outline of forest humus form classification, adopted by the Canadian Soil Survey Committee (Dumanski (ed.) 1978), has been used, until now, in classifying humus forms. This classification has greatly enhanced ecological sutdies. Its use over a decade, however, has exposed weaknesses concerning definitions of organic and Ah horizons, methods of describing organic horizons, terminology, treatment of non-conforming materials, the definition of moder, and the tentative classification status of humus forms associated with organic soils and grassland ecosystems. Because of their relationships to the ecosystem components, humus forms have been applied as differentiating or accessory characteristics for various taxa in the system of ecosystem classification in use by the British Columbia Ministry of Forests. However, a need for more precise classes and categories in the system was recognized.

A review of existing classifications of humus forms in the U.S.A. (Hoover and Lunt 1952, Wilde 1971) and in Europe (Hartmann 1952, Kubiena 1953, and Duchaufour 1960) did not indicate that any of the classification systems could be advantageously applied as a replacement to Bernier's system.

It is often said that the terminology used to describe humus forms (and hence classification) of organic horizons is a badly confused segment of soil science. This is particularly true when dealing with humus form nomenclature. It was stated that every expression in international use now has two or more meanings and the same form is known under several names; there are also doubts about whether these designations are really synonymous (Bernier 1968, Howard 1969, Wilde 1971). A difficulty with comprehensive appraisal of the literature also lies in the fact that even where the names of humus forms recognized by Kubiena (1953) or other works are employed, there is no complete uniformity in their application. The same is true for the horizon designation. The various authors often do not clearly state how they use these terms (Babel 1975).

The interpretive significan e of humus forms for forestry includes a wide array of relationships between humus form properties and soil conservation, forest protection, forest hydrology, silviculture (natural regeneration, plantation survival and initial seedling growth), and, above all, forest growth and yield. Perhaps the most important interpretive role may be in relation to forest productivity. In addition to relationships between humus form properties (such as those influencing aeration, and moisture and nutrient regimes of soils) and forest productivity, specific effects of humus materials on plant growth and vigor (Flaig 1975) should not be overlooked.

Classification

With new research data and a broader base of experience, the Ecological Program Staff realized that a revision of Bernier's classification system was needed in order to make more quantititive and reliable interpretations about humus forms. Therefore, by consulting the pertinent literature and using our own materials we proposed definitions and rules concerning the description of organic horizons,[1] methods of sampling and analysis and finally, a taxonomy of humus forms in ecosystems in British Columbia. The taxonomy has been tested to a limited degree to substantiate the significance of the differentiated units.

An ecosystematic approach to humus form studies has been adopted. Humus form is considered an important bond between the vegetation and soil components of an ecosystem (biogeocoenose; Sukachev and Dyllis 1964). Hence, humus studies, conducted within the framework of five basic ecosystem components - climate, soil, vegetation, microorganisms and animals - have a potential to address the interrelations between humus form and the individual components. It is recognized that humus studies are very complex. Despite the fact that the Ministry of Forests ecological program is very detailed, a study of the humus form is not yet complete. In the future we hope to include micromorphological, microbiological, and more advanced physical and chemical characteristics in the humus form studies.

In classifying humus forms morphological properties were employed as differentiating and accessory characteristics (taxonomic differentiae). This approach underlies most of the existing humus form classifications (Romell and Heiberg 1931, Heiberg and Chandler 1941, Mader 1953, Kubiena

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1 In the report, a methodology for field description of the organic horizons and layers is given.

1953, Barratt 1964, Wilde 1966 and 1971, Bernier 1968). Romell and Heiberg (1931), Wilde (1966 and 1971), and Babel (1975) placed the foremost emphasis on readily determinable morphological features of humus forms for the purpose of classification. Such an approach is not meant to suggest that little or no determination of physical, chemical, and biological properties of humus forms was undertaken. In addition to a detailed morphological description, some physical and chemical properties were determined in the current ecological program. However, a meaningful set of chemical analyses for humus materials is still the subject of research.

Definitions

Humus, in a broad sense, refers to all soil organic matter in which the original organic compounds have been transformed into more complex and stable compounds referred to as humus or humic materials. These materials are usually dark-colored although some may be pale-colored. Nearly all humus materials contain more than a trace of mineral materials.

"Forest floor" and "duff"[1] are terms used by forest scientists and practitioners in North America to designate humus forms and a kind of humus form, respectively. In the context of this study "forest floor" refers to organic materials that have formed at and near the soil surface. "Duff", apart from an inference to forest floor, refers to a formative element used in naming the taxa of mull humus forms in Romell and Heiberg's

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1 Duff - decaying vegetable matter on the ground in a forest (Webster's New World Dictionary 1968).

Duff mull - a type of forest humus transitional between mull and mor (Glossary of Soil Science Terms, SSSA 1970).

(1931), Heiberg and Chandler's (1941), and Hoover and Lunt's (1952) systems. The term "duff" is not used in this study.

The humus form, introduced by Müller (1879), designates those natural biologically-active soil materials formed at and near the surface of a pedon by organic residues in all stages of decomposition, and humus materials, arranged into organic or organic and mineral horizons. This definition agrees with that rendered by Bernier (1968). The concept of humus form is one of a natural body like the soil of which it is a part (Bernier 1968). The sequence of horizons in the humus form profile and morphological properties that can be seen or measured in the field or require measurement in the laboratory are used in classifying humus forms.[2]

Control Section

The organic and mineral horizons that form at and near the surface of a pedon (Soil Survey Staff 1975, CSSC 1978) constitute a control section of humus form. All organic horizons, but not all mineral horizons, of the control section make up a humus form profile. The organic and mineral horizons in the humus form profile are referred to as humus form.

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2 Hartmann (1952) and other workers recognized the need for two separate systems of classification: "humus type" classification for "humus units" that occur in the field and the term "humus form" for the kinds of humus. Our approach recognizes the humus form as the object of classification. Thus, "humus units" that occur in the field are synonymous to humus forms and "humus types" are the taxa in the system. The kinds of humus, i.e. the kind of organic (humus) materials are "classified" morphologically by identifying various horizons and layers in the humus form profile and by determining properties related to the nature of their materials.

The control section for humus form is based on arbitrary depth criteria. This is necessary to provide for a uniform taxonomic basis. The criteria are defined as follows:

1) If the horizons at or near the surface of a pedon are all organic horizons, the control section corresponds to the humus form profile and extends from the soil surface to a depth of 40 cm (i.e. it approximates the depth of a surface tier used in the classification of organic soils). If a lithic or paralithic contact, or fragmental materials occur at a depth shallower than 40 cm from the surface of a pedon, the humus form profile extends from the soil surface to the contact. These criteria are largely applicable to humus forms in organic soils (Figure 4 a).

2) If the horizons at or near the surface of a pedon are both organic and mineral, and if the combined depth of the former is less than 40 cm, the control section extends from the soil surface to a depth of 25 cm beneath the boundary between organic and mineral horizons. If a lithic or paralithic contact, or fragmental materials occur at a depth of less than 65 cm from the surface of a pedon, the humus profile extends from the soil surface to the contact. These criteria are largely applicable to humus forms in mineral soils (Figure 4b).

The humus form profile in criteria 2 may not correspond with the entire control section unless the mineral horizons within it qualify for inclusion. The mineral horizons that qualify are designated as diagnostic. In essence, we adopted the concept of the epipedon (Soil Survey Staff 1975)

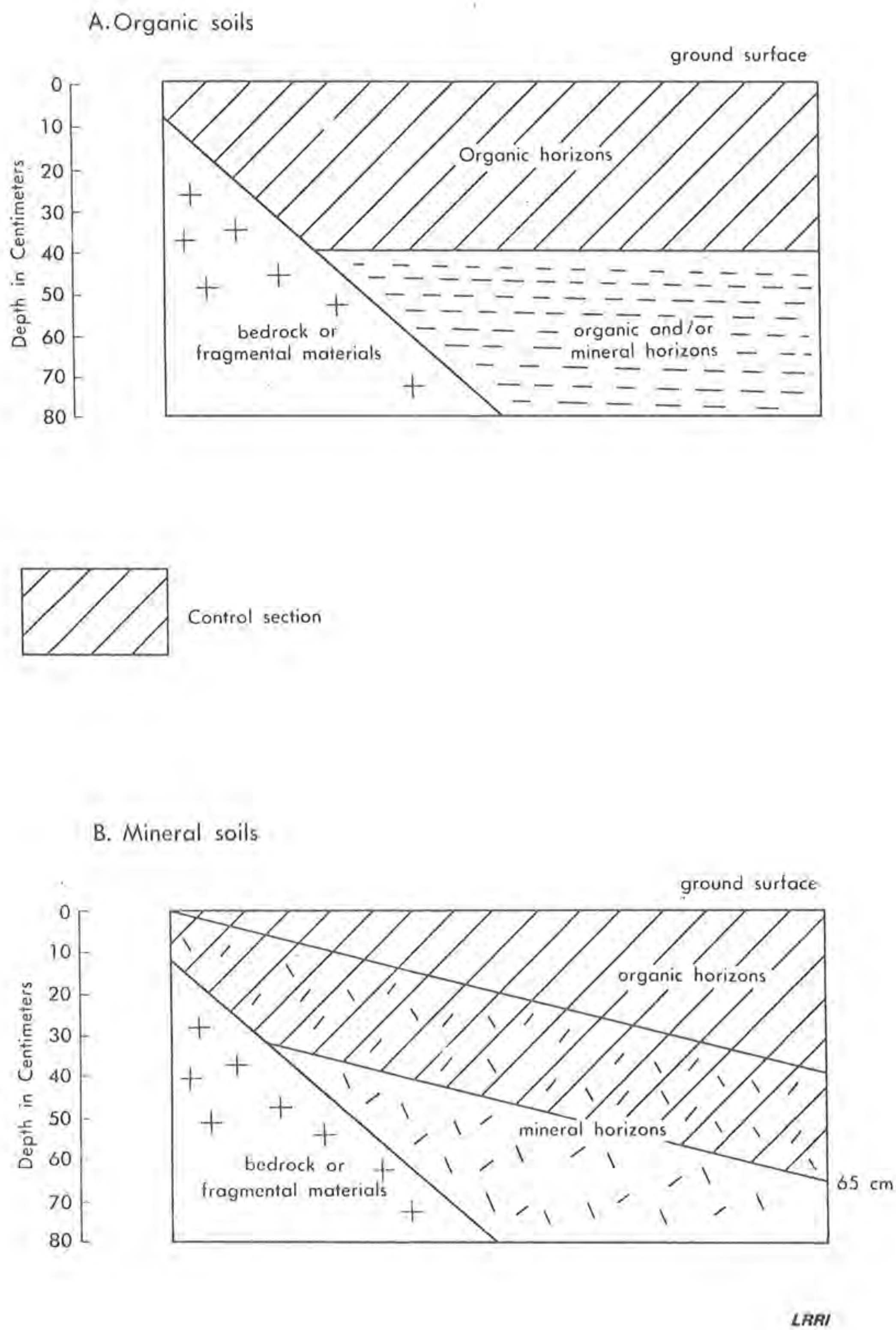

Figure 4. Control section of humus forms in organic (a) and mineral soils (b).

and the proposed 25 cm thickness is over the minimum depth requirement used for most of the defined epipedons. We propose that the control section as defined above is adequate to characterize humus formation in mineral soils.

It is expected that in special circumstances mineral materials may occur within organic horizons or on the soil surface; similarly, organic materials may occur within mineral horizons. Rather than propose a unique set of specifications we suggest a selection of one or more appropriate criteria to deal with such irregularities.

Taxonomy

The purpose of humus form classification is to organize our knowledge about studied humus forms. The objective of the proposed humus form taxonomy is to create a hierarchy of classes permitting us to understand the natural relationships between humus forms and the factors leading to their formation. In this first approximation we have aimed at a taxonomy in which differentiae are the humus form properties that can be observed in the field, or that can be inferred either from other properties that are also observable in the field or from the properties of an ecosystem under study.

The taxonomy has attempted to provide taxa for all humus forms that are known to occur in British Columbia and elsewhere under the influence of comparable climates. Some humus forms, however, have not yet been adequately described and studied. As far as reasonable definitions and predictions could be prepared, derived mainly from materials of other workers, they were included in the system.

An example of the hierarchical, three-categoric taxonomic system of terrestrial and semi-terrestrial humus forms is presented in Table 2. In order of decreasing rank and increasing number of differentiae the categories are: humus form order, group and subgroup. The terms "humus form order", "humus form group" and "humus form subgroup" are simplified in the text to "order", "group" and "subgroup", respectively.

The attributes thought to result from humus form genesis were selected for the characterization of orders and groups whereas those thought to be important to plant growth but subordinate or of less significance to the genesis have been considered for the characterization of subgroups and phases of subgroups. A humus form phase, however, is not a taxonomic unit. It is intended to be a functional unit allowing the description of subgroups by properties that are important to plant growth and for interpretations.

Thus, the taxonomic differentiae for orders and suborders are based on the presence or absence of diagnostic organic and mineral horizons (a characteristic horizon humus form profile sequence), the relative

Table 2.

Example of Synopsis and Names of Taxa in Each Category of the Proposed Humus Form Taxonomy

Order	Group	Subgroup		
1 Mor	11 Velomor			
	12 Xeromor			
	13 Hemimor	131 Orthihemimor	Compactic Aeric Dystrophic Eutrophic Ustic Charcic Clastic Psammic Pachic Tenuic Pergelic Terric Turbic Ruptic Albic	Adjectives in names of phases
		132 Myceliohemimor		
		133 Lignohemimor		
		134 Amphihemimor		
	14 Hemihumimor			
	15 Humimor			
	16 Hydromor			
	17 Histomor			
2 Moder				
3 Mull				

thickness of the horizons, and features of humus forms that are indicative of the dominant sets of humus-forming processes.

Orders are differentiated by horizon combinations and the kind of F horizon in the humus form profile, inferred to be indicative of essential differences in the nature of humus formation. Thus, Mor, Moder and Mull orders provide for segregation in:

1) mineralization (decomposition of fresh organic or synthesized humus materials into simple soluble compounds)
2) humification (a synthesis of humus materials)
3) the kind and degree of incorporation of humus materials into mineral soil.

Intergrades toward other orders are recognized at the group category of the Moder Order.

The differentiae for groups vary with the order. In general, they provide for segregation along the soil moisture gradient into xeromorphic, mesomorphic, and hydromorphic humus forms, and according to kind and arrangement of horizons. These differentiae were selected to reflect what seemed to be the most important variables within the orders.

The differentiae for subgroups vary with orders but show less variation within a group. They were intended to place together humus forms that have close similarities in kind and fabric of materials. There are three kinds of subgroups:

1. subgroups that conform to the central concept of the group
2. subgroups that deviate from the central concept by having abberant, apparently genetically subordinate features

3. intergrade subgroups that have a combination of features of subgroups in the same group.

Subgroups, however, do not provide for classes that have close similarity in physical, chemical and biological properties, which affect a response to management and manipulation for use. For this purpose we suggest the use of a phase of a subgroup, though phases of orders and groups may also be defined. The humus form properties used as differentiae include those that are important to plant growth and for interpretations. A phase of a subgroup may have nearly the full range that is permitted in a subgroup in several properties, but in one or more selected properties the range is restricted.

CONCLUSIONS

We hope this report will stimulate interest from soil scientists in other parts of Canada. Due to the importance of organic horizons, their definitions and criteria should be reviewed, studied, and updated. In relation to organic horizons and their implications for land resource management, the Folisol Great Group needs to be expanded. A revision of the humus form classification in Canada is mandatory considering its important relationships in various aspects of land classification, interpretation, and management. We look forward to comments on this report and will continue to work in these areas of concern.

ACKNOWLEDGMENTS

I would like to express the Working Group's appreciation to all of the people and government agencies involved in helping initiate, organize, and contribute to this report. In particular, Charles Tarnocai and Terry Lord deserve special recognition for their contributions. Special thanks are also due to Herb Luttmerding for preparing the Folisolic Soils section.

The members of the Working Group were Tim Ballard (University of British Columbia), Bob Green (B.C. Ministry of Forests), Andrew Harcombe (B.C. Ministry of Environment), Karel Klinka (B.C. Ministry of Forests), Lawrence Lowe (University of British Columbia), Herb Luttmerding (B.C. Ministry of Environment), Dave Moon (Agriculture Canada), and Rick Trowbridge (B.C. Ministry of Forests).

LITERATURE CITED

Babel, V. 1975. Micromorphology of soil organic matter. Gieseking J.E. (ed.). Soil components. Vol. 1 Organic components. Springer Verlag, New York, Heidelberg, Berlin. pp. 369-473.

Barratt, B.C. 1964. A Classification of humus forms and micro-fabrics of temperate grasslands. J. Soil Sci. 15:351-356.

Bernier, B. 1968. Descriptive outline of forest humus-form classification. Proc. 7th meeting of CSSC Edmonton. 16 pp.

Canadian Soil Survey Committee (CSSC). 1978. The Canadian system of soil classification. Canada Dept. of Agriculture. 164 pp.

Duchaufour, P. 1960. Precis de pedologie, 1st ed. M

Duchaufour, P. 1960. Precis de pedologie, 1st ed. Masson et Cie, Paris. 418 pp.

Dumanski, J. (ed.) 1978. Manual for describing soils in the field. Land Resource Research Institute, Research Branch, Agriculture Canada. 92 pp.

Flaig, W. 1975. Biochemistry of soil organic matter. In Organic material as fertilizer. Soil Resources, Development and Conservation Service, Land and Water Development Division, FAO, Rome. pp. 31-68.

Hartmann, F. 1952. Forstokologie, George Fromme & Co., Wien, 460 pp.

Heiberg, S.O., and R.F. Chandler. 1941. A revised nomenclature of forest humus layers for the northeastern United States. Soil Sci. 52:87-99.

Hoover, M.D., and H.A. Lunt. 1952. A key for the classification of forest humus types. Soil Sci. Soc. Am. Proc. 16:368-370.

Howard, P.J.A. 1969. The classification of humus types in relation to soil ecosystems. Systematics Association Publication No. 8: the soil ecosystem. Sheals, J.G. (Ed.). pp. 41-54.

Klinka, K., R. Green, R. Trowbridge, and F. Lowe (in print). First Approximation of Humus Form Classification in B.C.

Kubiena, W. 1953. The soils of Europe. Thomas Murby & Co., London. 318 pp.

Mader, D.L. 1953. The physical and chemical characteristics of the major types of forest humus found in the United States and Canada. Soil Sci. Soc. Am. Proc. 17:155-158.

Muller, P.E. 1879. Studies on natural humus forms and their influence on vegetation and soil (in Danish). Published in 1887 as Studien uber die naturlichen Humusformen und deren Einwirkung auf Vegetation und Boden. Springer, Berlin. 324 pp.

Romell, L.G., and S.O. Heiberg. 1931. Types of humus layers in the forests of northeastern United States, Ecology 12:567-608.

Soil Survey Staff. 1975. A basic system of soil classification for making and interpreting soil surveys. U.S. Dept. of Agriculture. 754 p.

Sukachev and Dyllis. 1964. Fundamentals of forest biogeocoenology. Oliver and Boyd Ltd., Edinburgh and London. 672 pp.

Wilde, S.A. 1958. Forest Soils. Ronald Press, New York. 537 pp.

1966. A new systematic terminology of forest humus layers. Soil Sci. 101 (5):403-407.

1971. Forest Humus: its classification on a genetic basis. Soil Sci. 3(1):1-12.

Nonagronomic Soil Interpretations

C.J. Acton

Introduction

Interpretation of soil survey information for engineering and recreational uses has been conducted in Canada over the past ten or more years. In 1968, the first report of the Subcommittee on Soil Survey Interpretations for Engineering Purposes was presented to the National Soil Survey Committee of Canada (NSSC 1968). Guidelines to assist in the interpretation of soils for engineering, recreation and forestry uses were suggested for testing in the 1973 proceedings of the Canada Soil Survey Committee (CSSC 1973).

Since that time, a number of soil survey reports in Canada have been published with a major effort given to soil interpretations. As expected, provincial or regional differences have developed in the approach used, or in the format of presentation. Conversely, there has been a considerable degree of uniformity in the manner in which interpretations have been made. The purpose of this report is to document current approaches to the interpretation of soil survey information for non-agronomic uses in Canada in order to evaluate the feasibility of, and the extent to which standardization of interpretations might be achieved in Canada.

Included in this report are discussions on soil interpretations for engineering uses, recreational development and for drastically disturbed areas. Separate reports on soil interpretations for forestry use and soil erosion follow this report.

Current State of the Art

A. Engineering Uses

Interpretation of soil survey information for engineering uses in Canada has followed closely the approach taken in the United States. Soils Memorandum SCS-45 (Rev. 2) "Guide for Interpreting Engineering Uses of Soils" (USDA 1971), and "Guide for Assessing Soil Limitations", Montgomery and Edminister (1966) have received wide Canadian use. Canadian guidelines for soil survey interpretations prepared by the Canada Soil Survey Committee (CSSC 1973) show strong similarities to these earlier publications.

In general terms, the approach in most provinces has been to estimate the suitability or limitations of soils for a specific use. Suitability classes (good, fair, poor and unsuitable/very poor) have been used in publications from British Columbia (Soil Resources Smithers - Hazelton Area, 1974), Manitoba (Soils of the Brandon Region Study Area, 1976; Soils of the Glenboro Area, 1979) and in New Brunswick (Soils of Northern Victoria County, 1976; and Soils of the Rogersville - Richibucto Area, In Press). Limitation ratings (none to slight, moderate and severe) have been identified in Alberta publications (Kananaskis Lakes, Soils of Yoho National Park, 1977), and in Saskatchewan (Biophysical Resources of Prince Albert National Park). It can be assumed that there are close similarities between the suitability classes and those expressing degrees of limitations. In all cases, the nature of the restrictive features were indicated, either with subclass symbols using numbers or connotative letters, or by means of one or two words.

In Ontario, the most specific information relating to suitability for engineering uses is given in Soils of Waterloo County (1971). The classification is mainly a two class system with ratings given as "suitable" and "unsuitable". For some engineering uses, only the major problems have been identified with no attempt made to establish the severity of the limitation for that use. The approach used in the Soils of Northumberland County (1974) was somewhat different with the soils rated in terms of capability for urbanization using a five class system. In the Soils of Halton County (1971), engineering uses are generalized into the category "Urban and Suburban Uses" with three suitability classes identified. In both cases, symbols identifying the soil or site factors important for establishing the classes were given for each of the soils.

The approach taken in the most recent Saskatchewan publication (Soils of the Saskatoon Map Area, 1978) was not to include interpretations for engineering uses, however, information on the engineering properties of selected surficial deposits has been included in the appendix of that report.

The practice in Quebec has been not to include information pertaining to soil interpretations for engineering and related uses in their soil survey publications.

Some general observations can be made relating to specific engineering uses:

1. Only in the most recent publications are guidelines presented which indicate the soil and landscape properties used, and their limits, for establishing interpretive ratings.

2. In many instances there is a close agreement in the properties chosen to rate a soil for a particular use, however, there are some differences in the interpretative criteria used from one region to another. Examples are:

In making interpretations for sand and gravel extraction, "depth of material" was a class determining factor in New Brunswick, whereas "depth to bedrock" and "depth to sand and gravel" were factors considered in Manitoba.

Where source of roadfill was the use considered, "depth to bedrock" was a class determining factor in Manitoba, but not so in the Rogersville - Richibucto area of New Brunswick where the bedrock was rippable, easily excavated and used as a source of roadfill itself.

3. Where the properties used for interpretive ratings are similar, there are sometimes differences in the application of these properties between regions in establishing the degree or severity of the limitations.

In interpreting soil materials for sand and gravel extraction, the critical depth to "average (or seasonal) water table" were not rated as severely in some provinces as in others.

In interpretations for septic tank absorption fields, there were differences in the limits of the classes for parameters such as subsoil permeability and depth to water table.

4. Use categories are more general in some regions than in others.

In most cases, interpretations for sand and gravel were grouped into one use category, and it was left to the user to determine whether the rating applied to use as sand or gravel material. The term "granular materials" was used in publications from several provinces, thus the interpretations related to several different types of materials.

Soil interpretations for permanent buildings were made in several publications, whereas in some cases information on soil suitability for building site development had to be deduced from information given on soil features affecting shallow excavations.

5. Soil interpretations for some uses are occasionally restricted to a particular region.

Only in publications from Manitoba has there been a consistent attempt to rate soils for "water management" uses. Interpretive classification has involved documenting, for all soils, those features affecting use for agricultural drainage, reservoir areas, and embankments, dikes and levees.

Research work is currently underway in Canada in the development of "Pedotechnical Soil Interpretations", which involves a different approach and emphasis on "engineering" interpretations. The current state of progress in this endeavor is presented elsewhere in the proceedings of these meetings.

B. Recreational Uses

Interpretations for recreational development have ranged from generalized statements on broad groups of soils, more so in terms of recreational capability (Soils of the Tulameen Area, B.C.), to suitability ratings for specific map units for extensive or intensive uses. Such uses include camp areas, picnic areas, playgrounds, paths and trails (Biophysical Resources of Prince Albert National Park; Soils of Yoho National Park, 1977; Soils of the Glenboro Area, 1979; and Soil Resources Smithers - Hazelton Area, 1974). Additional uses such as primitive camping areas, lawns and landscaping were considered in Alberta Provincial Parks, whereas interpretations were deleted for playgrounds for these users. All recreational uses in New Brunswick publications were grouped into two categories, namely athletic fields and outdoor living (Soils of Rogersville - Richibucto Area).

For almost all recreational uses, the properties used for establishing suitability or levels of limitations are generally similar. The range in parameters which have been used include flooding frequency, wetness, depth to water table, drainage, slope, permeability, surface stoniness and coarse fragments, rockiness, and surface soil texture. Regional differences do exist in the use of these properties.

In interpreting soils in Alberta Provincial Parks (Kananaskis Park), wetness or soil drainage class and depth to water table were always combined, as were the properties of surface stoniness and coarse fragments. In fact, because of severe surface stoniness problems, provincial parks personnel requested that this factor be ignored in future ratings for recreational use. In the most recent reports, the approaches used in Alberta and Manitoba are virtually identical. New Brunswick publications tend to treat parameters such as depth to water table, drainage, flooding, surface stoniness and coarse fragments separately.

In terms of interpretive ratings, both degree of limitations and suitabilities for selected uses have been given. The problem sometimes encountered when using guidelines for assessing degree of limitation or suitabilities is that ratings for many soils could be severe or unsuitable due to a single factor such as stoniness. In the style of interpretive tables used in the Notikewin or Kananaskis reports (Figure 1), many more limitations are shown without actually giving a single rating of slight, moderate or severe.

Types of Interpretive Information

In many publications separate chapters (sections) are presented on engineering and related uses, and recreational uses. In some of these, explanations have been given on matters such as engineering - pedological concepts, assumptions in the use of the information, and limitations or constraints to use. Definitions of suitability/limitation classes and subclass limiting factors also are given. In the more recent reports, guides for assessing soil suitability or degree of limitation for the various uses are presented. Information on these topics is very important as they provide the basis for proper use of the interpretive data.

In some cases the soils are classified into engineering groups which explain in narrative form the soil map units included in the group, their soil and landscape characteristics which are important for the uses proposed, and the limitations or hazards to be overcome if certain uses are contemplated.

The final product in the interpretive section is the tabular data evaluating all soils according to their suitability or degree of limitation for selected uses and identifying the major restrictive features which are responsible for their rating.

C. Disturbed Lands[1]

Considerably more work has been done relative to interpretations of disturbed soils in the United States than in Canada. Most of the literature involves mining and mine spoils. This could be due, in part, to the fact that in most instances mining involves larger areas or more drastic disturbance than other activities such as the laying of pipelines, etc. However, soil parameters and interpretations relative to mining are also somewhat applicable to pipelines, quarries, etc.

A wide range of soil properties have been identified, (Table 1) for characterizing soils occurring after mining (NCSS 1978). This table represents a compilation of most of the soil properties that could be considered for a particular area of disturbance. Although this list was prepared in a U.S. context, most or all of the properties listed could be adopted for Canadian use.

Most of the guidelines or suitability ratings use the categories good, fair, poor and unsuitable or a number system. The good, fair, poor category system does have some shortcomings (NCSS 1978). For example, in some areas of disturbance all possible soils could rate as poor. Therefore one must devise a means of selecting the best available of the poor material. On the other hand, adverse soil properties can in many instances be economically eliminated through the use of soil amendments.

[1] Information in this section has been prepared by Mr. Terry Macyk, Research Officer, Alberta Research Council, Soils Department, Edmonton, Alberta.

The USDA (1971) has developed a soil potential index which may be applied to rating the reclamation potential of minesoils. For example:

$$\text{Soil potential index (SPI)} = P - Ct - Cl$$

where:

P = Index of performance or yield of regionally important soils before mining.

Ct = Index of relative treatment costs to overcome limitations. These may include gypsum application, supplemental irrigation or fertilization, or erosion control.

Cl = Index of relative costs of continuing limitations. These may include maintenance, fertilization or irrigation; reseeding; or excessive erosion.

Other approaches in the U.S. have placed minesoils into land capability classes for dryland agricultural uses (Schafer, 1979).

Most work in Canada on interpretations for disturbed lands has been in Alberta and British Columbia, however, little mapping of disturbed soils or sites has occurred. Most map units relative to disturbed soils are designated as DML (Disturbed Mined Land), DUL (Disturbed Urban Land) or GP (Gravel Pit), etc. The reason for this is that the disturbed areas are generally small in relation to the total area involved in a mapping project. Also, making unit separations would be difficult since our classification system does not recognize disturbed soils.

Rather than actual mapping of disturbed areas of land, soils people have been more concerned with finding suitable methods to reclaim or rehabilitate these lands. In 1978 the Alberta Soils Advisory Committee established a subcommittee to consider quality criteria in relation to disturbed and contaminated soils.

The areas of activity of the committee which would be of interest to this session include:

a) soil mapping and sampling for baseline information
b) post disturbance mapping and sampling activities
c) criteria for evaluating the suitability of soil materials for revegetation of disturbed lands.

In the area of soil mapping and sampling, such parameters as scale of mapping, frequency of investigation, sampling frequency and depth of sampling are dealt with. More specifically, in the area of post disturbance mapping and sampling, separate guidelines will be established for orphan or derelict lands and for disturbed areas where some degree of materials handling was employed.

In attempting to establish criteria for evaluating soils it became obvious that all criteria do not apply in all areas of the province. Therefore, the province was divided into three distinct regions including the Plains, Eastern Slopes and the Northern Forested Regions. Each of these regions has major problems that may have to be overcome. For example, in the Plains region the presence of salts in the soils and overburden provide a challenge. In the Eastern Slopes the topography, climate and presence of shallow soils may be limiting factors. The soil properties that will be involved in the rating system include most of those which are present in Table 1.

The rating system proposed to define degree of suitability is as follows:

Good - none to slight soil limitations that affect use as a plant growth medium.

Fair - moderate soil limitations that affect use and need to be recognized but can be overcome by proper planning and good management.

Poor - severe soil limitations that make use questionable. Does not mean the soil cannot be used, but rather that careful planning and very good management are required. In many cases it may not be economically feasible to correct the limitations.

Unsuitable - Chemical or physical properties of the soil are so severe that reclamation requirements would not be economically feasible or in some cases possible.

Details of the report cannot be provided at this time until acceptance is granted by the Alberta Soils Advisory Committee.

User Reaction to Interpretations

Few studies have been done to determine whether soil survey interpretations are meeting users' needs and preferences. As a consequence the pedologist, to a large extent, is left to judge the utility of his product from ad hoc responses from users.

A study was conducted in Ontario to determine the use made of soil survey reports by extension, soils and crops and engineering specialists (McKnight, 1979). In answering a question on engineering interpretations in soil survey reports, 88 percent of the agricultural and drainage engineers thought that the inclusion of soil engineering properties in reports was extremely or moderately important. These users rated "soil waste disposal properties", "soil engineering properties", and "soil drainage" as the most important of 13 information categories. When the total group were polled, including engineers and non-engineers, only 8 percent expressed interest in the production of interpretive maps. This minority group also thought it needed the most help in understanding soil survey information.

A small group of engineers who were polled on this question were unanimous in their opinion that engineering interpretations should be included in soil survey reports. They also expressed a strong belief that the interpretations should reflect local or regional standards rather than national ones, e.g. guidelines for assessing the suitability for reservoirs and sewage lagoons should satisfy the conditions of provincial environmental standards. There also is general agreement amongst this group of users that professional engineers should be involved in the interpretation process.

The need for more information on soil conditions below the usual pedological control section was identified by engineering users as being a deficiency in soil survey reports. For uses such as septic tank disposal fields, specifications require information on water table levels and permeability to a depth of at least 6 feet. For interpretations on suitability for foundations, frost susceptibility of the soil materials to a similar depth is a necessity.

There appears to be divided opinions on the question "upon what should the interpretations be based". Some favoured a landscape approach while others preferred more site specific information based on representative pedons of soil series.

With respect to usefulness of recreational interpretations, most use of this type of information has been by Parks planners.

Parks Canada has supported considerable inventory work in Alberta (Banff, Jasper and Yoho National Parks), Saskatchewan (Prince Albert National Park) and Ontario (Pukaskwa National Park), however, with the exception of Prince Albert N. P., contracts have not included any requirement for development of interpretations. In general they have recognized the usefulness of resource inventories as a basis for management decisions. However, it is speculated that possibly the inventories are not as useful as they should be, because they require more expertise for interpretations than is currently available within Parks Canada.

Provincial Parks personnel in Alberta have requested that interpretations be made for primitive camping areas, fully serviced campgrounds, picnic areas, paths, trails and lawns and landscaping. It would seem that the interpretations are meeting their needs and are used for planning purposes. Difficulties in the use of the information most often result from a lack of knowledge about soils. Also, adequate detail is sometimes lacking on the soil maps.

It is felt that soils people have not met user needs in terms of interpretations for disturbed soils. However, this situation is changing and will change as more information is obtained. Experience in Alberta is that users have applied the information relative to disturbed soils that has been provided thus far. There is a great need in this area and it is felt that soils people will have satisfied some of this need within the next few years.

Summary and Recommendations

There does appear to be justification for standardization of soil interpretations, to some degree, in Canada. Procedures which could be implemented to achieve a greater degree of standardization than at present are as follows:

1. Interpretive classes should be expressed in terms of limitations for use, rather than suitabilities. "Limitations" tend to give more emphasis to soils, without any recommendations as to "land use". On the other hand, if the factors are listed as suitabilities, the user may assume that all soils are suitable for whatever uses desired. Standardized conventions should be used as much as possible to denote the class (level or degree of limitation) and subclass (kind of limitation). Three or four classes of limitations could be used (perhaps four on detailed mapping and three on less detailed maps), such as none to slight, moderate, severe and very severe. Alphabetic symbols (capitals) should be used for denoting degree of limitations, e.g. N, M, S, VS. The major limiting factor(s) should be identified by using subclass symbols, preferably connotative letters. Interpretive classification guidelines should be given in soil survey publications so that the user is aware of the parameters which are used and their limits for the various interpretive classes. A user who is not familiar with the inputs, assumptions, and the definitions pertinent to the ratings may be reluctant to use them.

2. Complete standardization of interpretive classification guidelines on a national scale does not seem desirable or feasible, but could be achieved within adjoining provinces or within a region. For many uses, the limiting soil or landscape properties reflect regional climatic or geologic conditions, and may not be appropriate criteria in another region. Also, guidelines must be flexible enough to reflect local or regional standards for soil properties, e.g. Ministry of Transportation and Communication aggregate standards for granular materials, or Ministry of Environment permeability standards for trench, reservoir or backfill material for pollution abatement.

3. Guidelines for interpretive classification of soils, and formats for presentation of information should be developed in consultation with the user. This should ensure that user needs are being met and also should improve its credibility among users. Probable interpretations should be considered at the time inventories are

being planned. The map units used in the survey then can be designed so that they can be readily interpreted.

4. Interpretations are being made by applying information from a pedon or several pedons, to a landscape or mapping unit through knowledge of both soil-landscape relationships and associated land characteristics such as slope, stoniness, etc. This process is considered to be interpreting map units rather than pedons. Only when concerned with site specific problems without regard to appreciable areal extent can pedons be interpreted per se.

   When mapping units are comprised of highly contrasting soils, each with differing interpretations for a given land use, the interpretive rating could be handled in one of two ways:
   a) Interpret the complex map unit as an entity giving a rating for the entire landscape.
   b) Interpret each landscape segment separately and leave it to the user to determine to what portion of the total landscape the interpretation applies. Map unit descriptions should enable the user to make this decision.

   It is important that the user recognizes this difference and is aware of which situation is relevant to the map he is using.

   Constraints of the soil survey and map units should be clearly outlined for the user so that he will be encouraged to use the information for preliminary design or planning purposes, and as a basis for carrying out more detailed studies.

5. The computer mapping capability of CanSIS should be utilized for the generation of interpretive maps for users. A "package" of maps comprised of the most common interpretive uses could be prepared for a region on a transparent base suitable for the preparation of ozalid print copies. These should be available for purchase by users on a request basis through provincial or regional distribution centres.

   An extended legend format could be developed which associates specific properties with given map units. The computer then could be instructed to select appropriate map units by searching for the desired properties and then print a map showing "limitations for xxx" or "suitability for xxx". Derivative or interpretive maps also could be prepared for single or combined properties identified in this extended legend.

Acknowledgement

The Chairman of the Working Group on Non-Agronomic Interpretations is grateful for the assistance provided by the following in the preparation of this report: G. Coen, G. Greenlee, T. Macyk, W. Michalyna, G. Padbury, E.W. Presant, R. Wells.

Table 1: List of Properties Important for Minesoil Classification, Interpretation and Characterization

Texture
Slope
Erodibility
Stoniness
Coarse fragments
Fragment rock type
Base saturation
Organic matter
Rock hardness
Fragment size
Toxic trace elements
Shrink-swell
Drainage
Fertility
Available water
EC
Permeability
Land use
Depth
Aggregation
Vegetation
Color, mottling
Fabric
Temperature
SAR
Saturation water %
$CaSO_4$
N, P, K

FIG 1: Soil Limitations for Fully Serviced Campgrounds[1]

Map Symbol[2]	Degree of Limitation			
	None to Slight	Moderate	Severe	Unsuitable
1/c0 1/d0		Flood Slip		
2/c0 2/d0		Slip Clay Sl Perm		
2/e0		Slope Slip Sl Perm		
3/c1 3/d1		Clay Sl Perm		
3/f1		Clay Sl Perm	Slope	
4/g2 4/H2		Slip		Slope Er
5/b0		Wet Flood Slip		
6/c0		Flood		

Map Symbol[2]	Degree of Limitation			
	None to Slight	Moderate	Severe	Unsuitable
7/c2	Nil			
8/c0		Sandy Er		
8/e0		Slope Sandy Er		
8/f0		Sandy Er	Slope	
9/d0	Nil			
10/b0			Wet	
TM/a0			Org Wet	

[1] Surface stoniness was not considered in determining these ratings.

[2] For explanation, see section entitled GENERAL DISCUSSION OF SOIL MAP

Abbreviations:

BR - Shallow depth to bedrock
Clay - High clay content
Er - Erosion hazard
Flood - Flooding hazard (overflow)
Org - Organic soil
Org Surf - Organic surface layer >15 cm(6") thick
Sandy - Sandy surface texture
Slip - Slippery or sticky when wet
Slope - Excessive slope
Sl Perm - Slow permeability
Solz - Solonetzic soil
Wet - Seasonally high groundwater table or surface ponding

References

Biophysical Resource Inventory of the Prince Albert National Park, Saskatchewan. 1978. Saskatchewan Institute of Pedology, Publication S185.

CSSC 1973. Report of the Subcommittee on Soil Interpretations. Proceedings of the Ninth Meeting of the Canada Soil Survey Committee. Edited by J.H. Day.

McKnight, M. 1979. Use of Ontario Soil Survey Reports by Selected User Groups. MSc. Thesis, University of Guelph.

Montgomery, P.H. and F.C. Edminster. 1966. Use of Soil Surveys in Planning for Recreation. In Soil Surveys and Land Use Planning, Publ. by Soil Science Society of America and American Society of Agronomy.

NCSS 1978. Committee 5 report on soils and soil materials disturbed by mining. Proc. of the Western Regional Technical Work Planning Conference of the National Cooperative Soil Survey. San Diego, Calif. Feb. 13-17, 1978.

NSSC 1968. Report of the Subcommittee on Soil Survey Interpretations for Engineering Purposes. Proceedings of the Seventh Meeting of the National Soil Survey Committee of Canada.

Schafer, W.M. 1979. Guides for Estimating Cover-Soil Quality and Mine Soil Capability for Use in Coal Stripmine Reclamation in the Western United States. Reclamation Review, Vol. 2, pp. 67-74.

Soils of the Brandon Region Study Area. 1976. Canada - Manitoba Soil Survey Report No. 30.

Soils of the Glenboro Study Area. 1979. Canada - Manitoba Soil Survey Report No. D-24.

Soils of the Halton County. 1971. Ontario Soil Survey Report No. 43.

Soils of the Kananaskis Lakes. Alberta Soil Survey.

Soils of the Northumberland County. 1974. Ontario Soil Survey Report No. 42.

Soils of Northern Victoria County. 1976. New Brunswick Soil Survey.

Soils of the Rogersville - Richibucto Area. (In Press). New Brunswick Soil Survey.

Soils of the Saskatoon Map Area 73B, Saskatchewan. Saskatchewan Institute of Pedology Publication S4.

Soil Resources Smithers - Hazelton Area, B.C. 1972. Soil Survey Division, British Columbia Dept. of Agriculture, Kelowna, British Columbia. Reprinted by E.L.U.C. Secretariat 1974.

Soils of the Tulameen Area, B.C. 1974. Report No. 13, British Columbia Soil Survey. Research Branch, Agriculture Canada.

Soils of Waterloo County. 1971. Ontario Soil Survey Report No. 44.

Soil Survey of Yoho National Park Canada. 1977. Alberta Soil Survey Report No. 37.

USDA 1971. Suitability Ratings of Soils as Sources of Topsoil. In Guide for Interpreting Engineering Uses of Soils. U.S. Government Printing Office, Washington, D.C.

Soil Survey Interpretation For Forestry In Canada,

A State-Of-The-Art Review

H. H. Krause[1]

Preparing for this paper I have reviewed soil survey reports from all provinces except Newfoundland. I have found formal interpretations of soil survey information for forestry in a number of reports published since the mid-sixties in the western provinces. In the following text I will review methods and criteria applied to soil-forestry interpretations in the Canadian reports, comment on the merits and limitations of previous approaches, and indicate some future needs.

Methods and Criteria for Forestry Interpretations in Canadian Reports.

Soils have been rated for forestry with respect to (1) potential productivity or land capability, (2) tree species suitability, (3) requirements for stand regeneration, (4) erosion hazard and (5) windthrown hazard. A sixth criterion, trafficability, is included in the guidelines for soil-woodland interpretations of the U.S.D.A. Conservation Service (Annon., 1967), but has not been used in Canadian reports.

Potential Productivity.

The Canadian Soil survey reports have placed major emphasis on soil productivity in their forestry interpretations. It has been customary to use the mean annual increment of merchantable volume in forests native to the area as estimator of productivity. However, forestry interpretors have applied different forms of the mean annual increment. While most reports have used the mean annual increment of the entire rotation, Dumanski et al (1972) applied a periodic mean annual increment, i.e. the average annual growth over a 5 or 10-year period usually at an advanced stage of stand development. Such differences in method will undoubtedly complicate comparisons of soils from different mapping areas.

Forest stands, more correctly the soils which support them, were arranged in productivity classes (Smith et al, 1964), capability classes (Smith et al, 1967, 1975; Lord and Green, 1974) or soil association capability groups (Dumanski et al, 1972). Here also differences are encountered in methods used by the various soil survey teams, further complicating regional comparisons.

In two cases (Smith et al, 1964, Dumanski et al, 1972), productivity classes and soil association capability groups, respectively, were defined on the basis of local growth data. In other cases (Smith et al, 1967, 75; Lord and Green, 1974) land capability classes were adopted as previously defined for national use in the Canada Land Inventory (McCormack, 1970).

[1]H.H. Krause, Department of Forest Resources, University of New Brunswick, Fredericton, N.B.

Following the general principles of land capability classification, all survey reports with forestry interpretations have identified limiting factors to forest growth and management. The forms of limitations recognized for this purpose were similar to or identical with those defined for the Canada Land Inventory. They include: Exposure, excess water, water shortage, shallow rooting, stoniness, excess relief, lack of fertility and toxicity.

Dumanski et al, (1972) referred to this type of limitations as land management factors. They further subdivided the soil association capability groups into soil series performance groups on the basis of soil chemical and morphological characteristics. Association productivity group, soil series performance group and land management factor were then combined to form a forest land capability index. Soil land clusters with the same index were presumed to be alike in terms of performance and use. Such soil land clusters were shown on special forest productivity rating maps accompanying the regular soil maps. These land units are comparable to woodlands suitability groups as defined by the U.S.D.A. Soil Conservation Service (Annon., 1967). Although soil productivity ratings were based only on the performance of one species, it is my impression that the Hinton-Edson survey of Alberta has significantly advanced Canadian soil-forestry interpretation.

The soil survey unit of Agriculture Canada in British Columbia has recently released a set of maps for the Mill-Woodfibre Creek area, presumably a pilot project for soil survey for forestry. These maps depict various land, soil and vegetation characteristics as well as inferred forestry and environment related features. The set of maps (Moon, 1980) does not include a soil capability rating by conventional methods. Presumably, a vegetation map, with types identified by indicator species, is to serve this purpose. This approach may offer an opportunity for integrating soil survey data with presently used methods of land classification by forestry administrations in that Province. However, we must remind ourselves that phytosociological methods have their limitations.

Species Suitability

This relates to an important question in forestry. Choice of species for artificial stand regeneration is dependent on more than soil factors. Besides the biological compatibility of species and site, economic factors, technological development and susceptibility to insect pest and disease must be given consideration. A forest manager must have, therefore, various options available to him. Ideally, a survey report should indicate a number of species or species combinations for a given group of soils, ranked according to potential productivity on this soil. This may have been accomplished in those reports (Smith et al, 1964, 67, 74) in which productivity or capability classes were listed for the most common species with each mapping unit.

The Mill-Woodfibre Creek project has generated a map of recommended tree species composition (Moon, 1980). It seems that the recommendations are based largely on the composition of the corresponding climax forest. I expect that a simpler system will be required as it may prove to be difficult for economic and technical reasons to replace some of these species to the same site after cutting.

Soils and Forest Regeneration

This is a topic rapidly gaining importance with the current intensification of forest management. Several Canadian soil survey reports have addressed themselves to soil-related regeneration problems. Dumanski et al. (1972) attempted to rate potential mortality of planted seedlings on the basis of soil chemical and physical conditions. Mortality of planted or naturally occurring seedling is also a criterion in the woodlands interpretation of the U.S.D.A. Soil Conservation Service.

I would be hesitant to assign a high value to this type of information. Seedling mortality and, equally important, planting check are difficult to predict as both may be due to the interaction of a multitude of factors, many of them not soil related. In fact there is a danger that a good rating based on soil conditions only could produce a false feeling of security. More information than given by potential seedling mortality is required in the planning process of forest regeneration.

Forestry interpretations contained in an earlier Manitoba report (Smith et al. 1964) indicated the type of site preparation that is required on extreme soils to assure regeneration success. Soil-woodland interpretations of the U.S.D.A. Soil Conservation Service have also spelled out minimal requirements for site preparation on a given soil. I believe this to be a promising avenue that we can follow in soil-forestry interpretations. However, lack of experience and a scarcity of research data may present difficulties in many parts of Canada.

Soil Erosion Hazard

Rating of forest soils with respect to erosion hazard has been based mainly on slope, soil texture and permeability, structural stability and rainfall intensity. Providing the forest manager with a soil erosion hazard rating is especially important today as tree harvesting and silvicultural operations have become mechanized to a high degree, and as a conscientious public is concerned about losses of sport fish habitats and salmon spawning grounds due to stream sedimentation.

In the Mill-Woodfibre Creek project of British Columbia, a generalized soil map was produced. Soil units were defined according to the nature of parent materials, drainage class and texture. Presumably the same soil information together with information on slope and vegetation was used to produce an additional map with polygons indicating the potential of the land to yield sediment.

Windthrow Hazard

Ratings of windthrow hazard take into consideration those soil features that are indicative to superficial rooting. Such features are shallow bedrock or water tables, hardpans, fragipans and compacted substrates under a shallow solum as in the perhumid regions of Atlantic Canada. High windthrow hazard ratings may alert the management forester to be extra careful in planning harvesting operations. He must avoid opening up a forest at a location facing the direction of prevailing winds.

Windthrow hazard ratings will probably be given less consideration in species selection for artificial regeneration. Productivity, economic value and resistence to insect pest and disease are overriding criteria. It would prove difficult to solve problems associated with shallow soils simply by species selection. Trees that develop a tap or heart root under favourable soil conditions most often change to superficial rooting on soils with mechanical impedance or poor aeration.

Soil Trafficability

This term refers to off-road transportation. In question are limitations to the use of heavy equipment. The U.S.D.A. Soil Conservation Service recognizes three degrees of equipment limitations on the basis of slope, surface stoniness and rockiness, prolonged periods of wetness, soil plasticity and several other factors.

Trafficability has not received attention in forestry interpretations of Canadian Soil Survey reports. However, the Wood-Millfibre Creek project in British Columbia has generated maps that interrelate soil and potential for environmental hazards following road construction. Environmental hazards are sediment flow, mass movement and disruption of the integrity of drainage systems. This should turn out to be valuable information as stricter environmental regulations are adopted and as intensified forest management is resulting in increased road building activity.

How Useful Are Soil-Forestry Interpretations

The information presented so far indicates that there has been a reasonable level of awareness in the Canadian Soil Survey for the need of forestry interpretations. However, it is also clear that individual soil survey units were left to take the initiative in developing and testing methods and criteria for forestry interpretations. As a result interpretations from different provinces vary to a considerable degree. This may have had its advantages. But the chances are that soil-forestry interpretation of a uniformly high calibre would have been found in a larger number of survey reports had national guidelines been in existence.

How useful are soil interpretations to management foresters? No survey among foresters has been conducted to provide the answer. Casual observations have shown that some industrial foresters in Alberta rely heavily on silvicultural planning in recently published soil maps and survey reports, but that principal managers of forests in other provinces will not use soil survey reports even if these reports contain soil-forestry interpretations.

It should be realized that the best forestry interpretation can only be as good as soil maps and biological information on forest growth are accurate or as the level of our understanding of soil-forest growth relationships. Unfortunately, weaknesses exist in all three areas. Most soil maps are printed at the small scale of one inch to two miles. In major portions of the country, foresters are not in possession of reliable site index curves or yield tables. This together with the fact that we are dealing largely with natural forests of diverse origin makes the evaluation of potential productivity difficult.

Furthermore, much is still to be learned about basic soil forest growth relationships under Canadian conditions. At present, research in this general area is not extensive.

Despite the above difficulties, I believe that every soils map contains at least some potentially useful information for foresters and that soil-forestry interpretations are an essential activity. Provincial governments have or are currently formulating new forest policies which call for intensified management and increased investment into forest lands. Soil survey information will be most valuable where tree planting is to become the principal form of forest regeneration. Soil survey information can be useful in the choice of management practices that endangers least environmental quality.

The Next Step

It is realized that by conventional methods and with presently available resources, it will not be possible to cover, in the near future, suitable portions of the extensive Canadian forest lands that are in need of survey. At least one province is now arranging for special forestry soil surveys by professional pedologists in areas of high priority. Such surveys would probably employ a simplified set of criteria. The general soil map of the Mill-Woodfibre Creek area in British Columbia may serve as one example of a special forestry soil survey.

With these developments in mind, establishment of a Forestry interpretations working group of the Expert Committee on Soil Survey appears to be an urgent task. The mandate of the working group should be:

(1) To develop guidelines for the interpretation of soil information for forestry from conventional surveys,

(2) to establish methods and criteria for survey and evaluation of forest lands which cannot be covered by conventional surveys in the near future, and

(3) to draw up a priority list of research that could aid soil-forestry interpretations.

National guidelines for forestry interpretation, although important, should be developed with enough flexibility to allow integration of current soil survey data with provincial systems of forest land evaluation where in existence. Excessive rigidity could become a barrier to the efficient use of soil survey information.

Who should be represented in the working group on Soil Survey Interpretation for Forestry? Guidelines developed for woodlands interpretation by the U.S.D.A. Soil Conservation Service state that accurate data are essential and that research information is important. The U.S.D.A. guidelines further recommend to take advantage of the experienced judgement from foresters and soil scientists. It would be most appropriate therefore that a new forestry working group be composed of delegates from various soil survey units, of foresters experienced in management and familiar with the requirements in long-range planning, and of forest soils specialists. Group members with a forestry background may be recruited from provincial governments, industries, universities and the Canadian Forestry Service.

References

Anon. 1967. Guide for developing and summarizing soil-woodland interpretations. Soils Memorandum - 26 (Revision 2), U.S.D.A. Soil Conservation Service,

Dumanski, J., T.M. Macyk, C.F. Veauvy and J.D. Lindsay. 1972. Soil Survey and land evaluation of the Hinton-Edson area, Alberta. Alberta Institute of Pedology Rep. No. S-72-31 (The University of Alberta Bulletin No. SS-14) Edmonton, Alberta.

Lord, T.M. and A.J. Green. 1974. Soils of the Tulameen area of British Columbia. British Columbia Soil Survey. Report No. 13. Canada Department of Agriculture, Research Branch, Ottawa, Ont.

McCormack, R.J. 1970. The Canada land inventory, land capability classification for forestry. Report No. 4 - 1967, Sec. edition - 1970. Canada Department of Regional Exonomic Expansion, Ottawa, Ont.

Moon, D.E. 1980. Maps of soil, vegetation and related features for the Mill-Woodfibre Creeks area of British Columbia, Canada Department of Agriculture, Soil Survey Unit, Vancouver, B.C.

Smith, R.E., W.A. Ehrlich, J.S. Jameson and J.H. Cayford. 1964. Soil Survey of the southeastern map sheet area. Soils Report No. 14. Manitoba Department of Agriculture and Conservation, Winnipeg, Man., and Canada Department of Agriculture, Ottawa, Ont.

Smith, R.E., W.A. Ehrlich and S.C. Zoltai. 1967. Soils of the Lac du Bonnet area. Soils Report No. 15. Manitoba Department of Agriculture, Winnipeg, Man., and Canada Department of Agriculture, Ottawa, Ont.

Smith, R.E., C. Tarnocai and G.F. Mills. 1975. Soils of the Red Rose-Washow Bay area. Soils Report No. 19. Manitoba Department of Agriculture, Winnipeg, Man., and Canada Department of Agriculture, Ottawa, Ont.

Quantification Of Soil Erosion Interpretations For Soil Resource Inventories

G.J. Wall[1] and W.T. Dickinson[2]

Erosion may be defined in a general sense as the detachment and movement of soil by the agents water, wind, ice, or gravity. Since diverse processes are associated with soil movement initiated by each of the preceding erosion agents, it is not possible to make a single all-encompassing rating for soil erosion. Instead, soils are usually rated for erosion susceptibility to the detachment and transporting agents of water, wind, ice or gravity independently.

Historically, there have been few attempts in soil resource inventory reports to qualitatively assess water and wind erosion problems. Recently, however, pedologists have been attempting to quantify soil erosion susceptibility, especially soil loss by water erosion. Wang and Rees (1981, In Press) have used slope, permeability, and textural properties to place soil series into slight, moderate, and severe classes of water erosion potential. Coen and Holland (1976) used soil erodibility indices and slope to assess low, moderate, and high susceptibility to water erosion. Further, soil erosion potential by gravitational agents (rotational slumping) was indicated by a system of footnoting.

Soil erosion by wind, ice or gravity occur all across Canada but often only in localized areas. On the other hand, rainfall and run-off induced soil erosion is common to much of the Canadian land base. Soil erosion by rainfall-runoff is usually considered to stem from: raindrop splash; and sheet, rill, gully, and channel bank erosion. Rainfall and runoff induced sheet and rill erosion have been found to be major causes of topsoil loss from agricultural and similarly disturbed land for much of the non mountainous terrain of North America. Similarly recent studies in the Great Lakes Basin have revealed that sheet and rill erosion from agricultural land is the major source of stream sediments. This dual significance of soil loss from agricultural land (field topsoil loss and streamwater pollution) has only just recently been fully recognized.

The purpose of this paper is to present a methodology for use in soil resource inventories to:

(a) assess rainfall and runoff induced soil erodibility;
(b) determine quantitatively the erosion potential of soil series (textural and slope phases) on the basis of soil erodibility, slope gradient and slope length factors;

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TABLE I - GUIDELINES FOR ESTABLISHING SOIL ERODIBILITY CLASSES

Class	Erosion Hazard	K-Value[1]	Soil Characteristics
1	Negligible	<10	Silt and very fine sand <20%; >4% organic matter; very fine granular structure; rapid permeability.
2	Very Slight	10-20	Silt and very fine sand content >20%; >4% organic matter; fine granular structure; moderate to rapid permeability.
3	Slight	20-30	Silt and very fine sand content >40%; <4% organic matter; medium or coarse granular structure; moderate permeability.
4	Moderate Severe	30-40	Moderately high (>60%) silt and very fine sand content; <3% organic matter; medium or coarse granular structure; slow to moderate permeability.
5	Severe	40-50	High (>80%) silt and very fine sand content; low (<2%) organic matter; blocky, platy or massive structure; slow permeability.
6	Very Severe	>50	Very high (>90%) silt and very fine sand content; low (<1%) organic matter; blocky, platy or massive structure; very slow permeability.

[1]Wischmeier, W.H., C.B. Johnson and B.V. Cross (1971)

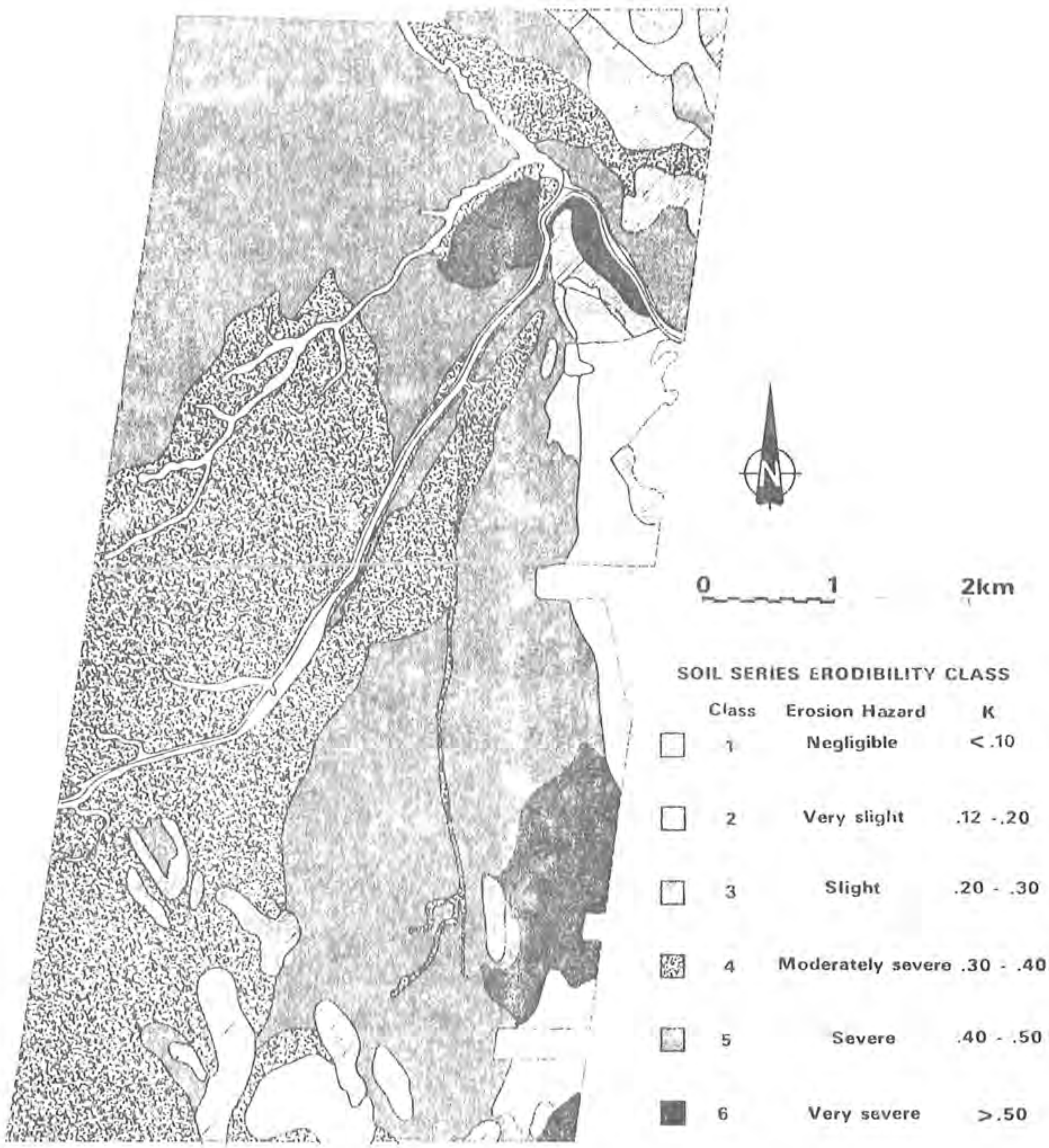


Figure 1. ERODIBILITY CLASS FOR SOIL SERIES
Nepean Township, Carleton County Ontario

(c) establish the effect of soil and slope factors on crop soil loss;
(d) illustrate the utility of CanSIS generated maps for soil erosion interpretations;
(e) illustrate the use of data collected from soil resource inventory to depict sediment sources to streams; and
(f) show how soil map and soil erosion data may be employed in site-specific farm management decisions.

Quantitative relationships between rainfall - runoff induced soil loss and soil erodibility, slope and crop cover parameters as described by Wischmeier and Smith (1978) are used to develop quantitative soil erosion interpretations for use in soil resource inventories.

Soil Erodibility Index

Soil erodibility may be defined as the inherent susceptibility of a soil material to erode when subjected to an erosive agent (water, wind, etc.). The important soil properties influencing erodibility are generally considered to be: texture, structure, organic matter, and chemical composition. Assessment of soil erodibility has been conducted by both actual measurement of soil loss and isolation of certain soil properties as indices of erodibility. Wischmeier et al (1971) have developed a soil erodibility index (K value) based on particle size data, organic matter content, soil structure, and permeability. This erodibility index (K-factor) has been used extensively in the U.S.A. with the universal soil loss equation (Wischmeier and Smith, 1978) and more recently in Canada by Coen and Holland (1976), van Vliet et al (1976), and Wall et al (1979). The K factor is well suited for soil survey use since it can be determined from data obtained routinely by the use of an equation or nomograph (Wischmeier and Smith, 1978).

Table 1 presents guidelines for establishing a six class soil erodibility scheme that has been employed in Ontario. The nomograph solution is used to compute a K value for each soil type that is then assigned to the corresponding erosion hazard class. The erosion hazard class for a soil type can be reported either in tabular form in the soil survey report and/or a single factor soil erodibility interpretive map. Figure 1 illustrates a CanSIS generated map for soil erodibility hazard for a portion of the Ottawa-Carleton map sheet.

Soil Erosion Potential Using Soil Erodibility and Slope Factors

Field research has indicated that two slope parameters, steepness (S) and length (L), affect the rate of soil erosion by water. In plot studies of soil erosion by water, Wischmeier and Smith (1978) found that the combined slope affects of steepness (S) and length (L) on soil loss could be expressed by the following equation:

$$LS = (\lambda/72.6)^{m} \, (65.4 \sin^2 \theta + 4.6 \sin \theta + 0.065)$$

where λ = slope length in feet

θ = angle of slope

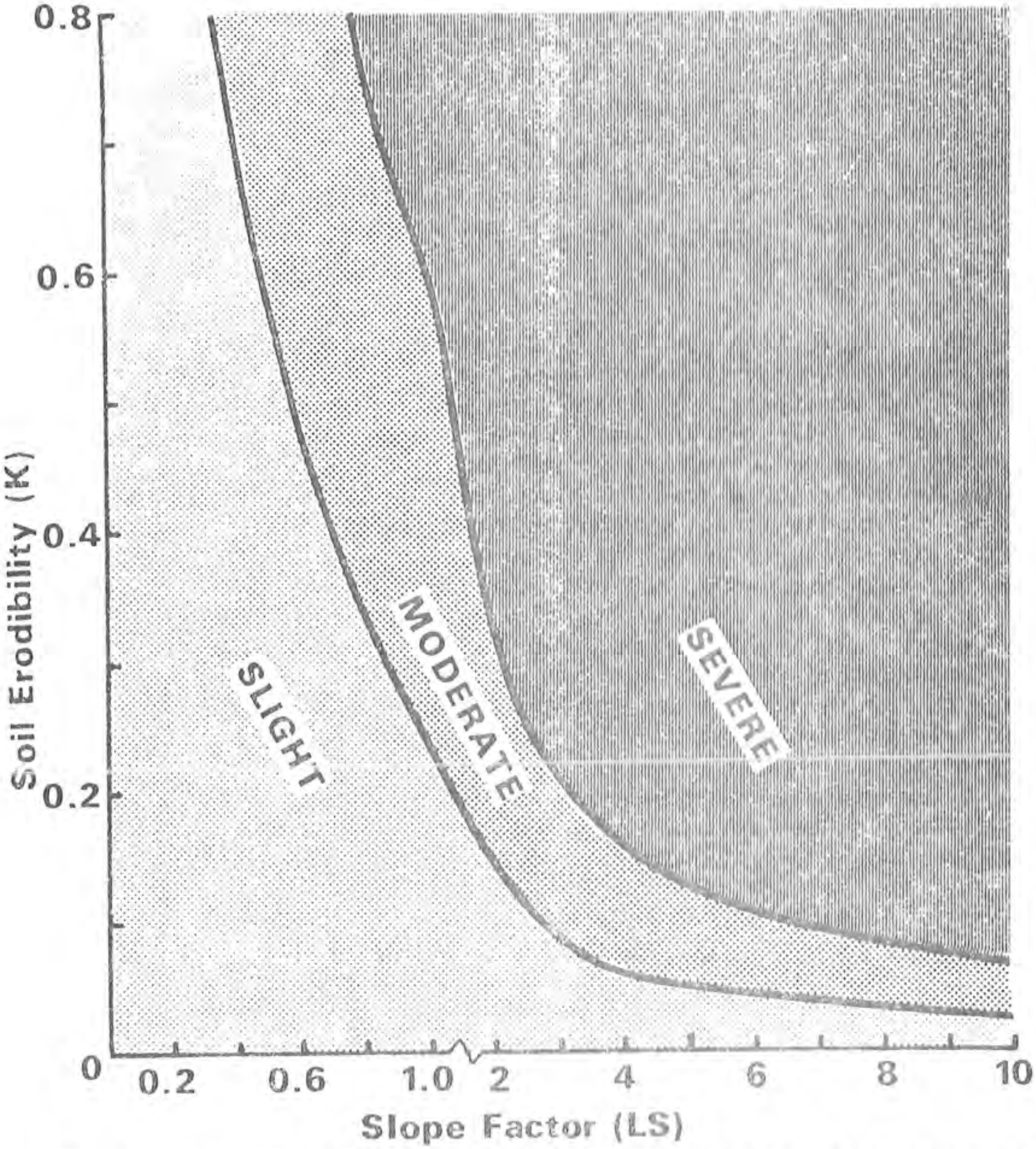


Figure 2. EFFECT OF SOIL ERODIBILITY AND SLOPE FACTORS ON SOIL EROSION POTENTIAL CLASSES FOR AGRICULTURAL LAND

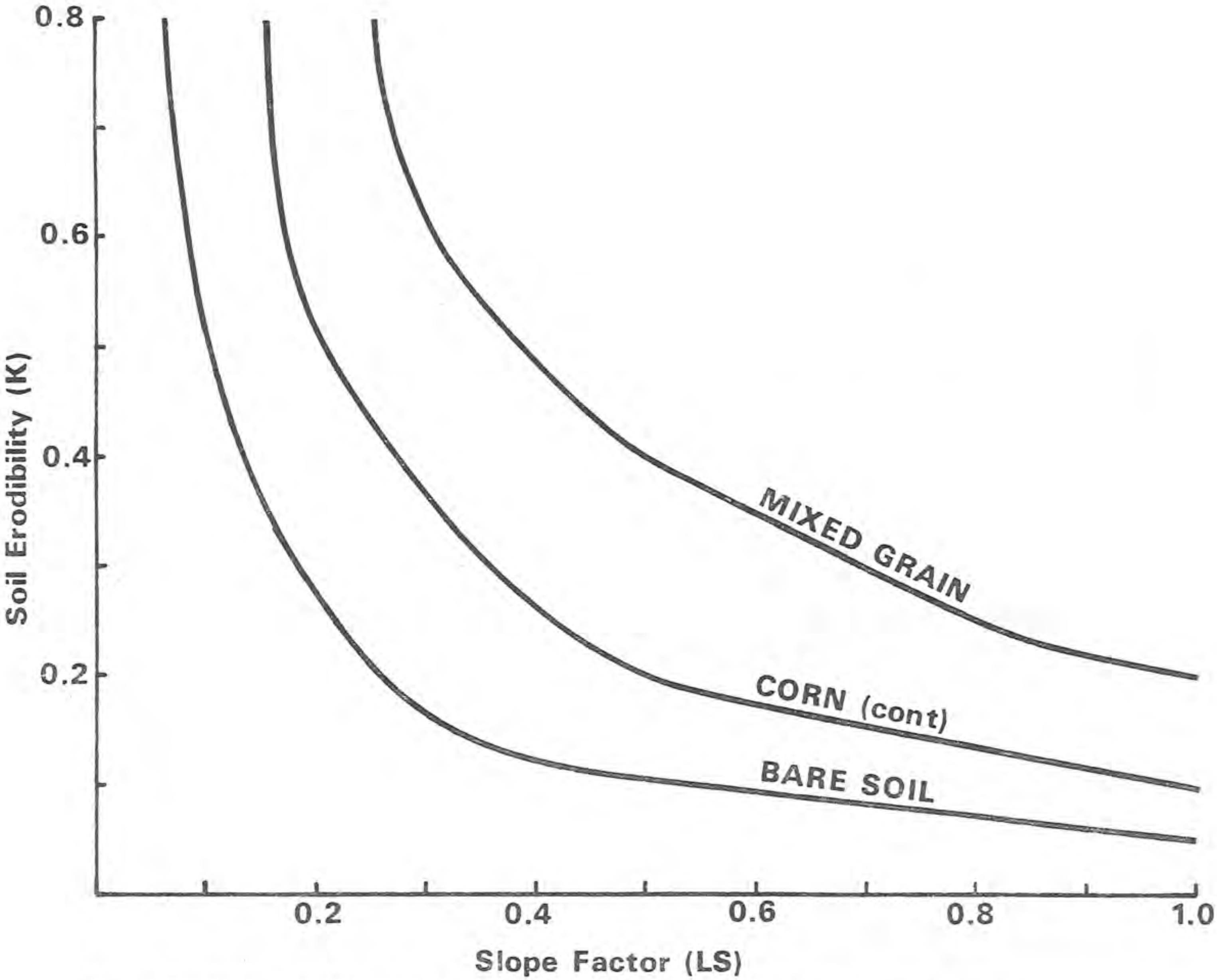


Figure 3. SOIL ERODIBILITY AND SLOPE LIMITS FOR SUSTAINED CROP PRODUCTION

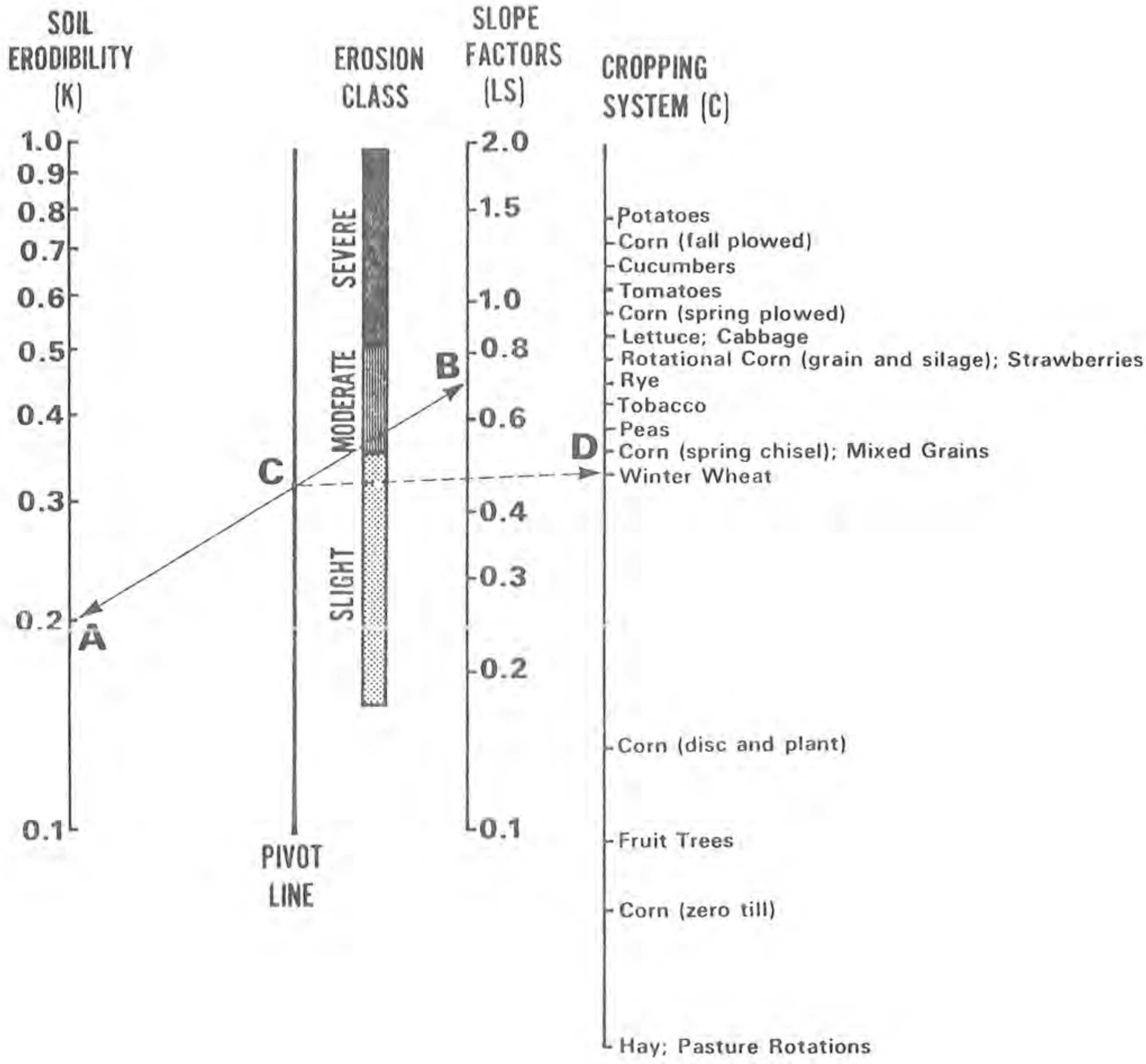


Figure 4. NOMOGRAPH FOR SITE SPECIFIC SELECTION OF CROPS FOR EROSION CONTROL ON GIVEN SOIL AND SLOPE CONDITIONS

$m = 0.5$ if slope is >5%
$m \doteq 0.4$ if slope is 3.5 - 4.5%
$m = 0.3$ if slope is 1 - 3%
$m = 0.2$ if slope is <1%

The author also provided a graphical solution to the preceding equation.

Soil erodibility, slope factors, and vegetative cover are the three dominant factors affecting soil erosion potential. If the vegetative cover factor is held constant, then the slope and erodibility factors can provide insight into the soil erosion potential of a landscape. Figure 2 illustrates the use of soil erodibility and slope factors to assess three soil erosion potential classes for agricultural land.

This procedure is well suited for use in soil resource inventories since the soil erodibility and slope data are available for all mapping units. It may be necessary to generalize on the slope length factor for a given soil series since these data are not currently recorded for each map unit. Each soil type and slope phase could be interpreted in this manner to provide a water erosion potential index. This erosion index could be presented in tabular form in the soil survey report or alternately a single factor map could be generated by CanSIS.

Soil Erosion Limitations to Crop Production

A useful agronomic interpretation for a soil survey report would be to establish slope limits for which a given soil series could be used to grow a given crop on a sustained basis. This obviously could not be done on a map unit basis since land use is not constant for a given map unit. However, a table could be included in the report that would permit the user to establish slope limits for a given soil and crop. Figure 3 illustrates the use of soil erodibility and slope limitations for sustained production of corn and small grains in southwestern Ontario. The crop can be grown on a sustained basis on all slope and soil erodibility combinations that occur below the lines on Figure 3. For soil erodibility and slope conditions above the lines, soil conservation measures could potentially be applied to permit the sustained growth of the crop.

For a given region, soil erodibility, slope and cropping system data can be prepared in nomograph form to assist agricultural extension personnel in making site specific crop-soil erosion recommendations. Figure 4 illustrates such a nomograph for southwestern Ontario. In the example plotted, a soil series with an erodibility of 0.20 and slope factor of 0.7 would result in a slight erosion potential. The use of such a soil erosion nomograph in soil survey reports would help to stimulate the use of soil surveys in agricultural communities, especially at the farm level.

Soil Resource Inventories for Prediction of Field Soil Losses and Fluvial Sedimentation Rates

Recent advances in modern computer techniques and data storage systems have made possible the use of data collected during the course of a soil resource inventory for predicting field soil erosion losses, stream sediment loads, or stream sediment contributing areas. However, to make such interpretations on a qualitative or quantitative basis, it is necessary to establish

Figure 5. POTENTIAL SHEET AND RILL EROSION LOSSES
Nepean Township, Carleton County Ontario

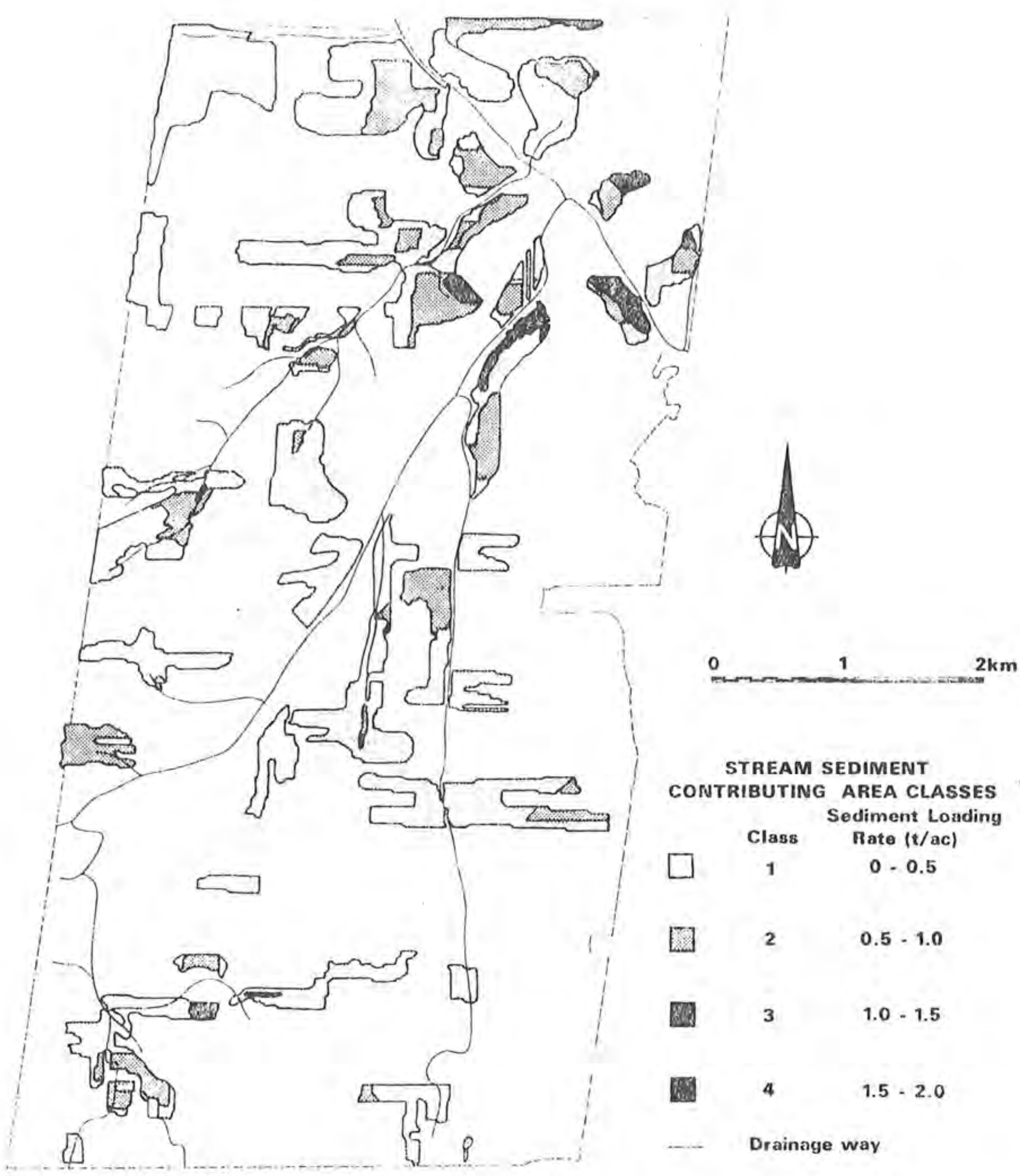


Figure 6. POTENTIAL STREAM SEDIMENT CONTRIBUTING AREAS
Nepean Township, Carleton County Ontario

relationships (e.g. additive, multiplicative) among several of the factors. A demonstration study was initiated to illustrate the utility of soil survey data for some soil erosion interpretations. Parts of the recently published soil and land use maps of Gloucester and Nepean Twp., Carleton Co., Ontario (1:25,000) were selected for study. Initially the possibility of using information from the CanSIS cartographic file was investigated. Even though the CanSIS file contains the necessary information, the data was not available for the project in the form required. As a result, all the data was digitized manually. Digitizing and computer programing was conducted by the company of Collins and Moon Limited, Guelph, Ontario with funds provided by grants from Dr. W.T. Dickinson, School of Engineering, University of Guelph.

The digitized data base was used to generate interpretive soil erosion maps on both a qualitative and quantitative basis. Qualitative erosion potential maps were generated by an overlay technique with a printout of those sites characterized by (a) high soil erosion potential (e.g. $K>0.35$), (b) sloping land (e.g. $S>0.5$) and (c) row crop land use (e.g. corn, soybeans). Maps generated in this fashion clearly illustrate the location of erosion-prone land in the map area.

Erosion potential maps can be made quantitative by assigning to the stored soil, land use, and slope parameters the appropriate numerical values employed in the solution of the universal soil loss equation (Wischmeier and Smith, 1978). Multiplication of these values with the appropriate rainfall factor yields gross field by field soil loss values in tons/ac./yr. Figure 5 provides an illustration of a map generated in this fashion, plotting three soil erosion classes (0-1, 1-2, 2-3 tons/ac./yr.).

Recent studies have shown that while soil erosion may be active on the entire landscape only a small proportion of a given agricultural landscape (usually <25%) actually contributes sediments to streams. Field observation of soil and surface drainage conditions, particularly in the spring of the year, is one method of identifying the location of these active sediment contributing areas. Figure 6 shows the location of stream sediment contributing areas in part of Nepean Twp., Ottawa, Ontario for which stream sediment delivery classes have been established. Research is currently in progress whereby a detailed soil drainage network is added to the existing digitized data set to generate the spatial location of the stream sediment contributing areas without extensive field observation. The authors feel that the map of stream sediment source areas will be of great use to the agricultural community, conservation and watershed management authorities and planners. The use of the stream sediment contributing area maps in conjunction with soil erosion interpretation data discussed earlier should satisfy the majority of needs for soil erosion interpretation.

Summary

Quantitative relationships between soil loss and soil erodibility, slope factors and land use as developed in the universal soil loss equation (Wischmeier and Smith, 1978) provide a means whereby routinely collected soil survey data may be used for making rainfall-induced soil erosion assessment.

A relative measure of soil erodibility for all soil types can be obtained by calculating K-values and assigning soil erodibility classes. Potential soil erosion classes (e.g. high, medium, low) for all soil map units can be computed by combining soil erodibility data (K-factor) with slope parameters (LS). These soil erosion interpretations can be reported either in tabular form in the text or as single factor maps generated through CanSIS.

Erosional limitations of soil series for crop production on regional or site specific basis can be made with appropriate figures and nomographs using soil erodibility, slope, and crop factors. For example, critical slope limits can be determined for a soil type for which a given crop can be grown on a sustained basis.

Recent advances in modern computer technology and data storage systems have made possible both the qualitative and quantitative assessment of soil erosion potential on a site specific basis. Research is continuing toward the use of the soil survey data base to map stream sediment contributing areas and stream sediment loads.

Bibliography

Coen, G.M. and W.D. Holland. 1976. Soils of the Waterton Lakes National Park, Alberta. Alberta Institute of Pedology S-73-73, Information Report NOR-X-65.

Van Vliet, L.J.P., G.J. Wall and W.T. Dickinson. 1976. The Effects of Agricultural Land Use on Potential Sheet Erosion Losses in Southern Ontario. Can. J. Soil Sci. 56:443-451.

Wall, G.J., W.T. Dickinson and L.J.P. van Vliet. 1979. Agricultural Sources of Fluvial Suspended Sediments. Prog. Wat. Tech. 11:481-499.

Wang, C. and H. Rees (1981 In Press). Soils of the Rogersville-Richibucto Area, New Brunswick.

Wischmeier, W.H., C.B. Johnson and B.V. Cross. 1971. A Soil Erodibility Nomograph for Farmland and Construction Sites. J. Soil and Water Conservation 26:189-193.

Wischmeier, W.H. and D.D. Smith. 1978. Predicting Rainfall Erosion Losses - a Guide to Conservation Planning. U.S. Department of Agriculture, Agriculture Handbook No. 537.

Pedotechnical Interpretations For Soil Survey

G. Wilson

A draft document entitled "A proposed pedotechnical interpretation systems for soil surveys in Canada" has already been reviewed by a review committee set up by John Nowland. These committees were made up of heads of all the soil survey units across the country plus part of the National Research Council committee on the use of geotechnical information in urban areas. In addition to this official committee, I have also had reviews by a number of professional engineers and geologists.

A considerable amount of very conscientious effort has been put into this review process and appreciation must be expressed to all concerned. The document has been adjusted in detail taking into consideration the many useful points raised, but the general theme is unchanged. Subsequent to the March 1980 meeting of ECSS, the method is at present being subjected to "a full-scale show and tell" process in 3 provinces. Failure to pass this text will result in a well documented case history.

Two documents have subsequently been prepared and presently available; these are the revised form explaining the pedotechnical approach to interpretations and a document illustrating its application to the Nepean-Gloucester Soil Survey. The interested reader is referred to those documents. That which follows is a brief resumé of my presentation at the ECSS March 1980.

In "selling" or otherwise encouraging others to take a greater interest in the work and publications of soil surveys, one should be prepared to answer the question "What's in it for me?". The engineer is likely to ask how can the soil survey map help me as a soil specilist, to find out what I want to know about the landscape so that I can do my job (of alterring the landscape) better. The planner is also likely to ask how the soil survey can help him to find out the significance of this soils information so that he can do his job (of making provisions for alterring the landscape) better. Manitoba Soil Survey refer to these major categories as "Active" and "Passive" users of soil survey information.

For the Active user the first requirement is a general legend showing (very briefly and in pedological terms) how the landscape has been mapped with the soils associated as Subgroups on a material basis. If more information than this very brief outline is available, then a second document termed the Pedotechnical Setting Sheet is provided whereby all of this extra information concerning the Soil Association is provided on one sheet of paper. The data shown represent what the pedologist considers to be the central theme of the dominant soil series of the association or subgroup.

The objective of making pedotechnical interpretations is now seen as a process of making the soil survey more useful to other specialists, rather than to actually attempt to make engineering judgements. For the planning specialists then the map unit symbol requires to be converted from the "active" to the "passive" mode. To make this conversion, an interpretation sheet is compiled that illustrates how a particular problem (e.g. Septic tanks as a pollution problem) may be broken down to show how soil survey may contribute towards its solution. The interpretative process thus involves only 3 documents; a list of the map units (to be interpreted), the pedotechnical setting sheet on which is set out all the information of interpretive value and the interpretation sheet illustrating how the map unit symbol can be replaced by an interpretation symbol.

For the passive user, special derived maps can be provided or the soil survey map can be used together with the list of interpretations symbols. The general legend to the derived map is the briefest statement concerning the interpretations. For more detailed considera-tion (e.g. mitigation measures, etc), the actual interpretation sheets will make up the detailed legend for these derivative maps.

Thus 6 groups of users can be catered for with this system:

Engineers (Active) - i) for quick reference are provided with a general legend (Map Units).

-ii) for more detailed considerations are provided with the Detailed Legend (Map Units) - {these are the Pedotechnical Setting Sheets for each Soil Association}.

Planners (Passive)-iii) for quick reference are provided with a general legend (Interpretations).

- iv) for more detailed considerations are provided with the detailed legend (interpretations) - {these are the interpretations sheets for each problem}.

Pedologists (Expert)-v) for Soil Surveyors providing the information in one place to facilitate the interpretation process.

- vi) for correlators, etc , to verify or discuss the interpretations because they will be based <u>only</u> on the information provided.

The professional Engineering input is in the compilation of the basic interpretation sheet and adapting this for local and regional use. The pedologist and the correlator are responsible for the build up of the mapping legend and for the accuracy of the mapping and delineation boundaries, not the engineer. The pedologist puts his map units through the interpretative process himself and the correlator does the checking. The process is pedotechnical.

APPENDIX 3. WORKSHOP SESSIONS ON CORRELATION

Establishment of Terms of References for Survey Projects

J.H. Day

The primary objective of soil surveys has been and is to study, classify, describe and map soils so that predictions can be made about their behavior for various uses and their response to defined management systems. The basic objective of soil surveys is the same for all kinds of land, although the number of mapping units, their composition and the mapping detail may vary with the complexity of the soil patterns and the specific needs of the soil map users. Although soil surveys help us increase our general knowledge about soils they are most commonly done for a more practical purpose. They satisfy a need for soil information about specific geographic areas useful in developing provincial, county, and community land use plans, resource conservation plans for farm and ranch planning, for reclamation projects, forestry management, preliminary planning for engineering projects and works, and many other kinds of land uses.

Soil surveys can be done to meet the needs of the intended users. Although soil surveys can be made to satisfy a single purpose, this is rarely done. Most commonly they are done for areas sufficiently large to have more than one kind of important land use and several or more users with varied interests and needs. These needs may be few and noncomplex for extensive use areas where land use is not expected to change in the foreseeable future. They may be many and complex in areas of intensive use and many land use changes are expected. The great value of soil surveys is in the large number and variety of uses to which the basic soil information can be applied.

Predictions for uses of soils other than for farming, grazing, wildlife and forestry have tended to concentrate on limitations of soils for the intended uses. Where investment per unit area is high, modifying the soil to improve its adaptability for the intended use may be economically feasible. Soil scientists can work with engineers and others to provide predictions of how to improve a soil's adaptability for specific uses. These kinds of predictions are becoming increasingly important in areas where the demands on soil resources are high and increasing.

Most soil surveys are conducted at medium scales and medium intensity levels. The demand for greater reliability in selected areas is increasing along with ever increasing costs. It is becoming much more important to adequately document the purpose, to thoroughly plan all aspects of a project before the field work begins, and the expected products of the survey.

A project planning checklist is attached. Your comments and amendments are sought. In your response please comment especially on the scope and completeness, organization, and the preferred format of a document prepared for distribution to participating agencies, party leader(s), correlators, and cartographic section.

Part A - Identification

1. Name and location of person filing this plan
2. Name, location, map reference of proposed survey area
3. Date of filing of this proposal
4. Date reviewed by provincial correlator,

   regional or national correlators

THE REQUEST

Part B - Organizations

1. Requesting Agency
2. Reasons given for the request
   a. Dominantly agricultural concerns
   b. Dominantly forestry concerns
   c. Dominantly urban concerns
   d. Dominantly soil-land research concerns
   e. Other (specify)
3. Requested start up date

Part C - Objectives

1. Information requested by the requesting agency
2. Scale and survey intensity level requested
3. Report and map format requested
4. Completion date requested

Part D - Contributions by Requesting Agency

1. Staff

   Party leader

   Surveyors

Students

Technical service - laboratory

- data processing

- draftsman

Resource persons - interpretations

Correlators

2. Equipment, Transport and Funding

Transportation - trucks

- helicopter

- fixed wing aircraft

- boat

Survey - backhoe

- drill

- stereoscopes

- transferscope

Funds - salaries

- rental

- travel costs

- fees

- data processing

- aerial photography

- map bases

- cartography

- publication: reports

: maps

: user packages

- contracting out

THE DECISIONS

A reconciliation of request and available resources

Part - E The Survey

1. Proposed mapping scale
2. Proposed publication scale
3. Survey intensity level
4. Interpretations to be prepared
5. CLI subclass management units
6. Cost-of-modification data and economic data to be collected
7. Soil potential ratings
8. What special or key data (irregular) are to be collected
9. Style of legend (open, ajar, closed)
10. Style of symbols on field maps   published maps

	field maps	published maps	
connotative	__________	______________	check
partly connotative	__________	______________	two
nonconnotative	__________	______________	

11. Map unit composition with respect to soil taxonomy
12. Interim maps required within what time span
13. What kind of map base: field maps
    : published maps
    : plotter printed maps

Part F - Reporting and Publication

1. Scale of maps, number of soil maps
   number of other maps
2. Maps to be printed? color? B&W? photobase?
3. Languages English, French, Both
4. Are interim or prepublication maps required

5. Legend: short, on the map, not all-inclusive

: long, expanded, on the map(s)

, in a legend booklet

6. Interpretations, soil potential and management ratings

- number and kinds
- tabular in report, by series

, by map units

- in map format with legend
- published - ozalid on demand

- microfiche in report

7. Report-type: preliminary with general area description and map

: interim with generalized description of land and soil with interpretation ratings

: complete monograph

8. Probable dominant readership of report

- lay
- technical

9. Report will include text figures?

- general soil map
- cross section diagrams
- photographs
- some sections of report or maps microfiche

10. User packages will be prepared

- explanation of ratings contained in it
- ratings packaged by use groups for all or part of map area?
- ratings packaged by individual map sheets?

11. Number of reports to be printed

12. Agency that will distribute the products

Part G - The Schedule

1. Party leader initiates legend establishment

2. Probable date for level 1 correlation

3. Probable date for initiation of mapping contract if any

4. Probable dates for correlation

   level 2 ________ level 3 ________ level 4 ________

5. Probable dates for submission of maps and report to printers

Part H - Organization and Management

	Requesting Agency	Participating Agencies 1	2	3
1. Management structure				
Responsible officer name				
Editorial - technical				
- style				
2. Staff and function				
Name if possible and indicate for which years				
Party leader				
Surveyors				
Correlators				
Students				
Resource persons by				
Interpretive speciality				
geology				
forestry				

	Requesting Agency	Participating Agencies 1	2	3
agronomy				
etc.				
Analytical laboratory				
Data processing				
Cartography				

Part I Estimated Costs

Include overhead, profit and DSS fees where appropriate

	Requesting Agency	Participating Agencies 1	2	3
1. Legend establishment and contract preparation				
2. Mapping				
3. Sampling				
4. Analyses				
5. Correlation				
6. Data - compilation				
- editing				
- processing				
7. Reporting				
- prepare report plan				
- prepare contract proposal				
- report writing				
- report technical edit				
- report style edit				
- map compilation				

	Requesting Agency	Participating Agencies 1	2	3
- legend compilation				
- map and legend technical edit				
- cartography				
- user package writing				
8. Publication				
- map production				
- data processing				
- map printing and folding				
- report printing and folding				
- user package printing				
- information meetings				

A Proposed Framework For Soil Correlation Procedures In Canada

J.A. Shields

Background

Draft papers on correlation procedures were prepared by Shields, Tarnocai and Nowland. These were patterned to varying degrees after the basic American approach but modified according to our manpower constraints. After review by Nowland and Day a 2nd Approximation was prepared incorporating their comments, and ideas contributed by the Manitoba paper of Mills and Smith.

This 2nd Approximation was reviewed by the regional correlators during a group discussion on this topic. In spite of the fact that all discussants were familiar with the American pattern there was still considerable uncertainty:

a. What is encompassed in informal correlation - does it include facets of planning a soil survey, or, is it confined strictly to correlation?
b. Field visits were listed as informal correlation in contrast to field reviews which were listed as formal correlation - what were the differentiating requirements?
c. What were the basic differences between initial, progress and final field reviews? - Again the manuscript (2nd Approximation) did not spell out the differentiating requirements.

Despite the uncertainty, there was also some agreement as follows:

a. The majority of soil correlation activities conducted in Canada in the past were of the informal type.
b. Although these informal correlation activities have played a very important role and have been effective to some degree, it was unanimous that some formal documentation procedures must also be introduced. After much open and frank debate some unanimity of thought began to take place.

General Soil Correlation - W5H

Soil correlation activities vary widely from province to province. Consequently we are attempting to draw together a set of nationally acceptable activities and documentations in order to facilitate the consistent classification and mapping of soils in accordance with our National Systems. Following is an outline of the 5 W's (what's, why's, wherefores) and H for How relating to soil correlation.

WHAT: To correlate is to show the relation between two or more things. Soil correlation deals with maintaining between different soils areas a consistent systematic relationship with reference to established national and regional guidelines in three elements of soil survey -- classification, mapping systems and interpretations. There is no universal definition of soil correlation since the activities involved are tailored to meet the particular needs of the individual programmes.

In Canada we propose that soil correlation is DEFINED as "the systematic procedure by which the data set (all significant characteristics) for each soil is systematically related to data sets of soils which are already:

a. defined and named in the soil classification system.
b. described and named in mapping units of different survey areas and
c. interpreted in relation to use and management of similarly mapped soils.

The smallest indivisible building brick of the correlation function is the establishment of a one-by-one correspondence or relationship between data sets of two soil areas.

WHY: The purpose of soil correlation is to ensure that kinds of soil are adequately described, and accurately and uniformly mapped and rated for use.

WHERE: Soil correlation activities and procedures are carried out in the survey office and in the field between adjacent map units or between widely separated regions.

WHEN: Soil correlation within an area commences with informal preparatory stages and continues at various stages through legend development, formal field review, and manuscript editing.

WHO: Soil correlation commences with the party leader who has a continuing responsibility for the quality of the services, interacting frequently with provincial correlators and occasionally with regional correlators.

HOW: Soil correlation within an area commences with informal preparatory soil survey activities and continues through legend development, documented field reviews and manuscript editing. The initial phase of soil correlation consists of describing soils at different sites within an area. These descriptions are used by correlators to compare and contrast different sets of properties at different sites. If evidence about the soils studied at two different places indicates they are of the same kind, they are identified by the same name. For example, when a soil described and named in another soil survey is judged to be of the same kind as a soil within the survey area, the same name is used. When the description of a soil is outside the range of properties of previously defined map units, the establishment of a new map unit is recommended.

As field work progresses, the process of correlation continues. At the initial correlation documentation, site descriptions are examined and tentative correlations represented by mapping units and soil classification units given in the legend are tested. The experience and knowledge of correlators is used to test the legend from the standpoint of both soil classification and usefulness of the map units from an interpretive standpoint. As mapping progresses, correlations of the sets of soil properties and landscape features used to define and differentiate mapping units are reviewed for adherence to national mapping system guidelines and criteria for soil and landform classification. At the same time, soil descriptions and other field data are accumulated. Laboratory analyses of sampled soils is also tested against established soil series descriptions and discrepancies recorded.

Accumulation of data from all these sources usually necessitates adjustment of definitions and names of some mapping units; other may be combined or deleted. Accordingly, the party leader makes the necessary correlation recommendations. Each adjustment is a refinement of correlating soils of the survey area. The validity of judgements concerning similarities or differences among kinds of soil identified and the usefulness of mapping units is tested for each interpretation of the survey information.

Soil correlation is dependent on consistent methods of observation and measurement and consistent terminology and conventions to make the necessary comparisons. Many criteria and guidelines have been prepared to help maintain uniform correlation. The "System of Soil Classification for Canada" provides a national taxonomic system and the differentiating characteristics for consistent classification of soils. It also describes the terminology and conventions to be used in describing and characterizing soils and landscapes in the field. More recently, a "Manual for Describing Soils in the Field" ensures a uniform method of data collection into the automated Canada Soil Information System (CanSIS) data bank. This permits use of great volumes of data for a more comprehensive study of soil properties. A proposed "Soil Mapping System for Canada" defines procedures which should ensure standards of accuracy and reliability consistent with current mapping systems. A laboratory methods manual for soil analyses ensures a uniform comparison of the chemical and physical properties of soils. Additional manuals for measuring soil properties in the field and others describing the consistent application of soil survey information for land evaluation are now being proposed.

Soil correlation then, takes evidence derived from soil surveys carried out according to national criteria and guidelines and seeks to establish and evaluate similarities and differences between soils. Soil correlation is an essential soil survey quality control procedure.

Conceptual Outline Of Proposed Framework

Initially, the assumption was made that prior to any correlation activities, preplanning and complete specifications of the project have been established including a) objective and purpose, b) scale and intensity, c) manpower required, d) publication format etc. Thereby, these specifications impose guidelines for the conduct of survey and correlation. A conceptual outline of correlation activities and documentation procedures which we think is in tune with our manpower resource base was developed; the details will be spelled out later.

Definitions

(1) Soil Correlation Activity - a survey activity relevant to soil correlation.

(2) Soil Correlation Level - time interval during which a proportion of the mapping has been completed for the project area OR during which final reporting and editing has taken place.

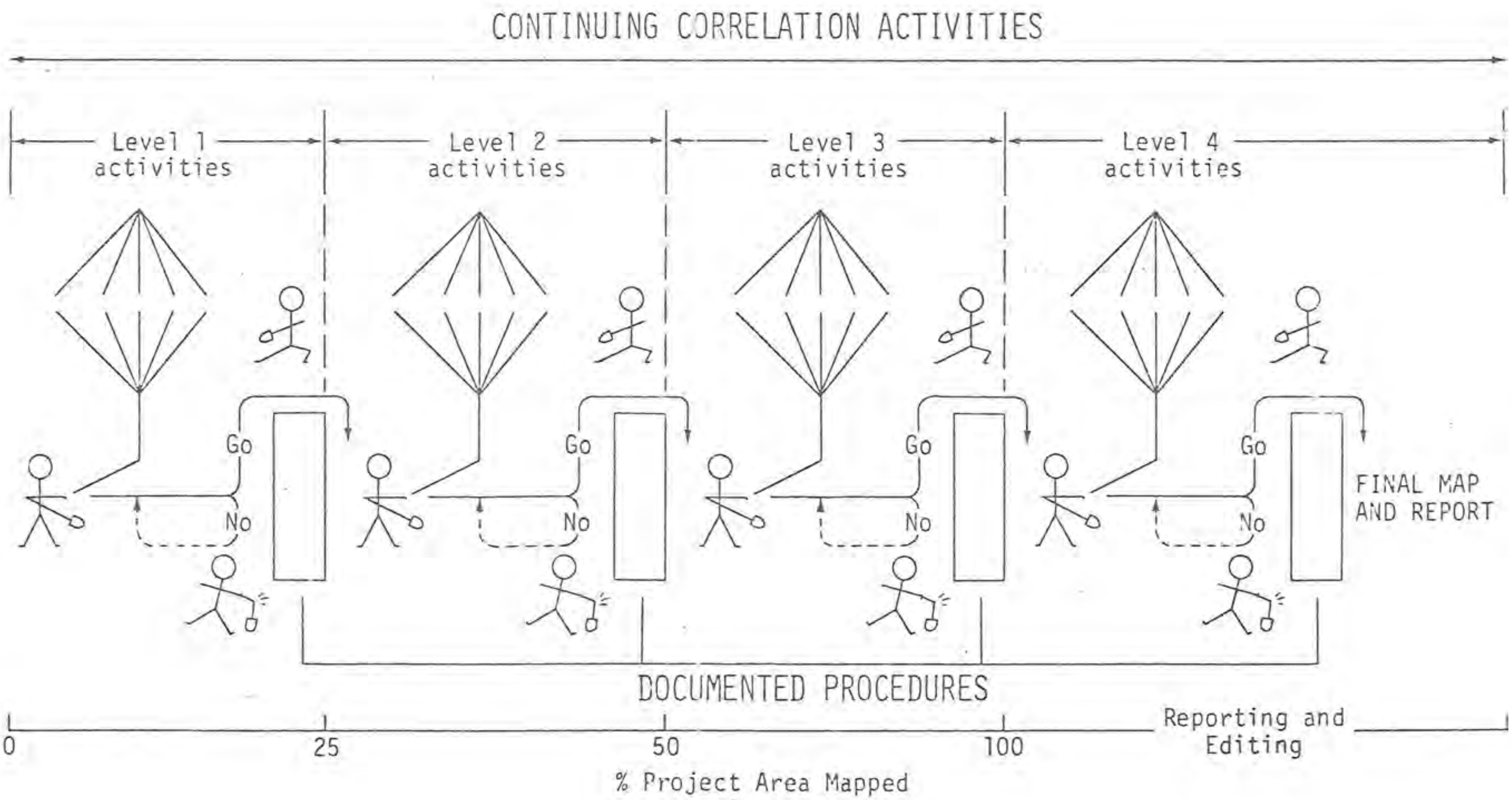
(3) Soil correlation documentation - reported documentation of a correlation activity required to progress from one correlation level to the next. These documentations are reported in Correlog or attached to it.

Correlation activities of an informal nature continue from commencement to completion of a soil survey project. When analyzed in its entirety, there emerged some distinct groups (or levels) of these activities. For example, we came up with 4 levels of progressive (or time-related) correlation activities practised to varying degrees in various parts of the country.

To pass from one activity level to another there are certain requirements that must be met. These requirements must also be well documented for future reference. In essence, these documented correlations are hurdles which must be cleared before getting on with the next survey phase and its relevant correlation activities. These hurdles (or levels) are set at critical time intervals related to the mapping progress for the project. The critical times chosen are when 25, 50 and 100% of the project mapping is completed; the fourth activity level consists primarily of reporting and editing. A great deal of emphasis is placed on documentations required after 25 and 50% of the project area is mapped. Don't be anxious (or uptight or turned off) about the documentation requirements. A checklist format (Correlog) is being prepared to facilitate these documentations at each required level.

In many cases, this concept is analagous to the party leader and the mapping parties jogging a long distance race (Figure 1). The correlation activities within each of the levels constitute the routine trail markers (or checkpoints) along the route that must be passed to make sure they stay on track and remain on schedule. At certain critical points along the route there are hurdles (or documentations) to be cleared before further survey progress can be achieved. If these are not cleared, it is necessary to backtrack a bit, tend to the unfinished business, renew the commitment with a little more determination and with the aid of local expertise (ie. provincial correlator), the obstacle can be cleared. Before starting, we know it is a long demanding race; the hurdles are particularly demanding during the first half of the route and preplanning to meet them is essential. However, they are relatively few and far between providing ample time for workouts, conditioning and coaching from appropriate experts. Keeping on track by adhering to these prescribed activities at scheduled intervals will necessitate a high degree of self discipline by the party leader and mappers thereby ensuring that quality control requirements of provincial and regional correlators are adequately achieved.

FIGURE 1 SIMPLIFIED CONCEPTUAL OUTLINE OF PROPOSED SOIL CORRELATION PROCEDURES



Basic Soil Correlation Activities and Documentations

An expanded explanation of the proposed framework is shown in Table 1 (see attached). Important soil correlation and survey activities are listed on the left and a check list is provided to indicate at which levels (1-4) these activities (A) occur and if their documentation (D) when completed is required; not all activities require documentation.

Some of the above activities are practised only during one level. For example activility no. 1 requires documentation only at level 1. In contrast, field legend development (activity 6) must be documented for the first 3 levels. Activity 29 is somewhat isolated occurring only at level 2 whereas activities 36 through 44 must be documented only at level 4.

Concluding Remarks

Having participated in developing this concept we are probably a bit predujiced. However, this is what we particularly like about this concept.

a. It is simple and straight forward approach, no jargon, not mind boggling etc.
b. It reflects many of the important traditional correlation activities and introduces some required documentation procedures. These procedures when inserted at critical times during the course of a survey will force decisions and thereby avoid the indecisions that have plagued many projects in the past, created costly delays on the final lap and forced unfortunate compromises.
c. The basic format is consistent with correlation responsibilities of the party leader, provincial and regional correlators.
d. It is uniquely Canadian.

Olympic year is an appropriate time for each group which wants to have its own version of the games to get it together. In keeping with time theme, the correlators have presented their contribution to Olympic competition -- the Correlation Sweepstakes. Lets all be competitors and agree on the rules.

Table 1. Occurrence of Soil Correlation Activity Levels and Documentation Required

Correlation and Survey Activities	Levels at which Activities (A) or Documentations (D) occur							
	Mapping						Reporting	
	1		2		3		4	
	A	D	A	D	A	D	A	D
1. Prepare literature review and assemble data on the environmental setting of the area.	✓	✓						
2. Traverse the area sufficiently noting kinds of soils as functions of topography, parent materials and drainage variations.	✓							
3. Develop models of the total population of soil bodies encountered.	✓							
4. Identify landforms and vegetative patterns that provide clues to different kinds of soils and their boundaries.	✓		✓	✓				
5. Conduct airphoto-interpretation of the area and evaluate the accuracy of interpreted boundaries in the field.	✓	✓	✓	✓	✓	✓		
6. Prepare draft copies of the field legend and the legend to be shown on the final map.	✓	✓	✓	✓	✓	✓		
7. Correlate soils and map units on field legend with those on legends from adjacent and other similar areas.	✓	✓	✓	✓				
8. Test provisional map units and systematically plan observations and sampling to differentiate map units reliably.	✓							
9. Develop transect procedures for quantifying descriptions of map units.	✓	✓						
10. Conduct training traverses for mappers.	✓	✓	✓	✓	✓	✓		
11. Conduct mapping in different quadrants of the area representative of the range of soils, landforms, climate and land use encountered during airphoto interpretation.	✓	✓	✓	✓				
12 Review mapping procedures and verify that they are in accordance with project plan.	✓	✓	✓	✓				

Table 1 (continued)

Correlation and Survey Activities	Levels at which Activities (A) or Documentations (D) occur							
	Mapping						Reporting	
	1		2		3		4	
	A	D	A	D	A	D	A	D
13. Determine that density of observations is appropriate to the established survey intensity level.	✓	✓	✓	✓				
14. Take and analyze "Grab Samples" required as definitive for soil classification or map units and summarize results.	✓	✓	✓	✓				
15. Ensure that data recording system (daily field sheet) is:								
(a) adequate for the objectives of the survey;	✓	✓						
(b) used effectively during the survey	✓	✓	✓	✓	✓	✓		
16. Conduct transect mapping to quantify descriptions of map units and to evaluate analytical data of sampled map unit components.	✓	✓	✓	✓	✓	✓		
17. Correlate soils and map units listed on the field legend within the area mapped.	✓	✓	✓	✓	✓	✓		
18. Prepare a plan for (a) installations required for field measurements	✓	✓						
and then (b) to take required measurements.	✓	✓	✓	✓	✓	✓		
19. Complete mapping for 25, 50 or 100% of project area.	✓		✓		✓			
20. Prepare proposals for establishing new series, associations or map units as required and to document differentiating criteria.	✓	✓	✓	✓	✓	✓		
21. Conduct soil correlation field review when 25, 50 or 100% of mapping is completed within project area.	✓	✓	✓	✓	✓	✓		
22. Review research needs in support of survey plan.	✓	✓						
23. Prepare documentation in support of departures from national guidelines or project guidelines.	✓	✓	✓	✓	✓	✓		

Table 1 (continued)

Correlation and Survey Activities	Mapping 1 A	1 D	2 A	2 D	3 A	3 D	Reporting 4 A	4 D
	Levels at which Activities (A) or Documentations (D) occur							
24. Review and complete all outstanding actions requested from previous documentation levels, resolve such problems, document and file them.	✓	✓	✓	✓	✓	✓		
25. Conduct soil sampling in mapped areas according to the planned sampling design and ensure that definitive properties are analyzed and summarized for area mapped.			✓	✓	✓	✓		
26. Review plans for preparing interim reports.			✓					
27. Prepare a brief, general description of the major land components in the area.			✓	✓				
28. Prepare detailed outline for the final soil survey report and assign authorship of sections.			✓	✓				
29. Prepare framework of final map legend and ensure it meets the interpretations envisioned.			✓	✓				
30. Prepare block diagrams or two-dimensional cross-section diagrams for incorporating in map legend or report.			✓	✓	✓	✓		
31. Initiate preparation of provisional interim maps at final publication scale.			✓	✓	✓	✓		
32. Initiate (a) interpretations of major map units and			✓					
(b) compile rating tables					✓	✓		
33. Initiate rough area measurements of map units.					✓	✓		
34. Prepare final map legend showing range of properties for each map unit and make provisions for amalgamating insignificant separations.					✓	✓		

Table 1 (continued)

Correlation and Survey Activities	Mapping 1 A	Mapping 1 D	Mapping 2 A	Mapping 2 D	Mapping 3 A	Mapping 3 D	Reporting 4 A	Reporting 4 D
35. Review final map legend for classification accuracy and editorial acceptability of sections explaining map symbols and how to use the map.					✓	✓	✓	✓
36. Compile descriptions of soil and map units in relation to land-form and vegetation patterns.			✓	✓	✓	✓	✓	✓
37. Prepare generalized soil maps for incorporation in soil report.							✓	✓
38. Finalize soil map and forward to Cartographic Section.							✓	✓
39. Review and coordinate map unit color scheme with previously published or adjacent maps; consult with Cartographic Section on choice of colors.							✓	✓
40. Perform quality control color check on final map and return to Cartography with color check.							✓	✓
41. Review legends for derived and interpreted maps.							✓	✓
42. Edit coding on legend statements of derivative maps.							✓	✓
43. Verify that legend on interpretive maps conforms to required standards.							✓	✓
44. Review final soil report manuscript for style and technical content.							✓	✓
45. Submit soil report to Research Program Services for style and readability edit.							✓	✓
46. Develop plans for public information meeting in survey areas, where appropriate.							✓	✓

Correlog: A Correlation Record

J.L. Nowland

The correlation group at Ottawa, and other correlators in the county, and expressed a need for a document to record all of the important observations and decisions taken during the field reviews conducted during the life of a survey project. The decisions taken must always be relevant to the terms of reference that were established when the survey project was organized and planned. But since many projects endure over a span of two to six or more years, and staff changes occur, memory, buttressed by scanty notes or other inadequate records, has in the past sometimes resulted in failure to adhere to the original terms of reference, confusion over timing of operations, failure to order necessary map bases appropriate to the final publication format, etc. Such undesirable events waste limited budgets and time, and may damage our credibility among users. In my opinion we should and can improve our productivity and performance by adopting improved and somewhat formalized procedures.

We offer Correlog for your study and comments.
It is four themprolled into one,

1. An outline of the soil correlation function as we see it.
2. A permanent correlation record for soil survey projects, itemizing the functions and tasks that normally are undertaken by the party leader at various periods during the life of the survey.
3. A permanent correlation record for soil survey projects, itemizing the things of interest to senior surveyors and correlators responsible for the first and most critical level of supervision of the conduct, progress and quality of a soil survey.
4. A permanent correlation record of soil survey projects itemizing the stage of progress and other matters of interest to unit heads, chief cartographer, and the LRRI section head who each year must complete annual reports and plans for future work.

The first draft is rather cumbersome because it is designed to display the components in a convenient way for debate, testing, modification and additions. Your input is invited, may, implored.

OUTLINE OF CORRELOG (1st draft)

Page	Entry No.	Item
1	1-10	HEADER INFORMATION AND INSTRUCTIONS
2	11-23	MAPPING PROGRESS AND CARTOGRAPHY SCHEDULING
3	24-34	MAPPING SYSTEM - GENERAL
4	35-63	MAPPING SYSTEM - MAP UNITS
8	64-71	MAPPING SYSTEM - MAP SYMBOLS
8	72-131	MAPPING SYSTEM - LEGEND
		Legend layout
		Categories of information in the legend
13	132-185	SOIL SAMPLING AND CHARACTERIZATION
		Sampling strategy
		Profile descriptions
		Field measurements
18	186-265	SOIL REPORT
		Interpretations in the report
24	266-294	CORRELATION PROCEDURES, MISCELLANEOUS INFORMATION
		Adequacy of documentation on correlation tours

CORRELOG for (name of project) Report No. ________

1 Dates of reviews: Level 1 ________ Level 2 ________ Level 3 ________ Level 4 ________

2 Agencies initiating survey:

3 Cooperating agencies:

4 Surveyors: (leader)

5 Correlators local: regional:

6 Date project commenced:

7 Expected completion (ready for printing):

8 Size of area: (ha)

9 Map output (ring): Working in-house map Interim map Final published map Interpretive maps

10 Transmittal and acceptance signatures:

Level 1:

Level 2:

Level 3:

Level 4:

Important Note: CORRELOG is for use by all participants in soil survey. Items in CORRELOG are of two kinds:

1. Mandatory Critical List. These items are indicated by underlined numbers of the Correlation Levels at which the specified conditions are to be met before the project advances to the next level. A "poor" or "negative" evaluation of such an item is to be resolved at the appropriate time, by agreement between all correlators.

2. Checklist items. These items are of secondary importance but constitute a correlation record of the project, a record of problems encountered, deci-

The "Applicable Correlation Levels" (CL) are those defined under "Documented Correlation Procedures" in the draft Canadian Soil Survey Handbook. Level 1: 25% of mapping completed; Level 2: 50%; Level 3: 100%; Level 4: Reporting and Editing. Items should generally receive attention only at the levels indicated (subject to review), but this is not exclusive.

"Data" items are entered in free format, except where a target value defining that CL has been entered already. "Evaluation" items (Y N G F P) are ringed. "Change sheet numbers" refer to permanent record change sheets that are appended to spell out details of changes agreed upon.

sions made and actions taken. They can be used by mappers and correlators as a checklist of items to be considered in planning and reviewing a project.

A master copy of CORRELOG for each survey project is retained on file in the provincial survey office and in LRRI. It is not for dissemination. Signatures by the Correlators, Unit Head and Project Leader at each Correlation Level indicates agreement with the Evaluation and the Actions Required.

CORRELOG (1st draft)

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	Evaluation G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
		MAPPING PROGRESS AND CARTOGRAPHY SCHEDULING						
11	1 2 3 4	Mapped to date. Rate of progress (G, F, P)	25% 50% 100%	Y N Y N Y N Y N	G F P G F P G F P G F P			
12	1	Literature review and compilation of background information		Y N	G F P			
13	1 2 3	Map bases requisitioned from Cartography		Y N				
14	1 2 3	Date map bases required	/ /					
15	1 2	Map title submitted		Y N				
16	1 2 3	Thematic transfer, % completed	% % %					

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
17		Expected dates of submission of maps to Cartography						
	2 3	- interim 1	/ /					
	2 3	- interim 2	/ /					
	2 3	- interim 3	/ /					
	3 4	- final	/ /					
18	2 3	Number of ozalid copies of interim maps required	#					
19	4	Author's verification copy of final soil map sent out on	/ /					
20	4	- receipt akcnowledge	/ /					
21	4	- date returned to Cartography	/ /					
22	4	Date of return of map unit area measurements to authors	/ /					
23	3	Generalized soil map to be produced, and scale	1:	Y N				
		MAPPING SYSTEM - GENERAL						
24	1	Survey Intensity Level (SIL)	12345					
25	2 3	SIL Uniform across map		Y N				
26	1	Final map scale; does it meet specifications?	1:	Y N				
27	1	Scale of field compilation maps/ airphotos	1:					

28	1 2 3 4	Minimum size map delineation 0.5 cm^2, OR	cm^2	Y N	
29	2 3 4	Average size map delineation	cm^2		
30	2 3 4	Map texture intensity ratio	%		
31	1 2 3 4	Average ground inspection density 1/cm^2, OR	#	Y N	
32	1 2 3	Use of daily field sheets		Y N Y N Y N Y N	G F P G F P G F P G F P
33	1 2 3	Mapping system used accords with project plan		Y N	G F P
34	1 2 3	Mapping system used accords with current national guidelines		Y N	G F P

MAPPING SYSTEM - MAP UNITS

35	1	Kind(s) of map unit, dominant (A), other (B)	single	A B
			compound 1	A B
			compound 2	A B
			compound 3	A B
			compound 4	A B
			compound 5	A B

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
36	1	Pre-1980 map units; series, series phase, catena, association, complex, family, land system, land type, combinations of these, other. (list under Remarks).						
37	1 2	Use of open phases (ie not included in map unit criteria) slope (T), stoniness (P), rockiness (R), erosion (E), surface texture (S), depth (D), parent material variation (PM), drainage (W), soil variants (V), other (specify).	T P R E S D PM W V					
38	1	Levels of taxonomy used in map unit..	_____ _____					
39	1 2	Appropriateness of chosen level of taxonomy			G F P G F P			
40	1 2 3 4	Correlation of taxonomic map units - with provincial master list		Y N Y N Y N Y N				
41	1 2	- with previously mapped areas		Y N Y N				
42	1 2 3	Reservation of names in Soils Names File		Y N Y N Y N				

43	1	Establishment of range of properties		Y N	
	2	for each taxonomic and map unit		Y N	
	3			Y N	
44	1	Documentation of range of properties		Y N	G F P
	2	for each taxonomic and map unit, and		Y N	G F P
	3	identification of competing units		Y N	G F P
45	1	Adequacy of mapping in all quadrants of survey area during legend building (Level 1)		Y N	G F P
		Use of transect sampling for statistical determination of			
46	1	- precision of n% of map units	%	Y N	G F P
	2		%	Y N	G F P
	3		%	Y N	G F P
	4		%	Y N	G F P
47	1	- variability of diagnostic criteria		Y N	G F P
	2	(attributes)		Y N	G F P
	3			Y N	G F P
	4			Y N	G F P
48	1	- variability within map units of main		Y N	G F P
	2	criteria used for specific		Y N	G F P
	3	interpretations		Y N	G F P
	4			Y N	G F P

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	Evaluation G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
49	1 2 3	Individual portions of map units (delineations) are normally repetitive in the landscape		Y N Y N Y N				
50	1 2 3	Do the map units adequately reflect groupings of related soil properties with the best chance of predictability across the landscape?		Y N Y N Y N	G F P G F P G F P			
51	1 2 3	Do the map units have the smallest number of inclusions and unidentified features as possible?		Y N Y N Y N				
52	1 2 3	Degree to which the range of properties of the map units allow interpretation for "uniform management" of the units			G F P G F P G F P			
53	2 3	Amalgamation of map units that occur only once or twice		Y N Y N	G F P G F P			
54	2 3	Amalgamation of map units separated on the basis of soils that occupy <15% of the map unit area		Y N Y N	G F P G F P			
55	2 3	Amalgamation of compound map units in which minor soils were "similar & non-limiting" and occupied <35% of the map unit, with the single map unit of the major soil		Y N Y N Y N	G F P G F P G F P			

56	1 2	Use of CanSIS requested for building and sorting map units	Y N	
57	1	Intention to request use of CanSIS for building and sorting map units	Y N	
58	1	Accuracy of map unit boundaries		G F P
	2			G F P
	3			G F P
59	1	Accuracy of airphoto interpretation		G F P
	2			G F P
	3			G F P
60	1	Accuracy of designated content of delineations		G F P
	2			G F P
	3			G F P
		Percentage thresholds used for components		
61	1	of map units to be classed as dominant	%	
62		significant	%	
63		inclusions	%	

MAPPING SYSTEMS - MAP SYMBOLS

64	1	Map symbols on working maps - legibility		G F P
	2			G F P
	3			G F P

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
65	1 2 3	Size is compact (c), medium (m), large (1)	C M L C M L C M L					
66	<u>3</u>	Map symbols on <u>final</u> map - legibility			G F P			
67	3 4	- size is compact (c), medium (m), large (1)	C M L C M L					
68	1 2	Example of working map symbol, with key						
69	3 4	Example of final map symbol, with key						
70	3 4	Number of characters in largest symbol on final map	#			(include hyphens etc.)		
71	1 2 3	Symbol format approved by Cartography		Y N				
		<u>MAPPING SYSTEM - LEGEND</u>						
72	<u>1</u> 2	Very closed, closed, partly open, open, very open	VC C PO O VO					
73	<u>1</u> 2	Framework of primary stratification used: climate (c), eco-regions (e), soil zones (z), vegetation (v), geology (g), physiography (p), none (n)	C E Z V G P	Y N	G F P			

74	<u>1</u> 2	Number of primary stratification classes	#		G F P
75	1 2 3 4	Number of primary subdivisions of legend below level of primary stratification (usually identified by colours)	# # # #		
76	2 3 4	Number of map units within primary subdivisions - average	# # #		
77	2 3 4	- maximum	# # #		
		<u>Legend layout</u>			
78	1 2 <u>3</u> <u>4</u>	- map unit stratification adequately explained		Y N	G F P
79	1 2 3 4	- map units arranged alphabetically for whole legend		Y N	
80	1 2 3 4	- map units arranged alphabetically within stratified groups		Y N	
81	3 4	- single and compound units kept separate		Y N	

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
82	4	Consultation with Cartography on choice of map unit colour scheme for published map		Y N				
83	4	Coordination of map unit colour scheme with previously published and adjacent maps		Y N	G F P			
84	1 2 3 4	In what respects does the legend differ from the current concept of a standard legend format for the province at this SIL?				____ ____ ____ ____		
	1 2 3 4	Categories of information supplied for most map units in the legend (ring as appropriate) (check in Remarks column those items identified in legend column headings)	in-house map	interim map	final map			
85		Classification of dominant, significant and included soils	G F P	G F P	G F P			
86		Explanation of proportions of components in map units	G F P	G F P	G F P			
87		Definitions of dominant, significant, inclusions	G F P	G F P	G F P			
88		Adequate descriptions of soil/ landscape relationships	G F P	G F P	G F P			

89		Adequate descriptions of wave-length (scale) of repetitiveness	G F P	G F P	G F P
90		Climate	G F P	G F P	G F P
91		Parent Material	G F P	G F P	G F P
92		Landform type	G F P	G F P	G F P
93	<u>1</u> <u>2</u> 3 4	Landform surface expression	G F P	G F P	G F P
94		Lithology	G F P	G F P	G F P
95		Soil depth	G F P	G F P	G F P
96		Drainage	G F P	G F P	G F P
97		Soil water regime	G F P	G F P	G F P
98		Erosion	G F P	G F P	G F P
99		Soil Fertility	G F P	G F P	G F P
100		Soil Reaction	G F P	G F P	G F P
101		Salinity	G F P	G F P	G F P
102		Stoniness	G F P	G F P	G F P
103		Rockiness	G F P	G F P	G F P
104		Vegetation	G F P	G F P	G F P
105		Humus form	G F P	G F P	G F P

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	Evaluation G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
106		Wetlands classification	G F P	G F P	G F P			
107		Water bodies	G F P	G F P	G F P			
108		Land use	G F P	G F P	G F P			
109		Soil capability - CLI Agriculture	G F P	G F P	G F P			
110		- CLI Forestry	G F P	G F P	G F P			
111	1 2 3 4	- CLI Recreation	G F P	G F P	G F P			
112		- CLI Wildlife	G F P	G F P	G F P			
113		- urbanization	G F P	G F P	G F P			
114		- other (specify)	G F P	G F P	G F P			
115		Soil suitability - specific crops (indicate under remarks)	G F P	G F P	G F P	Crops:		
116		- specific nonagricultural uses	G F P	G F P	G F P	Nonagric uses:		
117		General soil problems	G F P	G F P	G F P			
118		Other interpretations (specify)	G F P	G F P	G F P			
119		Other interpretations (specify)	G F P	G F P	G F P			
120		Other interpretations (specify)	G F P	G F P	G F P			
121		Key to map symbol conventions	G F P	G F P	G F P			

122	1 2 3 4	Block diagrams	G F P	G F P	G F P
123	1 2 3 4	Two-dimensional cross-sectional diagrams	G F P	G F P	G F P
124	1 2 3 4	Reliability/precision ratings for map units	G F P	G F P	G F P
125	1 2 3 4	Fieldwork access/mapping density map	G F P	G F P	G F P
126	1 2 3 4	Mappers names and agencies	Y N	Y N	Y N
127	1 2 3 4	Cartography credits	Y N	Y N	Y N
128	1 2 3 4	Map scale	Y N	Y N	Y N
129	1 2 3 4	Other information	G F P	G F P	G F P
130	1 2 3 4	Other information	G F P	G F P	G F P
131	1 2 3 4	Other information	G F P	G F P	G F P
		SOIL SAMPLING & CHARACTERIZATION Sampling Strategy	Data	Evaluation Yes/ No	G F P
132	1 2	Target number of sites per map unit	#		G F P

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
133	1 2 3 4	Percent completed	% % % %		G F P G F P G F P			
134	1 2 3 4	Sample sites shown on soil map		Y N				
135	1 2	Planned frequency of formal sampling - established single map units good, average >4 sites per map unit; fair, 2-3 sites; poor <2 sites			G F P G F P			
136	1 2 3 4	Actual frequency of formal sampling - established single map units. Criteria as above.			G F P G F P G F P G F P			
137	1 2	Planned frequency of formal sampling - established compound map units and new single map units. good: >8 sites per map unit; fair: 4-8 sites; poor: <4 sites			G F P G F P			
138	1 2 3 4	Actual frequency of formal sampling - established compound map units and new single map units. Criteria as above.			G F P G F P G F P G F P			
139	1 2	Planned frequency of formal sampling - new compound map units Good, >10 sites per map unit; fair 6-10 sites; poor <6 sites			G F P G F P			

140	1	Actual frequency of formal sampling			G F P
	2	- new compound map units. Criteria			G F P
	3	as above			G F P
	4				G F P
141	1	Grab sampling			G F P
	2				G F P
	3				G F P
142	1 2 3 4	Special detailed sampling (cores, micromorphology research projects etc.). Specify under remarks.		Y N	G F P
143	1	Use of random transects for sampl-		Y N	G F P
	2	ing major map units.		Y N	G F P
	3			Y N	G F P
		Percentage of mapped map units for which one basic analysis (minimum acceptable package completed			
	1	-	%		G F P
144	2	- >80%:G 65-80%:F <65%:P	%		G F P
	3	- 100%:G 90-100%:F <90%:P	%		G F P
	4		%		G F P
145		Percentage of planned formal sampling of mapped area completed			
	1		%	Y	G F P
	2		75%	Y N	G F P
	3		100%	Y N	G F P
	4		100%	Y N	G F P

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
146	1 2 3 4	Use of standard samples for most determinations		Y N	G F P			
147	1 2 3 4	Use of standard samples for some determinations		Y N	G F P			
148	1 2 3 4	Completed analysis package is comprehensive (G), minimum acceptable (F), inadequate (P)			G F P G F P G F P G F P			
149	1 2 3 4	Planned analysis package is compre- (G), minimum acceptable (F), inadequate (P)			G F P G F P G F P G F P			
150	1 2 3 4	Analysis results entered in CanSIS (%)	% % % %	Y N Y N Y N Y N				
151	1 2 3 4	Number of horizons sampled and depth of sampling			G F P G F P G F P G F P			
152	1 2 3 4	Profile descriptions - number made	# # # #					

153	1	- number entered in CanSIS	#		
	2		#		
	3		#		
	4		#		
154	1	- general adequacy (GFP)			G F P
	2				
	3				
	4				
	1 2 3 4	Properties recorded			
155		- horizon labels		Y N	G F P
156		- colours and mottles		Y N	G F P
157		- texture		Y N	G F P
158		- structure		Y N	G F P
159		- consistence		Y N	G F P
160		- pores		Y N	G F P
161		- root distribution		Y N	G F P
162		- clay films		Y N	G F P
163		- carbonates		Y N	G F P
164		- salts		Y N	G F P
165		- coarse fragments		Y N	G F P
166		- pH		Y N	G F P

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
167		- variability over the pedon		Y N	G F P			
168		- horizon boundaries		Y N	G F P			
169		- other (specify)		Y N	G F P			
		<u>Field measurements</u> (quantitative field investigations)						
170	1 2 3 4	Zone of saturation (water table)		Y N	G F P			
171	1 2 3 4	Number of dipwells installed	#	Y N				
172	1 2	Number of dipwells planned	#	Y N				
173	1 2 3 4	Saturated transmissibility, number of sites	#	Y N	G F P	Method:		
174	1 2 3 4	Water content		Y N	G F P	Method:		
175	1 2 3 4	Bulk density, no. of sites	#	Y N	G F P	Method:		
176	1 2 3 4	Volume of coarse fraction	%					
177	1 2 3 4	Soil strength, bearing capacity etc.		Y N	G F P	Method:		
178	1 2 3 4	Crop yield sampling		Y N	G F P			
179	1 2 3 4	Forest productivity		Y N	G F P			
180	1 2 3 4	Erosion, number of plots	#	Y N	G F P			
181	1 2 3 4	Soil temperature		Y N				

182	1 2 3 4	Precipitation		Y N		
183	1 2 3 4	Other (specify)		Y N		
184	1 2 3 4	Other (specify)		Y N		
185	1 2 3 4	Other (specify)		Y N		
		SOIL REPORT				
186	1 2	Authors identified		Y N		Names:
187	1 2 3 4	Target date for completion 1st draft	/ /			
188	1 2 3	Planning of specifications completed (C), in preparation (P), not as advanced as they should be (F), not started (N)	C P F N C P F N C P F N		G F P G F P G F P	
189	3 4	Outline of contents completed (C) in preparation (P) not started (N)	C P N C P N	Y N Y N	G F P G F P	
190	3 4	Will the text be technical for limited readership (T), comprehensible for wider readership (C) contain sections for both (B)?	T C B			
191	1 2	Kinds of report. In-house (I), provisional/interim (P), final polished (F), expanded legend (E), none (N)	I P F E N			

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
192	1 2 3	Length of report. Expanded legend (E); <25 pp (A), 25-100 pp (B); 100-200 pp (C); >200 pp (D)	E A B C D E A B C D E A B C D					
		Estimated number of figures in report:						
193	4	- line drawings	#					
194	4	- black & white photographs	#					
195	4	- colour photographs	#					
196	4	- text maps in colour	#					
197	3 4	Dimensions of report	x cm					
198	1 2	Languages	E F					
199	3 4	Status of report. Not started (A); <25% (B); 25-75% (C); >75% (D)	A B C D A B C D		 G F P			
200	4	Number of copies to be printed	#					
		Manuscript editing - Interim report						
201	2 3 4	- report; technical and style edit by provincial correlator completed		Y N	G F P			
202	2 3 4	- map: edit by provincial correlator completed		Y N	G F P			
203	2 3 4	- report and map: edit by regional correlator completed		Y N	G F P			

		Manuscript editing - Final report		
204	4	- report and map: technical and style edit by provincial correlator	Y N	G F P
205	4	- report and map: technical edit by regional correlator	Y N	G F P
206	4	- report: style edit by provincial agency	Y N	G F P
207	4	- report: style edit by Research Program Services	Y N	G F P
		Interpretations in the Report		
208	1	Planned interpretive package		G F P
	2			G F P
	3			G F P
	4			G F P
209	1 2 3 4	CLI Agriculture - basic	Y N	G F P
210	1 2 3 4	CLI Agriculture - with stratification of subclasses	Y N	G F P
211	1 2 3 4	Suitability for field crops (specify)	Y N	G F P
212	1 2 3 4	Suitability for forage crops (specify)	Y N	G F P
213	1 2 3 4	Suitability for vegetable crops (specify)	Y N	G F P
214	1 2 3 4	Suitability for tree fruits (specify)	Y N	G F P

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
215	1 2 3 4	Suitability for small fruits (specify)		Y N	G F P			
216	1 2 3 4	Suitability for irrigated crops (specify)		Y N	G F P			
217	1 2 3 4	Suitability for rangeland (specify)		Y N	G F P			
218	1 2 3 4	Suitability for farming systems (specify)		Y N	G F P			
219	1 2 3 4	Other agricultural uses (specify)		Y N	G F P			
220	1 2 3 4	Crop yield potential		Y N	G F P			
221	1 2 3 4	Erosion hazard		Y N	G F P			
222	1 2 3 4	Trafficability		Y N	G F P			
223	1 2 3 4	Other agricultural interpretations (specify)		Y N	G F P			
224	1 2 3 4	Other agricultural interpretations (specify)		Y N	G F P			
225	1 2 3 4	CLI Forestry - basic		Y N	G F P			
226	1 2 3 4	Forest productivity potential		Y N	G F P			
227	1 2 3 4	Suitability for specific tree species		Y N	G F P			
228	1 2 3 4	Seedling regeneration		Y N	G F P			
229	1 2 3 4	Forest access roads		Y N	G F P			
230	1 2 3 4	Other forestry interpretations (specify)		Y N	G F P			
231	1 2 3 4	Other forestry interpretations (specify)		Y N	G F P			

232	1 2 3 4	Urban development - general	Y N	G F P
233	1 2 3 4	Septic tank absorption fields	Y N	G F P
234	1 2 3 4	Sewage lagoons	Y N	G F P
235	1 2 3 4	Sanitary landfill (trench)	Y N	G F P
236	1 2 3 4	Sanitary landfill (area)	Y N	G F P
237	1 2 3 4	Shallow excavations	Y N	G F P
238	1 2 3 4	Houses without basements	Y N	G F P
239	1 2 3 4	Houses with basements	Y N	G F P
240	1 2 3 4	Housing - general	Y N	G F P
241	1 2 3 4	Local roads and streets	Y N	G F P
242	1 2 3 4	Source of topsoil	Y N	G F P
243	1 2 3 4	Source of fill	Y N	G F P
244	1 2 3 4	Source of sand	Y N	G F P
245	1 2 3 4	Source of gravel	Y N	G F P
246	1 2 3 4	Ponds and reservoirs	Y N	G F P
247	1 2 3 4	Embankments, dykes etc.	Y N	G F P
248	1 2 3 4	Drainability	Y N	G F P

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
249	1 2 3 4	Grassed waterways		Y N	G F P			
250	1 2 3 4	Picnic areas		Y N	G F P			
251	1 2 3 4	Campsites		Y N	G F P			
252	1 2 3 4	Playgrounds		Y N	G F P			
253	1 2 3 4	Paths and trails		Y N	G F P			
254	1 2 3 4	Recreation potential		Y N	G F P			
255	1 2 3 4	Identification of specific hazards		Y N	G F P			
256	1 2 3 4	Pipelines		Y N	G F P			
257	1 2 3 4	Other engineering uses (specify)		Y N	G F P			
258	1 2 3 4	Soil potential ratings (USDA)		Y N	G F P			
259	1 2 3 4	Explanation of interpretive criteria			G F P			
260	3 4	Ease of understanding interpretations			G F P			
261	2 3 4	Planning of interpretive map retrievals		Y N	G F P			
262	3 4	- specify which categories of interpretive map retrievals to be issued with the published report (use reference numbers in left margin above): black and white or two colour (indicate under remarks)	# # # #					

263	4	- specify which categories to be issued after publication of soil map, or instead of soil map (use reference numbers in left margin above): black & white or 2 colour	# # # #	
264	4	- specify which categories to be issued as microfiche	# # # #	
265	4	Indication to users of availability of interpretive retrievals	Y N	G F P

CORRELATION PROCEDURES, MISCELLANEOUS INFORMATION

266	1	Adequacy of documentation on corre-	Y N	G F P
	2	lation tours	Y N	G F P
	3	- airphotos, soil field maps	Y N	G F P
267	1	- working legend	Y N	G F P
	2		Y N	G F P
	3		Y N	G F P
268	2	- draft final legend	Y N	G F P
	3		Y N	G F P
269	1	- documentation of existing and proposed	Y N	G F P
	2	map units including criteria of differ-	Y N	G F P
	3	entiation from competing units	Y N	G F P
270	1	- documentation of existing and proposed	Y N	G F P
	2	series or other taxonomic units, includ-	Y N	G F P
	3	ing differentiation for competing units	Y N	G F P

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
271	1	- records of random transect results		Y N	G F P			
	2			Y N	G F P			
	3			Y N	G F P			
272	1	- general characteristics of landform types (map or brief report)		Y N	G F P			
	2			Y N	G F P			
	3			Y N	G F P			
273	1	- information on character and distribution of natural vegetation communities		Y N	G F P			
	2			Y N	G F P			
	3			Y N	G F P			
274	1	- geology maps		Y N	G F P			
	2			Y N	G F P			
	3			Y N	G F P			
275	1	- climatic data		Y N	G F P			
	2			Y N	G F P			
	3			Y N	G F P			
276	2	- analytical data		Y N	G F P			
	3			Y N	G F P			
277	2	- record of field measurements		Y N	G F P			
	3			Y N	G F P			
278	2	- crop yield data		Y N	G F P			
	3			Y N	G F P			
279	2	- forest productivity data		Y N	G F P			
	3			Y N	G F P			

280	1	- correlation tour documentation	A B NA		G F P
	2	supplied to participants in	A B NA		G F P
	3	advance (A), on tour (B), not	A B NA		G F P
		available (NA)	A B NA		G F P
281	1	Organization of correlation tour			G F P
	2				G F P
	3				G F P
282	2	Attention to actions required from		Y N	G F P
	3	previous review		Y N	G F P
	4			Y N	G F P
283	1	Documentation of research needs		Y N	
	2			Y N	
	3			Y N	
	4			Y N	
	1 2 3 4	Representation of disciplines among survey personnel. Indicate full-time (F), part-time (P) or occasional (O)			
284		- soil science	F P O	Y N	
285		- agriculture	F P O	Y N	
286		- forestry/ecology	F P O	Y N	
287		- geology/geomorphology	F P O	Y N	
288		- climatology	F P O	Y N	
289		- hydrology	F P O	Y N	
290		- geotechnical/engineering	F P O	Y N	

	Applicable Correlation Level (CL)	Item	Data	Evaluation Yes/ No	G F P	Action Required & Remarks	Action Taken ( )	Change Sheet (#)
291		- planning	F P O	Y N				
292		- other (specify)	F P O	Y N				
		Plans for public information meetings						
293	2 3 4	- before completion		Y N				
294	3 4	- at completion		Y N				

Transect Mapping And Its Application

C. Wang

Introduction

Since the first soil survey program was introduced in Canada in 1913, continuous effort has been made to develop a better soil classification system for Canadian soils. A good soil classification system reflects the current stage of knowledge and concepts and it must be modified as knowledge grows and new concepts develop (Canada Soil Survey Committee, 1978). In recent years, more quantitative measurements of soil properties have been defined for use as criteria in classifying soils. This is a result of the progress of soil science over the years as well as of the increasing public demand for more quantitatively interpreted soil survey reports.

A good soil survey report starts with a reliable soil map. And a reliable map requires well-defined map units. Well-defined map units not only have the dominant soils and subdominant soils quantitatively defined, but also have the soil variability well-defined within the map units and between the different map units.

If one accepts the above requirement of well-defined map units then it may be stated that some of our map unit descriptions prepared in the past were not well-defined. We recognized these problems some years ago and thereafter began the work of developing a "mapping system for Canada". There are numerous methods developed to check the accuracy of a map after the field work is completed; most depend on a return to selected sites for sampling on a more intensive scale.

The emphasis, however, needs to be placed on the development of methods of examining soils early in the phase of map legend development. These should help us to understand and clearly describe to other specialists, and to the nonspecialist public, the degree of variability among the components included in the map units.

Here we reintroduce the transect method. This proposal is a fresh look at methods of examining landscapes, of recording the observations, of analyzing the results, and of describing the variability observed. This approach should assist us to achieve better control of quality and accuracy (correlation) of the survey at all stages from beginning to completion and, not coincidentally, enable us to better inform the users of the data as to its reliability.

Application

The application of soil transect methods can be used in three different aspects of soil survey.

A. In legend establishment and field mapping - Soil transects can be used to estimate the extent, kind, and nature of potential map units during legend construction by the party leader. The preliminary map unit can thereafter be subdivided or combined as accumulated information dictates during the process of mapping (Arnold 1977). Soil transects can also be used to replace conventional mapping methods. Steers and Hajek (1979) demonstrated that the transect method increased mapping productivity up to 500% over the conventional soil mapping method while maintaining the same map quality.

B. In finalizing soil map and soil correlation - Information collected from the transects during the course of the field survey can be used to estimate the composition of map unit delineations and to quantify map units (Steers and Hajek, 1979).

By using Arnold's "Graphical solution of binomial confidence limits in soil survey" (1979), random transects can provide a quick and reliable method in mapping area correlation.

C. In soil interpretation - In soil interpretation, it is not always important to know the composition of a mapping unit (i.e. the soil series involved) but rather it is more important to know the range of a certain soil property or properties which is (are) crucial for a certain type of land use. It is, therefore, important to state the range of soil characteristics of a map unit with a certain level of confidence. Made aware of the risk, the user can thereafter more safely plan his investment in site preparation.

Methodology

A. In legend establishment and field mapping - The transect method involves the following steps (Hajek, 1977):

1. Soils are mapped and investigated in the field by conventional means. An adequate amount of time is devoted to soil series identification and landscape evaluation so that key soil association patterns for mapping units are established. After map units are designed, areas are traversed and delineated on field sheets. All delineations are investigated to some extent and project boundaries are checked by on-site soil investigation.

2. As a part of the preliminary (20%) field mapping and investigation, available transects* are identified which in the soil scientist's judgement fairly represent all components of the delineation. These available transects are distributed evenly among the map unit delineations in the survey area in order to characterize areas significant to the expected average-size management plots for the most common probable use. These transects are examined and site data recorded.

Hajek (1977) has used a ratio of 1 transect for every 120 to 240 ha in reconnaissance surveys for woodland planning, but this ratio was varied in accordance with area and needs. Each delineation, no matter how large or small, should include a minimum of 1 potentially available transect. Transects were commonly located at right angles to drainage patterns, included as much of the complete range in elevation as possible, and represented the typical landscape for the area delineated.

3. A record of each available transect completed is maintained (example 1a). After a sufficient area of a particular mapping unit is mapped (about 20% of its expected occurrence) transects are selected by use of a random number table. The total number of transects for initial sampling varies with extent of the unit, number of delineations, and complexity of soil patterns.

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*Those transects reasonably accessible to the surveyor.

Example 1a

SOIL TRANSECT DATA SHEET

Page No. ________

County | Soil Mapping Unit

Transect No. | Direction | Boring Interval | Length

Starting Location

Date | Photo | By

Remarks

Profile No. ________

Percent Slope | Aspect | Erosion

Position on Slope

Horizon	Depth	Color	Tex-ture	Struc-ture	Consis-tence	Mottles	Frag-ments	Clay Films	pH

Additional Notes *

Series

Classification

Profile No. ________

Percent Slope | Aspect | Erosion

Position on Slope

Horizon	Depth	Color	Tex-ture	Struc-ture	Consis-tence	Mottles	Frag-ments	Clay Films	pH

Additional Notes *

Series

Classification

Profile No. ________

Percent Slope | Aspect | Erosion

Position on Slope

Horizon	Depth	Color	Tex-ture	Struc-ture	Consis-tence	Mottles	Frag-ments	Clay Films	pH

Additional Notes *

Series

Classification

*If soil sample is taken for analysis, check (✔) the appropriate horizon where sample was taken and record the soil sample no. as additional notes.

Example 1b

MAP UNIT Eustis - Troup

Soil Series	Transect Numbers														
	26	32	33	34	36	37	38	42	43	44	46	47	48	49	50	ΣX
							%*									
Eustis	37	25	29	37		13	13	8			8	25	9	36		240
Dorovan	9	8			7		6				21	16				67
Esto	18	17	14	10	28	13	13	15	45	18	35		17		17	260
Osier	9	8	7	9	7	8	6	8				25	8	19		114
Troup	18	25	36		43	33	31		19	8	14	17		36	34	314
Bibb	9		7	9				8	9	8	8		17		8	83
Norfolk		17	7	18	15	33	31	61	27	58	14	17	41	9	41	389
Goldsboro				18						8			8			34

* x = % of a certain soil in a transect

Map Unit Eustis-Troup Example 1c

STATISTICAL ANALYSIS

	Soils							
	Eustis	Dorovan	Esto	Osier	Troup	Bibb	Norfolk	Goldsboro
ΣX	240	67	260	114	314	83	389	34
$\bar{X} = \frac{\Sigma X}{n}$	16	4.5	17.3	7.6	20.9	5.5	25.9	2.2
$\Sigma(X^2)$	6672	927	6408	1538	9506	837	14679	452
$(\Sigma X)^2$	57600	4489	67600	12996	98596	7744	151321	1156
$\Sigma(X - \bar{X})^2 = \Sigma(X^2) - \frac{(\Sigma X)^2}{n}$	2832.06	627.20	1901.20	672.00	2933.00	378.00	4590.60	3752.0
$s^2 = \frac{\Sigma(X - \bar{X})^2}{n - 1}$	202.29	44.8	135.8	48.0	209.5	27.0	327.9	26.8
$s_{\bar{X}}^2 = \frac{s^2}{n}$	13.47	2.99	9.05	3.20	13.97	1.80	21.86	1.79
$s_{\bar{X}}$	3.67	1.73	3.00	1.79	3.74	1.34	4.68	1.34
$t\,s_{\bar{X}}$ at 80% confidence level	4.94	2.33	4.04	2.41	5.03	1.80	6.29	1.80
Confidence interval (%) $\bar{X} \pm ts\bar{X}$	11.1-20.9	2.2-6.8	13.3-21.3	5.2-10.0	15.9-25.9	3.7-7.3	19.6-32.2	0.4-4.0
sample size $y = \frac{t^2 s^2}{d^2}$	16	41	9	16	10	17	10	103

where:

- $\bar{X}$ = mean percentage of a certain soil found in a map unit
- n = number of transects observed. In this example, n 16
- s^2 = estimate of variance
- $s\bar{X}$ = standard error
- t = see Table 1. In this example, at 80% confidence level and df = 15, t = 1.341
- y = number of transects needed for a specific confidence level. In this example, the confidence level is 80%
- d = $\bar{X}(0.3)$ for 80% confidence level. For 90% confidence level, d = $\bar{X}(0.2)$

Table 1

Degree of freedom (df=n-1)	t value Confidence level			
	70%	80%	90%	95%
1	1.963	3.078	6.314	12.706
2	1.386	1.886	2.920	4.303
3	1.250	1.638	2.353	3.182
4	1.190	1.533	2.132	2.776
5	1.156	1.476	2.015	2.571
6	1.134	1.440	1.943	2.447
7	1.119	1.415	1.895	2.365
8	1.108	1.397	1.860	2.306
9	1.100	1.383	1.833	2.262
10	1.093	1.372	1.812	2.228
11	1.088	1.363	1.796	2.201
12	1.083	1.356	1.782	2.179
13	1.079	1.350	1.771	2.160
14	1.076	1.345	1.761	2.145
15	1.074	1.341	1.753	2.131
16	1.071	1.337	1.746	2.120
17	1.069	1.333	1.740	2.110
18	1.067	1.330	1.734	2.101
19	1.066	1.328	1.729	2.093
20	1.064	1.325	1.725	2.086
21	1.063	1.323	1.721	2.080
22	1.061	1.321	1.717	2.074
23	1.060	1.319	1.714	2.069
24	1.059	1.318	1.711	2.064
25	1.058	1.316	1.708	2.060
26	1.058	1.315	1.706	2.056
27	1.057	1.314	1.703	2.052
28	1.056	1.313	1.701	2.048
29	1.055	1.311	1.699	2.045
30	1.055	1.310	1.697	2.042
40	1.050	1.303	1.684	2.021
60	1.046	1.296	1.671	2.000
120	1.041	1.289	1.658	1.980
∞	1.036	1.282	1.645	1.960

4. Transects should include between 10 and 20 observations. Intervals between observations vary depending on the length of transects. Data are recorded in terms of percent composition of various included soils (example 1b).

5. Statistical analysis include a simple one-way analysis of variance (Steel and Torrie, 1960) that provides estimates of variance and gives the following useful parameters (example 1c):

a. arithmetic mean for each specific soil component,
b. number of traverses (y) needed to determine soil components at a specific confidence (80%)*, and
c. confidence interval (of a mean) at a specific level of confidence (80%).

6. The statistical data are used by party leaders in writing their mapping unit descriptions. These data become the basis for land use planning and interpretations before completion of the survey. A few map units may be inconsistent in soil composition at the first sampling. Further study of these map units likely will reveal that some delineations are mapped too broadly for the original mapping unit definition. In these instances a reinvestigation of questionable delineations should be performed, and an additional map unit should be designed and evaluated by the same random transect procedures. Such inconsistencies commonly show up at the time transects are completed and before statistical analysis.

7. After 80-100 percent of field mapping is completed another random sampling is conducted. A guide for the number of transects (sample size) needed is determined by considering data from the initial sample. In determining the number of transects for final sampling, we use "y" values that give the transects needed to characterize about 80 percent of soil occurrence. Populations for final random sampling include the complete available transect population and each has an equal possibility of being selected. These data are analyzed in the same manner as the initial sample, summarized, recorded, and used in preparation of the soil survey manuscripts.

Examples 1(a,b,c) show the field data form used, summarized data, and a statistical worksheet for the Eustis-Troup complex map unit in Alabama. The number of transects needed to characterize this unit was based on the highest "y" value (i.e. 16) calculated from among the series that make up 80 percent of the mapping unit (Σ largest $\bar{x}$ = 80%), that is, Eustis, Esto, Troup, and Norfolk.

For less complicated map units, the calculated "y" value almost always found to be less than 10 and usually less than 5 at the stage when 20% of the mapping was completed. These values were confirmed when 95% of the area was mapped.

B. In finalizing the soil map and in soil correlation - The method described above can also be used in finalizing the description of the soil map unit at the end of the field survey instead of at the 20% completion stage as suggested above. For the purpose of correlation,

*The confidence level can be set at any desirable level (see Table 1).

FIGURE 1

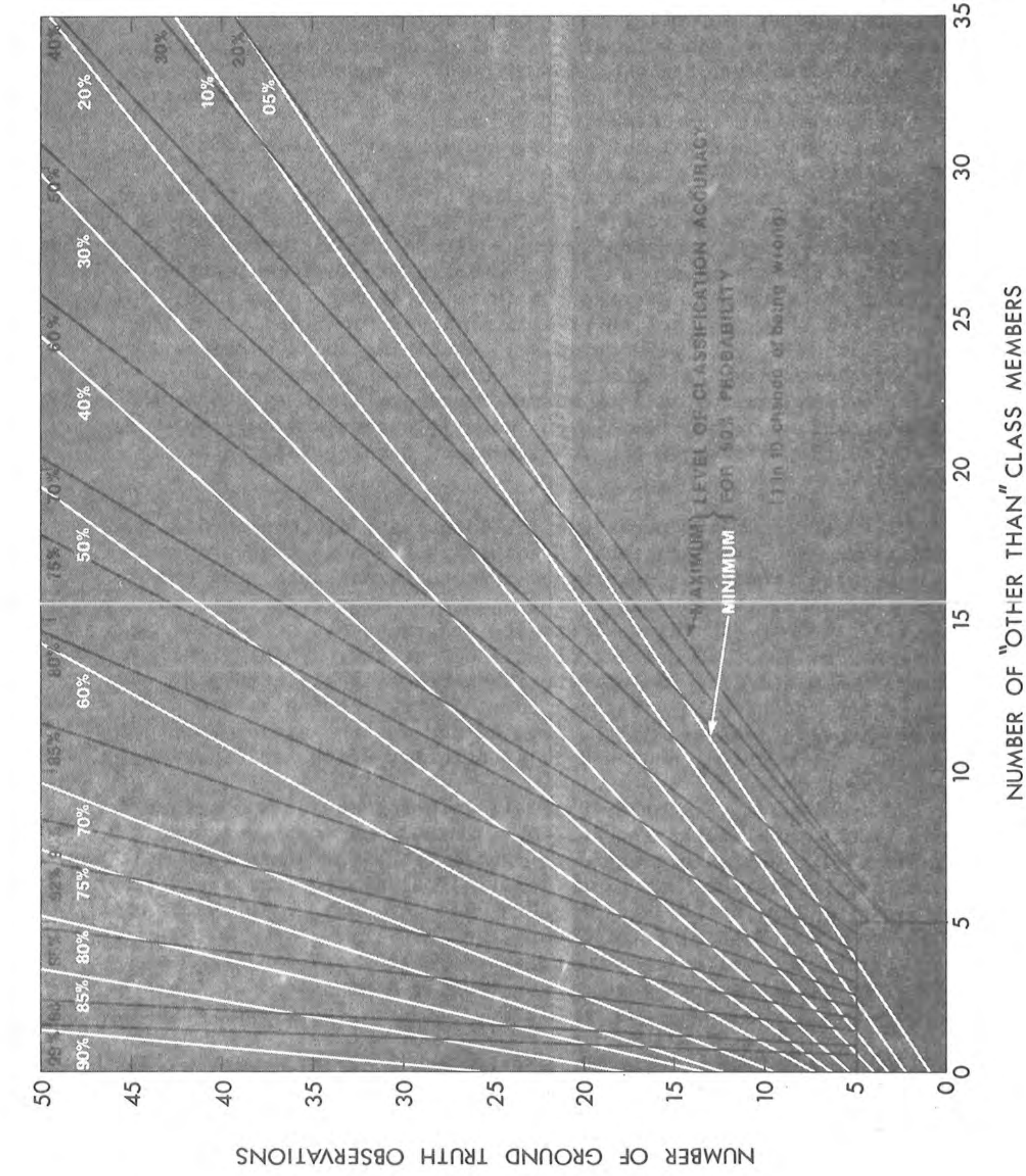
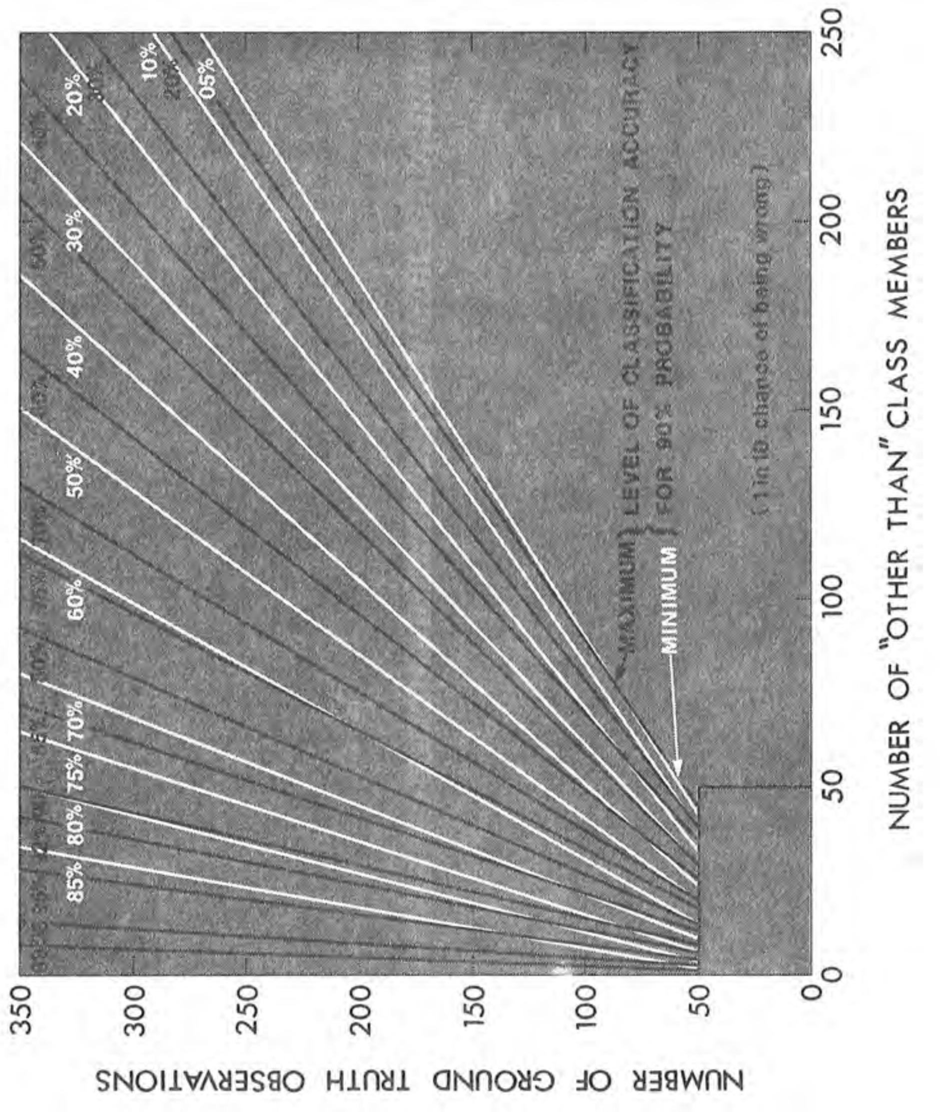

NUMBER OF "OTHER THAN" CLASS MEMBERS
NUMBER OF GROUND TRUTH OBSERVATIONS
MINIMUM
0
5
10
15
20
25
30
35
40
45
50
90%
85%
80%
75%
70%
60%
50%
40%
30%
20%
10%
05%

FIGURE 2


NUMBER OF GROUND TRUTH OBSERVATIONS
NUMBER OF "OTHER THAN" CLASS MEMBERS
0
50
100
150
200
250
300
350
MAXIMUM } LEVEL OF CLASSIFICATION ACCURACY
MINIMUM } FOR 90% PROBABILITY
(1 in 10 chance of being wrong)
85%
80%
75%
70%
60%
50%
40%
30%
20%
10%
05%

Arnold (1979) introduced the graphical binomial confidence limit method, which is simple and effective. The transects used are randomly selected by methods similiar to those of Hajek (1977) described above.

1. Use of Confidence Limits

In making probability statements there are trade-offs to be evaluated. For any set of observations, one can vary the chances of being wrong (confidence level) or one can vary the limits of accuracy (degree of correctness). It is always a compromise.

For illustration purposes, the graphs presented here is only one level of confidence, 1 in 10 chances of being wrong (90% confidence level). For each confidence level there are 2 graphs; Figure 1 gives confidence limits for 0 to 50 samples, Figure 2 for 0 to 350 samples. Thus, one has some flexibility in the size of sample chosen.

A lower limit (or minimum accuracy) lets the surveyor make an at least statement. An upper limit (or maximum accuracy) lets him make an at most statement.

Assume the surveyor completes 4 transects having 13, 9, 7, and 11 observations for a total of 40. Out of that 40 only 30 belong to the same class. The predicted maximum accuracy is calculated to be about 83% and the minimum accuracy about 62%. He, therefore, estimates that the map unit contains between 62 and 83% of the major component based on the observations and acceptance of a 1 in 10 chance of being wrong.

2. How Many Samples to Take

The minimum number of observations to make varies with the chances of being wrong (confidence level) and the level of accuracy (degree of correctness) desired.

The graphs for the lower confidence limit can be used to estimate how many samples are needed. If one sets the probability at 90% and desires the estimate to be at least 80% accurate when applying the sample results to the rest of the map unit, then Figure 1 is used in the following manner.

Follow the 80% line for minimum level of classification accuracy down to the Y axis where there are 0 "other than" class members and read 14. This means there will be 14 random observations all belonging to the same class, that is, 14 out of 14. If, on the other hand, one finds 3 observations that belong to other classes, then go to 3 on the X axis and vertical to intersect the 80% accuracy level and over on the Y axis where it indicates a need for about 34 observations. This means that with 31 out of 34 observations belonging to the same class, one will expect an 80% accuracy of the major component.

Another way to think about the number of samples required is exemplified by the following. Two hundred observations must not include more than about 27 of "other" classes if 80% accuracy is to be achieved.

The graphs for upper confidence limits are not applicable to estimate sample numbers. By looking at one of the upper limit graphs, the reader will see that the lines do not intercept the Y axis above zero, because we do not know what constitutes a negative sample.

C. In soil interpretation - In soil interpretation certain properties of map units often hold the key to interpretation. For example, hydraulic conductivity to septic tank; soil texture, climate and drainage to frost action; slope and texture to erosion etc. Each soil property of a map unit observed during the field survey and the analytical data measured in the field or laboratory can be analyzed by modern statistical methods and quantitatively expressed.

A Local Example

A relatively uniform soil map unit near Ottawa was chosen to demonstrate how soil variability can be quantitatively expressed by statistical means. Some of the results are also briefly discussed.

Dalhousie map unit (D/4.1) on the soil map of Gloucester and Nepean Townships (Marshall and Dumanski, 1979) were used for this study. Dalhousie is developed on marine clay with relatively flat landform. All the delineations of Dalhousie map unit were numbered on the map. The numbered delineations were divided into two groups, one group has all the delineations greater than 50 hectares, the other group less than 50 hectares. The reason for the split into two groups is that we can also test whether the soils in small delineations differ from the soils in large delineations. Because the marine clay is relatively uniform in composition and landform, we randomly chose only five delineations from each group, and one transect was randomly located on each of the chosen delineations (the transect was located more or less near the center of the delineation). For each transect, a total of ten (10) sites at a prefixed distance interval were opened, a brief soil description and two soil samples (a surface sample at 0-15 cm and a subsoil sample at 50-60 cm) were taken from each site. Soil samples were air dried, sieved (passing 2 mm sieve) and analyzed for a number of selected soil properties.

Results and Discussion

Selected results are presented in Table 2, 3 and 4. Methods for calculating means ($\bar{x}$), standard deviation (s) and deviation of means ($S\bar{x}$) are in Example 1c. The equation for calculating pooled deviation can be found in Steel and Torrie (1960). Following are our main findings:

1. Laboratory data (Table 2 and 3) as well as field data (Table 4) can be quantified by statistical means.
2. The range of soil properties are usually realistically wider when quantified by random transect method than we did traditionally by central concept or model profile method.
3. There is no difference between large and small delineations in this map unit among the properties tested.
4. Transect method may or may not increase the demand for soil analysis. In the past, we also did a lot of analysis, but the soil samples we took were not properly designed.
5. Should a major map unit having too wide of a range of certain characteristics, transect method can detact this problem at the early stage of mapping.

Table 2. % Org. Carbon in A Horizon

Transect No.	$\bar{x}$ (Mean)	S (Standard Deviation)
T1	2.03	0.76
T2	2.45	0.65
T3	1.71	0.25
T4	3.07	0.94
T5	3.58	0.73
T6	2.29	0.56
T7	3.08	2.19
T8	2.67	0.47
T9	2.09	0.63
T10	2.83	0.55

Mean of 10 transects	Deviation of means	Pooled deviation (100 samples)
2.58	0.54	0.90

At 80% confidence level:

1. Range of % Org. Carbon for a randomly selected transect

   $= 2.58 \pm 0.54 \times 1.3$

   or, from 1.88 to 3.28 (%)

2. Range of % Org. Carbon for a randomly selected sample

   $= 2.58 \pm 0.9 \times 1.3$

   or, from 1.41 to 3.75 (%)

Table 3. % Clay in Subsoil (50-60 cm)

Transect No.	$\bar{x}$ (Mean)	S (Standard Deviation)
T1	34.0	4.9
T2	36.8	7.5
T3	42.7	8.5
T4	40.1	6.6
T5	25.6	5.0
T6	47.1	5.3
T7	49.0	3.4
T8	34.1	6.1
T9	31.8	9.6
T10	35.4	4.6

Mean of 10 transects	Deviation of means	Pooled deviation (100 samples)
37.7	6.8	6.8

At 80% confidence level:

1. Range of % Clay for a randomly selected transect

   = 37.7 ± 6.8 x 1.3

   or, from 28.9 - 46.5 (%)

2. Range of % Clay for a randomly selected sample

   = 37.7 ± 6.8 x 1.3

   or, from 28.9 - 46.5 (%)

Table 4. Value of Soil Color

Transect No.	$\bar{x}$ (Mean)	S (Standard Deviation)
T1	4.0	0.447
T2	3.5	0.415
T3	3.4	0.436
T4	3.4	0.450
T5	3.0	0
T6	3.9	0.391
T7	3.9	0.320
T8	2.8	0.403
T9	3.1	0.150
T10	3.1	0.350
	Mean of 10 transects	Deviation of means
	3.4	0.396

At 80% confidence level:

Range of value = 3.4 ± 0.396 x 1.3

or, Range from 2.9 to 3.9

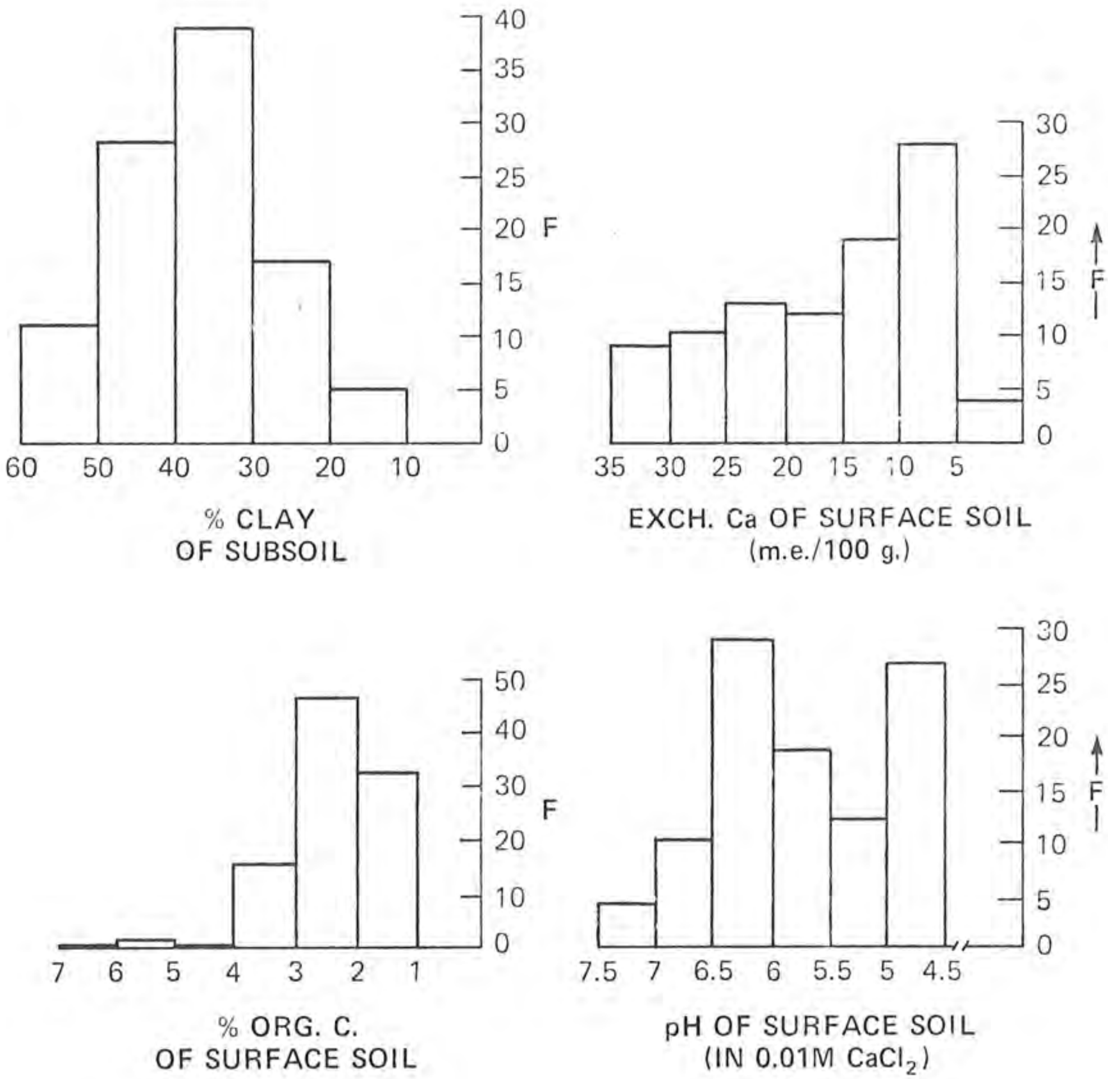


Figure 3. Frequency Distribution of Some Selected Soil Properties.

6. The statistical methods used to quantify soil properties described in this paper can be applied only to the properties which have a normal frequency distribution (i.e. % of clay and % of Org. C. in Figure 3). For the properties which are not normally distributed (i.e. Exch. Ca. and pH in Figure 3), a statistician should be consulted to transform the data into normal distribution before the final analysis.

List Of References

Arnold, R.W. 1977. CBA -- ABC -- clean brush approach achieves better concepts. Proceedings of New York Conference on soil mapping quality. Bergamo East, New York.

Arnold, R.W. 1979. Strategies for field resource inventories. Agronomy Mimeo 79-20. Dept. of Agronomy, Cornell Univ., Ithaca, New York. 14853.

Canada Soil Survey Committee. 1978. The Canadian system of soil classification. Can. Dept. Agric. Publ. 1646. Supply and Services Canada. Ottawa, Ont. 164 pp.

Hajek, B.F. 1977. Evaluation of map unit composition by the random transect method. Agronomy Mimeo No. 77-23. Dept. of Agronomy, Cornell Univ. Ithaca, New York. 14853.

Marshall, I.B. and Dumanski, J. 1979. Soils of Gloucester and Nepean Townships, Carleton County, Ontario. Land Resource Research Institute, Canada Dept. of Agriculture.

Steel, R.G.D. and Torrie, J.H. 1960. Principles and Procedures of statistics. McGraw-Hill Book Co. Inc.

Steers, C.A. and Hajek, B.F. 1979. Determination of map unit composition by a random selection of transects. Soil Sci. Soc. Am. J. 43:156-160.

The Role Of Taxonomy In Mapping

W.W. Pettapiece

The replies received indicate the following:

1. taxonomy be used to define our soil map units (Nfld is an exception, using taxonomy at subgroup level to characterize?).
   - actually using the rest of the info provided one could argue that they are using phases of subgroups.

2. the level of taxonomy used can vary from one survey intensity level (SIL) to another and even within one SIL as long as it is consistent with the purpose of the survey or particular map unit.
   - series and phases of subgroups are the two main taxonomic units being used.
   - in some cases, wet soils in particular, the map unit may use the taxonomy at a higher level - Great Group or Order.

3. the legend may or may not include taxonomy - suggestions both ways - but even if included it should be downplayed.

Given the above I will try to come up with an approach to the use of taxonomy in our mapping system. Other terms of reference (boundary conditions)I would like to recognize are a) that mapping will be done on a map unit basis (rather than mapping individuals à la Manitoba) and b) that a good deal of control will be exercised in legend development and mapping.

Taxonomy gives us sets of parameters with limits or boundaries established by experience. For example, chernozemic soils are grassland soils characterized by organic-rich surface horizons. This allows one to make some kinds of interpretations about those soils, but is still quite general at that level. Other levels of taxonomy may have more restricting sets of <u>parameters</u>, but about which we can be much more specific in estimating their behaviour. For example, Dark Brown Chernozemic soils-smooth lacustrine phase, gives us a more definitive set of characteristics and we could now suggest crop suitability, possible yields and maybe some engineering interpretations. Lethbridge silt loam is an even further refinement. We know that the soil is not calcareous, saline, or gleyed, it has excellent moisture characteristics and we have specific yield and management figures.

These "sets of parameters" we call taxonomy should be used in the basic definition of our map units and in the legend development. This is true whether we are working at SIL 2 where a phase of a series may be our taxonomic entity or at SIL 4 where an association of phases of subgroups is used.

It might be useful to emphasize here that I use taxonomy in a very broad sense. The taxonomy per se is our classification system, but it is given material or other pertinent attributes by using phases. For example, Orthic Gray Luvisol, medium-textured till phase or Gleysols, fine clayey lacustrine phase. The Orthic Gray Luvisol, medium-textured till phase is very close to, and in fact might be equivalent to, a family separation if the other family criteria of pedoclimate etc. happen to be satisfied. Using this approach I would argue that Nfld could satisfactorily define their units on the basis of "taxonomy".

To carry on, I would follow this to the Map Unit stage of adding landform or slope phases and, depending on the complexity of soils and scale of mapping, by recognizing and including accessory or included soils. We could therefore have units such as:

a) Red River series, class 2 slope with minor inclusions of Osborne series.

b) an association of Orthic, Eluviated and Gleyed Dark Brown Chernozemic soils, developed in medium-textured, strongly calcareous till, undulating moraine with class 3 slopes. The relative proportions of each major subgroup as well as minor inclusions would be noted. These would be the in-house definitions.

If one wished to downplay taxonomy in a published legend the, the unit descriptions could be:

a) Deep imperfectly drained very fine clayey soils on nearly level lacustrine materials.

b) Deep, well to imperfectly drained, medium-textured soils on undulating morainal materials.

The legend might also have a column for the soil taxa if one so desired. But, in any event, these units are still taxonomically defined units.

The extension of taxonomic definition always seems to be that it therefore follows that every time there is a change in taxa there must be a change in map unit. This does not follow. The map units are designed to fit the needs of the survey being conducted. When a survey legend is being prepared, the pedologist must determine what level of soil taxa is most suitable to identify the mapping units, and what soil map units are necessary to best satisfy the purpose of the survey (USDA Soil Survey Manual). Map units can be identified by one or more names of taxonomic classes, but they are not the same as soil taxa. Also, "Taxonomic purity has never been the primary objective of making soil surveys. (contrary to popular belief and some mapping too), nor should it be construed as a test of the usefulness of soil surveys". (Miller at al Soil Survey Horizons, fall 1979). The basic, most important, principals are that the map separations are identifiable, definable and meaningful. If they happen to be taxonomically uniform then it makes the description and possibly interpretations easier, but taxonomic purity is not a prerequisite for good soil mapping.

The kind of information to be included in a legend depends on the kind and purpose of the legend. If the legend is an identifier only, to direct the user to a page in the report, then only the symbol needs to be considered (see eg. U.S. reports). If, on the other hand, an extended legend is used (such as most of our reconnaisance maps) to allow the map to be used separately from the report then much more information is required. Such legends have traditionally used material phases and the taxonomic system along with texture and often climate (zone or ecoregion) and physiography (St. Lawrence Lowlands, Appalachian Uplands). Other attributes which have been used from time to time are drainage, reaction, slope, landform, vegetation, agriculture capability and acreage. Many combinations have been used, but "material" is the only item which occurs in the legend of every map. Nova Scotia, for example, does not list taxonomy in the legend but does use it extensively in the series descriptions.

The U.S. reports describe the series in terms of attributes such as drainage, kind of material, consistence, texture, permeability, depth of rooting zone and reaction. They then describe the map units which include slopes, landform inclusions, erosion potential and capability. The classification of soils is given in a table. Their series are established on the basis of taxonomy, but is strictly an exercise in-house.

Soil Mapping Systems*

K.W.G. Valentine

Initial Remarks

The general reaction of the Proposed Mapping System for Canada (Working Group on Soil Mapping Systems, 1979) over the last year has been favourable. Everyone found something of use in it, and most correspondents agreed with most of it. Only one province, Quebec, had serious reservations about the practicality of attempting such a large and difficult project.

The proposed system was not reproduced and widely distributed until September 1979. It has not yet had a full summer's field trial. Therefore, no changes are to be proposed at present. The only proposals contained in this report are for new legend definitions, and the definition of an inspection, which is necessary for planning the survey and for general survey procedures.

Many modifications have been suggested over the past winter. A full revision of the proposal will be necessary in the near future to reflect the progress of our thinking, and to eradicate such inconsistencies as the inclusion of the "map subunit" discussion. Perhaps spring 1981 will be the appropriate time after the system has had a full summer's trial and two winter's digestion.

Restricting the Terms of Reference

The working group would like to divest itself of the responsibility for a number of subjects that could be handled more appropriately by other groups. For instance sections 6. The Soil Report, 7. Interpretations, and 8. Other Recommendations of the Proposed Mapping System 1979 could best be handled elsewhere. Similarly, there are parts of section 2 such as inspection density, rate of progress and the survey planning sequence that a Soil Survey Procedures working group should deal with. However, the definition of survey intensity levels should remain a responsibility of our group, because the intensity level is central to much that happens subsequently in the mapping procedure. Similarly the minimum size delineation and map legibility would remain part of the recommendations for the soil map.

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The Nucleus of an Acceptable System

Inevitably most of the correspondence regarding the Proposed Mapping System 1979 concentrated on points of disagreement. However, when the dust had settled it became clear that there were large parts of the proposal that most people could accept. It will be well to emphasize these before they become overshadowed by the more contentious issues. The following is a list of the sections on which all (or a large majority) of the correspondents agreed.

1. - A System: the need for the rationalization of soil mapping at any intensity level or scale; in other words the raison d'être of the working group. However, there are still some reservations as to how "national" it needs to be.

   - The concept and contents of Table 1: distinguishing between maps by the criteria used to differentiate areas.

2. - Objectives: that it is important to have the objectives stated very early in the survey, and that these will govern much that comes later.

   - 2.1 Minimum size delineation: that it should be 0.5 cm^2 (with the average delineation being x4 - x20 larger).

   - 2.2 The concepts and contents (with some revision and expansion) of Table 3, Survey Intensity Levels.

3. - 3.1 The concepts and definitions of -

   Soil
   A Soil
   Nonsoil Individual
   Nonsoil Feature

There were some dissensions to the pedon as a soil individual and the polypedon as a soil mapping individual. However, there is a tendency for correspondents to insist on different names for things that are only subtly different. It sometimes appears that precise names become an end in themselves instead of only the beginning of communication.

- 3.2 The concept, definition and name Map Unit (omitting the map subunit). The map unit is established by a classification procedure (involving division and agglomeration) of parts of the soil landscape. It can be labelled with a name from any category (level) of our soil classification. It is represented on the map by all delineations that carry the same soil symbol (or combination of soil symbols) in the numerator portion.

- 3.3 Inclusions - the concepts and definitions of

  Similar soils.
  Taxadjuncts.
  Dissimilar soils.
  Nonlimiting inclusions.
  Limiting inclusions.

- 3.4 Use of on-site symbols (no definite agreement on actual symbols).

- 3.5 Stratification in the establishment of map units - including the concept that it need not be absolutely definite.

- 3.6 The establishment of map units (apart from the fact that portions of them are repetitive).

- 3.7 The concept and definitions of Single and Compound Map Unit, although we are still not completely agreed on how much taxonomy should contribute to the differentiation of map units.

- 3.9 Types of Compound Units. Most surveyors still wish to differentiate formally between a map unit with uniform parent material and one with contrasting parent materials.

- 3.10 Map Subunits - most people agreed with the rejection of this concept.

- 3.12 The concept that the establishment of map units involves the same procedure at any survey intensity level or scale; also the concept that the range of each criterion used to establish them (Table 6) and the meaning of uniform parent material must change at each Survey Intensity Level.

- 3.13 The attributes of phases and the two possible ways of treating them on a map, either 1) as a differentiating criterion for a map unit, or 2) as a subdivision of a map unit shown by a symbol in the denominator on the map. Most people advocated the latter approach.

4. - 4.2 Maps should have similar numbers of map units regardless of the survey intensity level.

- 4.6 Symbols. If the symbol is connotative soil names should be in the numerator, and phases, which are optional, should be in the denominator. There should be a maximum of three phases. The inclusion of genetic material as a phase in the symbol is usually superfluous.

5. - 5.1 Map delineation - definition and its relationship to the map unit (Figure 7).

   - 5.3 Phase symbols - seemed generally acceptable (though Newfoundland wanted 4 and possibly 5 irregular phases in the denominator - not 3).

   - 5.4 The use of color as more than just the differentiation of one delineation from another was accepted.

   - 5.5 Type sample site locations are to be shown. If inspection sites are also shown they should be put on a smaller map - not on the soil map itself.

Points of Disagreement

There is either a general disagreement with the proposed system, or a lack of agreement between correspondents, on the following points:

2.3 Inspection density - most people felt that 1 inspection per/cm^2 was unrealistic. Alternative estimates were -

Newfoundland	- 0.5 to 0.1 inspections per cm^2
British Columbia	- 0.02 inspection per cm^2 (N.E. Coal project)
Manitoba	- 0.4 - 0.5 inspection per cm^2

However, only British Columbia is completely outside the recommended range from 0.25 to 2 inspections/cm^2. It was pointed out that we need a definition of inspection. One is proposed in a subsequent part of this report.

A number of correspondents questioned the uncritical use of inspection density as a measure of reliability, without taking into account the ease of extrapolation or the experience of the surveyor etc.

- Rate of Progress - appeared conservative - other estimates

Ontario	- Haldimond - Norfolk 300 ha/day
	Ottawa - Carleton 650 ha/day
B.C.	- N.E. Coal Project (S1L 3) 150 km^2/man-month
	Pend d'Oreille (S1L 2) 1000 ha/man-month
Manitoba	- 1:20,000 scale 300 ha/day

If a Survey Procedures working group deals with this in the future they should stipulate what activities are to be considered in this calculation. For instance it should include sampling, but does it include correlation and transect checking?

2.4 Planning Sequence - the sequence of the steps and the feasibility of establishing the "minimum field delineation" as early as step ii were questioned.

3.2 and 3.6 Map Units - there was some discussion on the contribution of soil taxonomy to the differentiation of map units. This whole question will be discussed by W.W. Pettapiece in a separate presentation.

There is still no agreement (by explicit dissension or by implication) as to whether portions of map units need be repetitive.

4.1 Legends - open, controlled, closed - this is the biggest single source of disagreement. It is important that a number of basic concepts and definitions are agreed upon. The topic is therefore discussed separately below.

4.3, 4.4 and 4.5. Some correspondents advocate the uncontrolled form of published legend. Map unit descriptions, description forms and a CanSIS map unit file are not envisaged.

5.2 Map Texture Intensity. The idea was acceptable but most people baulked at "texture". Map Delineation Intensity was suggested.

5.6 Reliability - as mentioned above the use of inspection density as a measure of reliability was not completely acceptable.

Appendix 6: Those who commented at all, felt we should consider generic names in the future or not at all.

Inspection: proposed definition

"A ground examination which the pedologist can use to verify the differentiating characteristics of a map unit. It is a point whose location and soil landscape characteristics have been determined with confidence and from which one can extrapolate. This will usually mean a soil exposure by shovel or augur, but could range up to a fly-past in the case of a rock outcrop."

The Legend Debate

This is where the fun begins. It is where we are farthest apart. Our working group was requested to propose different legend formats for different Survey Intensity Levels. However, that is impossible until we can agree on what we mean by the terms open and controlled etc. Therefore, a number of definitions are offered in the following few paragraphs, along with a brief discussion of the advantages of controlled and uncontrolled legends.

Legends: stages and forms

The discussion that has revolved around the terms open and closed, controlled and uncontrolled embodies two ideas relating to the establishment and description of map units. Firstly, there is the idea of the freedom that a surveyor has to create new map units in the course of his survey. Secondly, there is the question of whether each map unit is described in one place in the legend, or whether the map unit symbol is a composite of letters and numbers that are described in different parts of the legend.

It appears necessary to separate and define both these concepts. Therefore definitions are offered under the headings Stages and Forms:

STAGES:

1. Stage 1. - Information is collected about groups of related soil landscape characteristics. New information about soil characteristics relevant to the survey is added as the mapper works through his area. In effect the polypedons are identified.

2. Stage 2. - Characteristics (or groups of characteristics in the form of polypedons) are assembled into soil landscape components that are significant to the purpose of the survey and that are generally repetitive. In effect the establishment of map units is begun.

3. Stage 3. - The significant components of the soil landscape are combined into a finite number of map units.

   These stages are not completely sequential. They will overlap to a large extent during the course of the survey. Some map units will be fully established very early (from adjacent published surveys for instance). Others may await the identification of new information up to the end of the field work (inaccessible areas of exploratory surveys for instance).

FORMS:

1. Open Form - classes of selected soil and landscape properties are assigned different letters or numbers which are defined in separate portions of the legend. Each delineation is described by a composite symbol made up of these letters and numbers. Each portion of a composite symbol is connotative. There are no portions of the symbol that, for instance, represent a Soil Series and imply many associated characteristics. Most delineations contain unique composite symbols. In effect the change of one class of one soil or landscape property creates a new map unit, or phase of an existing map unit. A hypothetical example is given in Figure 1.

2. Uncontrolled Form - All the soils (groups of polypedons) that are of significance in extent and characteristics for the purpose of the survey are listed in the legend, either singly or in groups. They are usually given names, symbols and unique colors. Where they are listed in groups the dominant soil carries the name, symbol and color. Mappable portions of the soil landscape (map delineations) are labelled on the map by using soil symbols, either by themselves, or in combination with one or two others. These combinations are not listed or described in the legend. More than one line of the main legend will have to be consulted in order to gain information about soils represented by different symbols. The aggregation of all delineations carrying a unique group of soil symbols is a map unit. In effect map units containing two or three soils from the legend are not described. Phase symbols are described in additional parts of the legend. The delineation takes the color of the first soil in the numerator. A hypothetical example is given in Figure 2.

3. Controlled Form - All the soils (groups of polypedons) that are of significance in extent and characteristics for the purpose of the survey are listed in the legend. They are usually given names and unique colors. A map unit is represented by all delineations carrying a unique group of soil symbols. All map units for each soil are listed and described in the legend. Limited map phase symbols may be described in other parts of the legend. The delineation takes the color of the predominant soil in the map unit. A hypothetical example is given in Figure 3.

4. Closed Form - All map units for each soil, including all map phases are listed and described in the legend. In this case the map unit is represented by all delineations having a unique combination of soil symbols and map phase symbols. The map delineation takes the color of the predominant soil of the map unit. A hypothetical example is given in Figure 4.

FIGURE 1. AN OPEN FORM OF LEGEND AND MAP

LEGEND

Parent Material

A - Marine clay
B - Alkaline stony till
C - Alkaline sandy till
D - Sands over marine clay
E - Sands over stony till

Surface Texture

s - sand
sl - sandy loam
l - loam
cl - clay loam
c - clay

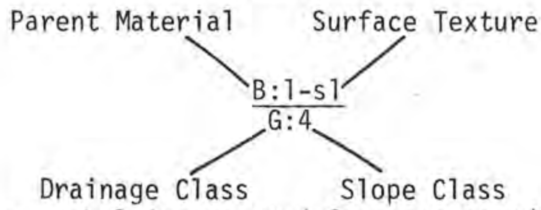
Drainage Class

G - Good
I - Imperfect
P - Poor

Topographic Class

1 - 0-0.5% slope
2 - 0.6-2% slope
3 - 3 - 5% slope
4 - 6 - 9% slope

Symbol



Note: The symbol is repeated for a compound map unit.

MAP

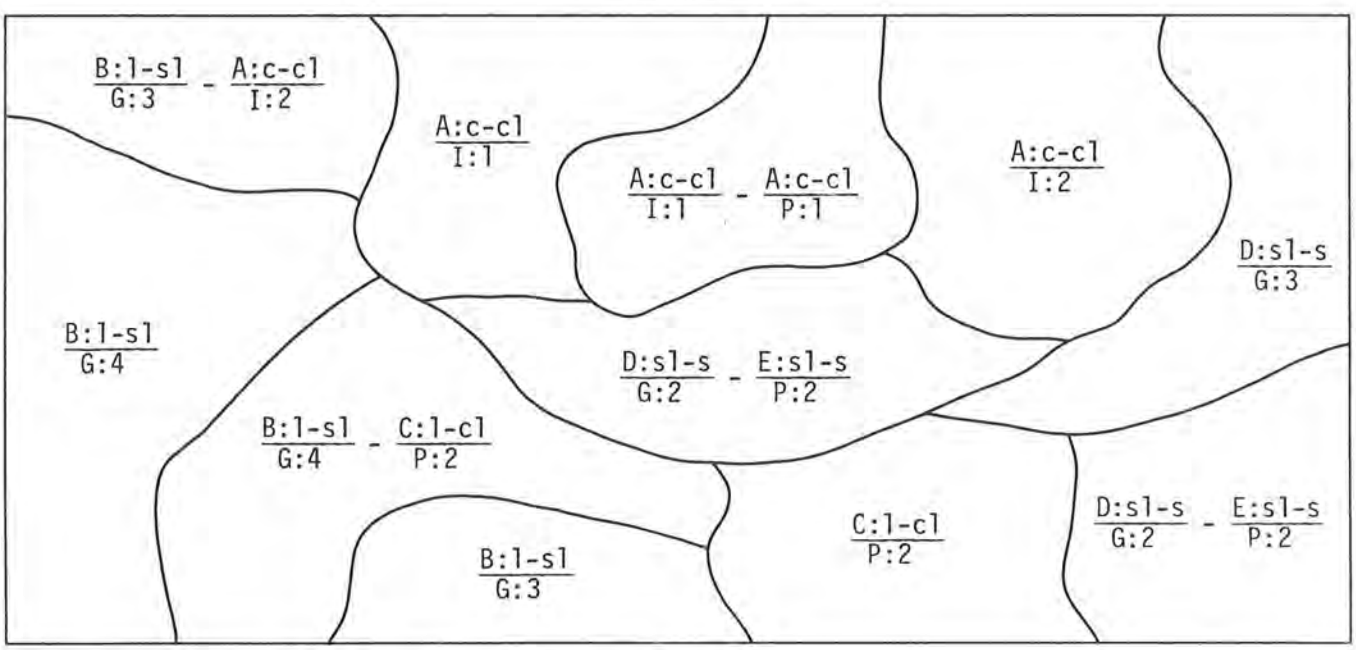


FIGURE 2. AN UNCONTROLLED FORM OF LEGEND AND MAP

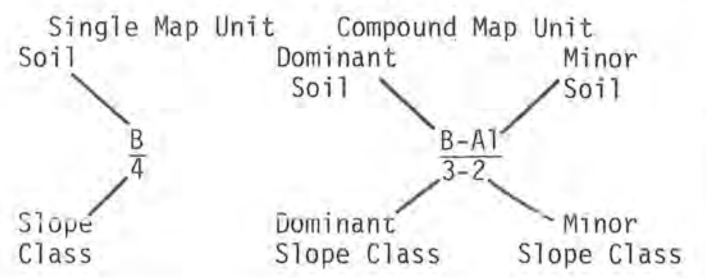
LEGEND

Symbol	Parent Material	Surface Texture	Drainage Class
A1	Marine clay	Clay to clay loam	Imperfect
A2	Marine clay	Clay to clay loam	Poor
B	Alkaline stony till	Loam to sandy loam	Good
C	Alkaline sandy till	Loam to clay loam	Poor
D	Sands over marine clay	Sandy loam to sand	Good
E	Sands over stony till	Sandy loam to sand	Poor

Topographic Classes

1 - 0-0.5% slope
2 - 0.6-2% slope
3 - 3 - 5% slope
4 - 6 - 9% slope

Symbol



MAP

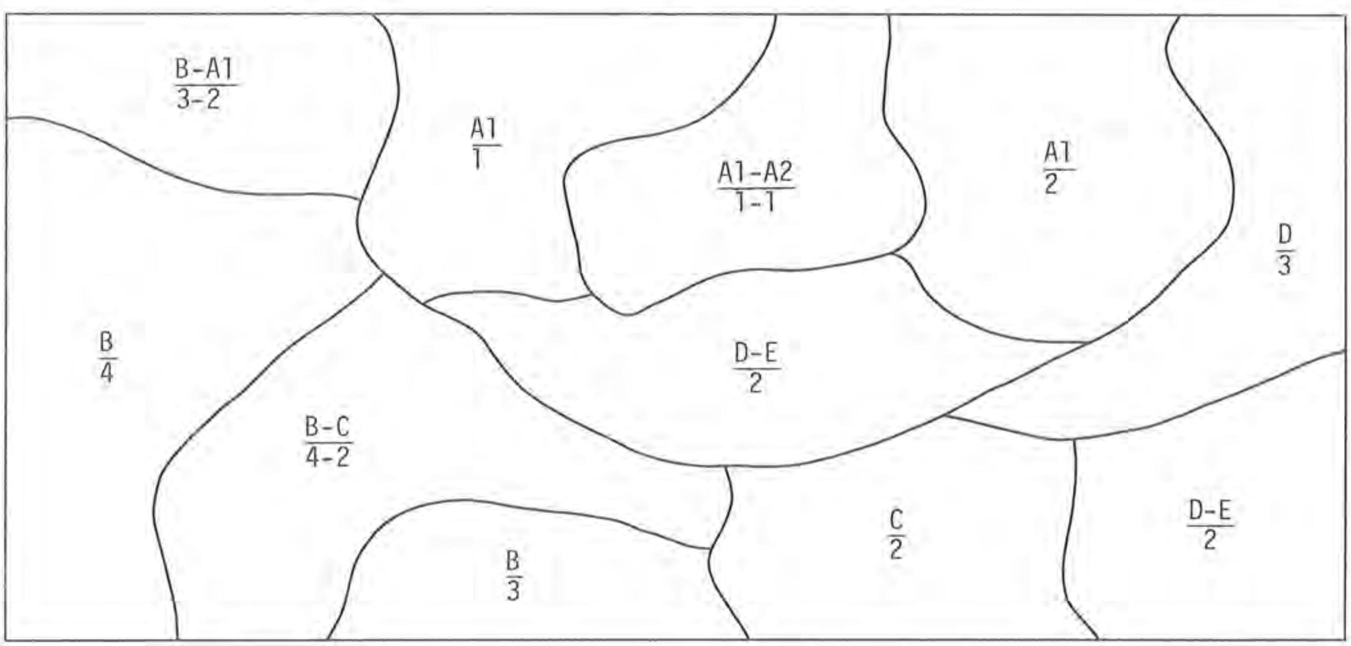


FIGURE 3. A CONTROLLED FORM OF LEGEND AND MAP

LEGEND

Symbol	Description of predominant soil			Description of minor soil (25-45%)		
	Parent Material	Surface Texture	Drainage Class	Parent Material	Surface Texture	Drainage Class
A1	Marine clay	Clay to clay loam	Imperfect			
A2	Marine clay	Clay to clay loam	Imperfect	Marine clay	Clay to clay loam	Poor
B1	Alkaline stony till	Loam to sandy loam	Good			
B2	Alkaline stony till	Loam to sandy loam	Good	Alkaline sandy till	Loam to clay loam	Poor
B3	Alkaline stony till	Loam to sandy loam	Good	Marine clay	Clay to clay loam	Imperfect
C	Alkaline sandy till	Loam to clay loam	Poor			
D1	Sands over marine clay	Sandy loam to sand	Good			
D2	Sands over marine clay	Sandy loam to sand	Good	Sands over stony till	Sandy loam to sand	Poor

Topographic Classes

1 - 0-0.5% slope
2 - 0.6-2% slope
3 - 3 - 5% slope
4 - 6 - 9% slope

Symbol

$\frac{B3}{3-2}$

Soil Symbol

Predominant Soil Slope Class

Minor Soil Slope Class (where applicable)

MAP

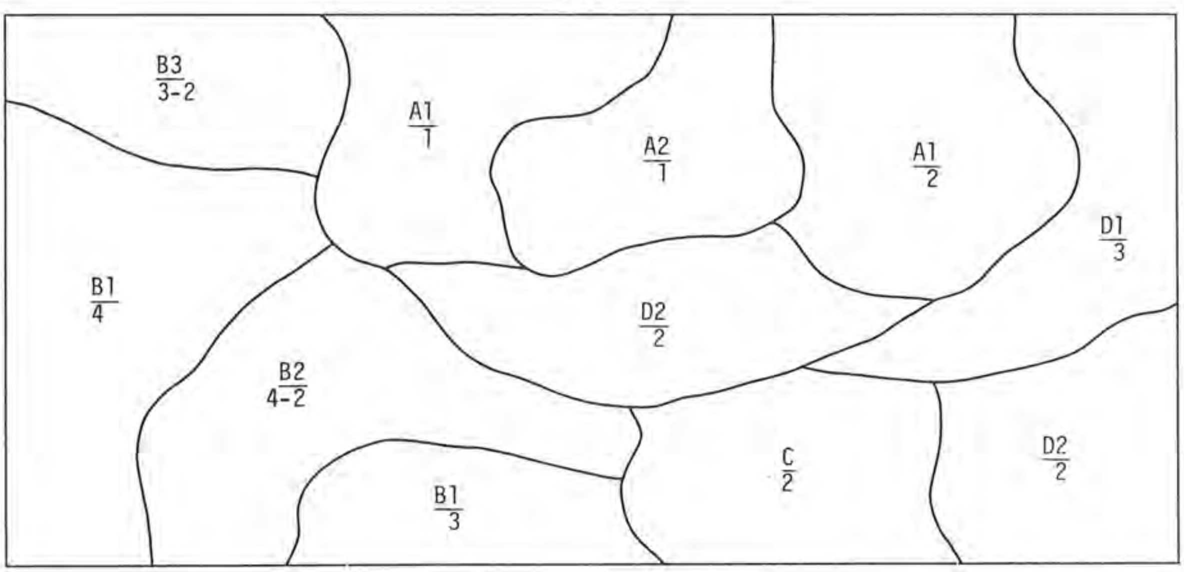
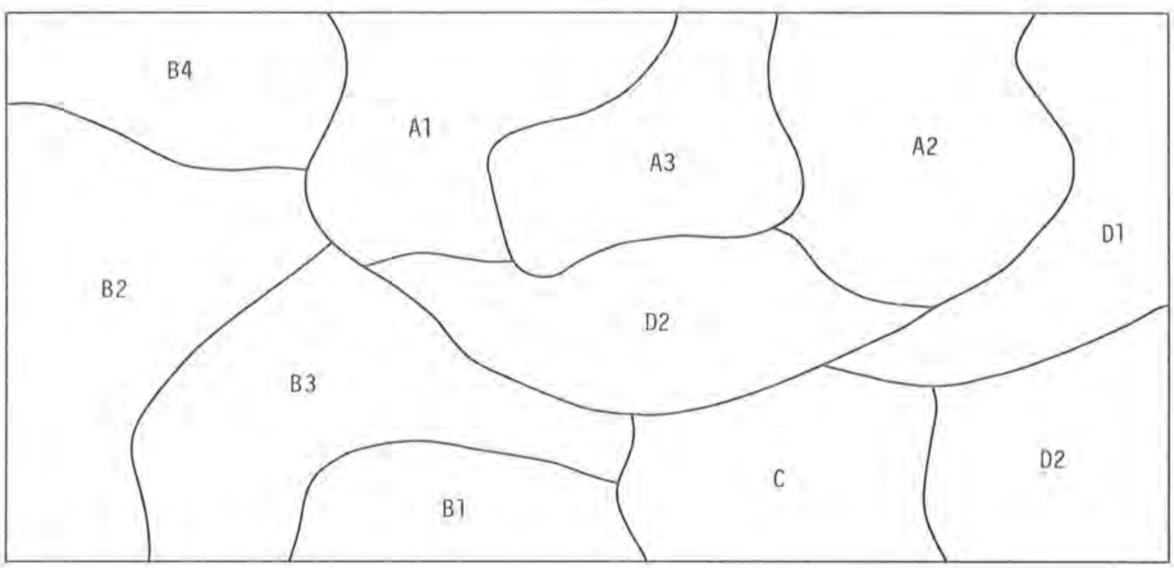


FIGURE 4. A CLOSED FORM OF LEGEND AND MAP

LEGEND

Symbol	Description of Predominant Soil				Description of Minor Soil (25-45%)			
	Parent Material	Surface Texture	Drainage Class	Slope%	Parent Material	Surface Texture	Drainage Class	Slope %
A1	Marine clay	Clay to clay loam	Imperfect	0-0.5				
A2	Marine clay	Clay to clay loam	Imperfect	0.6-2				
A3	Marine clay	Clay to clay loam	Imperfect	0-0.5	Marine clay	Clay to clay loam	Poor	0-0.5
B1	Alkaline stony till	Loam to sandy loam	Good	3 - 5				
B2	Alkaline stony till	Loam to sandy loam	Good	6 - 9				
B3	Alkaline stony till	Loam to sandy loam	Good	3 - 5	Alkaline sandy till	Loam to clay loam	Poor	0.6-2
B4	Alkaline stony till	Loam to sandy loam	Good	3 - 5	Marine clay	Clay to clay loam	Imperfect	0.6-2
C	Alkaline sandy till	Loam to clay loam	Poor	0.6-2				
D1	Sands over marine clay	Sandy loam to sand	Good	3 - 5				
D2	Sands over marine clay	Sandy loam to sand	Good	0.6-2	Sands over stony till	Sandy loam to sand	Poor	0.6-2

MAP



Note on Figures 1,2,3 and 4: In order to produce comparable illustrations of Legend forms each Figure contains exactly the same information. In addition the map delineation boundaries are identical. Only the layout of the legend and the delineation symbols change. The Figures are based very loosely on soils information from Cumberland Township, Municipality of Ottawa-Carleton supplied by Larry Schut and Eric Wilson.

Controlled and Uncontrolled legends: pros and cons

Most of the discussion about published legends is between the relative merits of what have been defined as controlled and uncontrolled legends. The relative merits of each approach are listed below.

Reasons for an Uncontrolled Legend

1. The preparation of legends is easier and less time consuming because each unique combination of soil symbols used for map delineations does not have to be described separately.

2. Most users are interested in learning about the relatively homogeneous soil type and not the map delineation or map unit as a whole.

3. A Controlled legend with a limited number of map units would seriously impair our ability to describe the map delineation accurately.

4. Table 7 (PSMSC 1979) indicates that 75% of the map can be covered by less than 50 map units, but there is no indication of how the other 25% of the area will be covered. Either it will be incorrectly mapped, or the initial 50 map units will have to be generalized further to incorporate the remaining area.

5. Often significantly less than 25% of the map area contains over 75% of the problems associated with use. These critical areas may very well be the ones lost in the generalization process, especially in terms of location.

6. Mappers can concentrate on identifying the different soils in their area. They do not have to spend time developing and describing map units.

7. Correlation is easier; it concentrates on soils not map units.

8. Map unit description and a CanSIS file are unnecessary.

9. Interpretations are made about the soil directly avoiding the contentious question of how to rate a map unit with contrasting soils.

Reasons for a Controlled Legend

1. If parts of the soil landscape are important enough to draw lines round and separate from other parts on a soil map, then we should be able to describe them. Uncontrolled Legends allow us to describe separate soils and their proportions. But we cannot describe the relationship of the soils; where they are in the map unit, which are at higher elevations, whether they occur as a few large exposures or many small ones etc. Controlled legends allow and encourage us to describe a piece of land not individual pits.

2. Many of our maps have become too complicated and almost illegible because uncontrolled legends have lead to very long symbols. A controlled legend would restrict the number of map units and simplify the symbol.

3. Field checks have shown that our mapping accuracy usually varies from 65% to 80%. Yet we are still establishing many map units on the basis of differences between only 10 to 15% of the soils they contain. It is not logical to differentiate between map units on the basis of differences that are smaller than our levels of reliability.

4. Small areas of highly contrasting soils can still be shown by a phase in the individual delineation (which is an 'open" aspect of the recommended system) or even by on-site symbols.

5. A controlled legend by simplifying map unit symbols and limiting map units will speed up and reduce the costs of map digitizing and publication.

6. Controlled legends will add to our knowledge of soil geographical relationships because mappers will have to identify the major soil groupings rather than all the individual soils.

7. With map unit description forms and a CanSIS map unit file we will be able to store information about the mapped portions of land, rather than individual pedons.

Subjects for Future Consideration

There are a number of important subjects that the proposed system did not discuss. Among them are:

The differentiating criteria for map units at different survey intensity levels.
Recommended layouts for different legend forms.
The relationships between map units at different survey intensity levels (ie. how a map unit at SlL 4 breaks down to a number of map units at SlL 2).
Soil and map unit names.

These subjects are interconnected and should be addressed before a revision of the proposed system is attempted in 1981.

That we use different criteria (or the same criteria in a different sequence,with a different priority) to establish map units at different survey intensity levels is implied in Table 3 (column 4) and Table 6 of the Proposed Mapping System 1979. It would be useful to acknowledge this formally by creating a table showing "Criteria vs. SlL." It should not be looked upon as definitive but could be a useful guide.

Having done this (and having established names and definitions for different legend forms) it would be much easier to design recommended formats for different legends at different survey intensity levels.

The relationship between map units from surveys of different intensities is still a thorny problem. A related question is how should we name map units.

It is suggested that the working group should pursue these three problems prior to a revision of the proposed system in 1981.

Present Provincial Soil Mapping Systems

K.W.G. Valentine

During the discussion that followed the first presentation of the Proposed Soil Mapping System for Canada in March 1979, D.F. Acton suggested that it would be very useful to have statements from all the survey units describing the way they map soils now. His point was that it would be easier for the working group to know where we should be heading if they know where everybody is coming from. The suggestion was approved and I as chairman of the working group approached each unit in 1979 to prepare a statement about their present methods of mapping. So far all units except one have replied. I would like to thank all those who took the time to do this. Inevitably it had to be done by the more senior people who have many other demands on their time.

There is no time this afternoon to make any useful presentation of such a large amount of material. Suffice it to say that a cursory reading of all the submissions showed no approaches that could not be handled fairly satisfactorily within the present proposed Soil mapping system. I would suggest that all the submissions should be edited and submitted for publication by the Expert Committee on Soil Survey. This could be done during the course of 1980.

Market Surveys for Soil Maps in British Columbia

K.W.G. Valentine

In the summer of 1979 a group of students employed under the summer CORPS program conducted two surveys in British Columbia to determine how well soil maps were serving their purpose. A working group has been considering a system for mapping soils in Canada, but so far there has been little attempt to ask the user what he wants. Therefore two questionnaires were designed. One was aimed at a wide variety of users with fairly general questions. The other one was sent to people involved in forest management on the west coast. It contained more technical questions, and was part of an MSc thesis which will be reported more fully later by E. Pottinger.

In the case of the first survey a list of addresses was obtained from such sources as the British Columbia Institute of Agrologists, some Environmental Consultants organizations and the list of requests for maps that the Resource Analysis Branch, Ministry of the Environment, Victoria had received. A total of 250 probable users were listed and 40 were chosen for interview. Questionnaires were mailed to the other 210, and 63 were returned, of which 30 were users of soil maps. With the interviews this gave a total of 70, which represents a 30% return.

The results from the mailed returns and the interviews were analyzed separately at first. There was no difference between the answers of the two groups, and therefore they were combined.

A large majority of people use soil maps principally in the office. This implies that the physical size of the # map is less important than has been thought. The image of that frustrated user trying to flatten acres of paper onto the hood of his truck on a windy day is just not real.

In reply to the question about what sort of information they wanted from soil maps, 32% said they wanted site specific information, 23% said they wanted more general information such as the location of wet or gravelly soils, and 45% said they wanted both. This has implications about legend construction. For those looking for site specific information you can just list all soils alphabetically. On the other hand if you know the objectives of the survey are to locate soils of a certain texture or fertility, the legend should be stratified in that way. Nevertheless the 45% who want both types of information put us back into that impossible position of trying to be all things to all men.

The most common scales used were between 1:40,000 and 1:80,000 (see Table 1). This is just a reflection of the general policy of providing manuscript maps at 1:50,000 in British Columbia. However there was a preference for scales between 1:14,000 and 1:40,000. Again we face the situation of a demand for a level of detail that is completely irreconcilable with the areas that must be covered by a finite number of surveyors with a limited budget.

Another question asked, "What characteristics of the soil do you need to know?" Twelve characteristics were listed and people were asked to rank them in order of importance. The results of this question, arranged according to occupation groups are given in Table 2. Texture, slope and soil water were consistently considered the most important. Indeed the rankings of all characteristics by all the occupation groups were similar as tested by the Kendall Coefficient of Concordance (see Table 2). This means that it should be possible to create general purpose soil maps because most people want the same information.

Two very simple examples of Legend forms were given; in effect what we are now calling "open" and "closed". The open form was preferred by 51%, and the closed form by 40% (9% didn't understand the question, or didn't care). This runs contrary to the recommendation of the working group or soil mapping systems. However, it should be noted that professional people who were using only one map were the types who liked the open legend. Others found the complex symbols difficult to understand.

A final question regarding the types of difficulties people were having with the maps elicited an enthusiastic response! Fully 58% of the respondents had some criticism or suggestion. The major problem seems to be the difficulty that people have in getting information from the map. The symbols are too complex. There is "hair-splitting" in symbols and legends, as well as jargon and unfamiliar terminology (especially the soil classification names). Legends and symbols are not standard. Some maps do not have legends, and when they are printed in black and white they are difficult to read. Apart from that they are quite satisfactory! A second type of problem appears to be one of communication. Many respondents do not know who publishes soil maps, nor do they know what is available.

The second questionnaire was much more specific. It was sent to foresters working on the west coast. Responses were obtained from 80% of the 230 that were either mailed or conducted by interview.

The principal results showed that people wanted maps at 1:20,000 scale; the symbols should be semi-connotative (although here again professionals that had got used to one map preferred a connotative "open" type of symbol); and the main criteria used to differentiate map units should be slope, vegetation and moisture regime. It is also interesting to note that the idea of variable intensity and reliability across the map was quite acceptable, and that the more experienced a person was in using soils maps the more comprehensive a legend he wanted. Colored maps were preferred by all.

The main conclusion that we come to was that soil surveyors must be prepared to go out and "sell" their maps once they are finished. Most important of all the user has to have some idea of how the map was made, how precise the information is and therefore what he can and cannot use it for. There are still people out there who expect to dig a hole anywhere on any map unit and find exactly the soil that is described. Secondly we certainly need to strive for more standardization and simplicity than we have achieved so far.

However, we must not accept the answers to these or any future questionnaires uncritically. Sometimes people must be encouraged into wanting something more. The most glaring example is the rejection of taxonomic names. We must not allow users to persuade us to omit taxonomy completely. We know it can be useful in carrying so much associated information within a very precise phrase. We must spread the word. The whole process therefore must be two way. We should take more notice of what the user wants, but he also has to be encouraged into wanting the right things.

Table 1. Scale being used versus scale preferred

	Scale used (% of respondents)	Scale preferred (% of respondents)
1:14,000 or larger	6	26
1:14,000 - 1:40,000	24	40
1:41,000 - 1:80,000	54	29
1:81,000 - 1:160,000	10	0
1:161,000 - 1:800,000	2	1
no response	4	4

Table 2. Rankings* of the importance of some soil characteristics given by each occupation group

Soil Characteristic	Occupation							
	Assessors	Agriculturists	Planners	Land Managers	Engineers	Foresters Biologists	Others	All Groups
Texture	=2	1	1	1	1	1	1	1
Mineralogy	=9	10	10	10	7	10	8	10
Chemical data	=9	8	8	9	9	9	7	9
Slope	=2	2	4	2	2	3	5	2
Geological materials	8	5	6	5	4	7	2	4
Wetness or dryness	1	3	2	3	3	4	4	3
Associated vegetation	5	9	5	=7	8	2	3	6
Erosion hazard	6	4	3	4	5	6	10	5
Rock	4	6	9	6	6	8	9	7
Type of organic surface	7	7	7	=7	10	5	6	8

*1 is most important, 10 is least important.

Kendall Coefficient of Concordance: W = 0.716 (significant at .001 level).

Utility Of Our Products

Bob van den Broek

Introduction

For a number of decades, soil survey work has been carried out in Canada, resulting in the publication of a variety of soil maps and reports. Over these years, the level of sophistication with which this work has been carried out has increased significantly. This level of sophistication has been achieved in part through internal research and experience, and in part through feedback from individuals.

Traditionally, soil survey has been linked with agriculture, and as such, our products have been geared to agricultural uses. However, we have recently seen more non-agriculturally oriented groups using our information. Pressure for the preservation of farmland has required that planners for example look more closely at the soil maps in evaluating development programs. Construction companies use the soil information for selecting suitable sites for their needs. Extractive industries use soil maps to locate potential sources of sand and gravel. These are only a few examples to illustrate uses that are being made of the soils information, originally collected with an agricultural bias.

Although we have improved the quality of our product significantly, by collecting more information at larger scales, it remains to be seen if we have satisfied many of our potential users. By increasing the number of users (from different disciplines and with different interests), there arise conflicts between the individual needs of these potential users. It remains to be seen as to what degree do we try to fill the needs and where do we stop collecting more and more information. An important aspect to consider there is the frame of reference the user has. A planner might like to have generalized soils information for a whole county, whereas a farmer might like to have detailed soils information for a particular field. Thus, it can be seen that one user may be satisfied with a reconnaissance map, but the other may not find the answers he is looking for. In the above mentioned case, a simple educational program conducted by the pedologist might have helped to overcome this problem.

It thus becomes imperative that we find out exactly what the users want to get out of our soil survey information. It will probably not so much affect our field methodology, as it will affect the way we document and present our information. With the potential of computer derived maps, we are now in the position to tailor a package of information that will suit individual users.

User Surveys

Over the past couple of years, we undertook two user surveys, to find out what users extracted from soil survey reports and what they actually needed. The following paragraphs described the technical details of each of these surveys:

1. PROFESSIONAL REACTION TO PUBLISHED LAND INFORMATION IN SOUTHERN ONTARIO, by John A.G. Hansen and N.R. Richards (1978).

The authors looked for a comparative view of the status of information sources as far as users are concerned. Aspects of information availability, content, scale, and the need for a report or explanatory documents to accompany the information were examined. Mail questionnaires were sent to a sample of 509 people, stratified by occupation and location. The sample canvassed professional land information users, including urban, rural, and regional planners; engineers; agrologists; soil and crop specialists; and natural resource managers. Seven regions were selected on the interests of economy and the land use mix or differences in political structure. Of the 509 questionnaires sent, 154 useful questionnaires were returned (30% response). No statistically sound conclusions could be drawn from such a sample but certain trends were evident.

2. USE OF ONTARIO SOIL SURVEY REPORTS BY SELECTED USE GROUPS, by Murray D. McKnight (1979)

The study was conducted to assess some of the information needs and preferences of soil survey report users. Two hundred and twenty-nine questionnaires were sent to staff personnel of three branches of the Ontario Ministry of Agriculture and Food. A total of 195 individuals responded (85% response). The responses were tested on their statistical significance.

Results And Discussion Of The User Surveys

Who are the users and what information do they use?

Since it was only possible to reach either governmental institutions and people associated with professional organizations, both surveys are somewhat biased in nature. In terms of what type of land resource information they are using (e.g. Geology, Climate, Topographic, Soils, or C.L.I. maps) it appears (from Survey 1), that over 80% of the people polled use soil maps in one way or another. C.L.I. maps for agriculture are used by over 70% of the people polled. There is some variation in the actual percentage between the user groups, as to what type of information source is top ranked. From our second survey, it appears that younger (less experienced) O.M.A.F. staff personnel, use the soils information less frequently than more experienced staff. When the question was raised in the second survey if the preference was a "regular" soils map or interpretive map, 13% of the respondents preferred the soils map, whereas 20% favoured interpretive maps. The remainder did not indicate precisely what they wanted. Sofar, the only interpretive map the user is exposed to is actually the C.L.I. map for agriculture.

Frequency of the use of soil information

In our second survey, the question was raised as to how often soil survey information was used in the time span of one year. Although we are dealing here with one professional group (Agrologists), one should recognize, that this group is stratified according to their position within the O.M.A.F. Organization (e.g. Area Coordinator, Agricultural Representatives, Agricultural Engineers, Soils and Crops Specialists, and Horticulturalists). The results indicate that 47% of the Area Coordinatorsand Agricultural Representatives use soil survey information more than 20 times a year. Agricultural Engineers responded with 31% using it more than 20 times a year, whereas field crop specialists responded only with 12%. The data seem to indicate, that soil survey information is used as an overview rather than for more specific purposes (e.g. farm management, site selection, etc.). This seems to be in line with the general nature of the soils maps for Ontario (Reconnaissance Surveys).

For what purposes do they use the soils information?

In the first survey, this question was not raised that specifically. However, general comments indicate, that the majority of the respondents are utterly confused with the amount of information that is available (detailed as well as generalized). Quite often, the user will therefore choose the most convenient or best understood information rather than what may be the most significant for his or her purpose.

In the second survey, the question was raised as to how important the particular information (e.g. Agricultural Capability, Soil Management, Soil Productivity, Agrometeorological Information, and Engineering Information) was for the user. The following table summarizes the findings.

Table 1 - distribution of importance of soils information by main reasons for using soil survey reports

Main Reasons	Type of Information reiquired
1. Determining Agric. Capability	- Agric. Capability Information - Soil Productivity Information - Soil Management Information - Agrometeorological Information - Engineering Properties
2. Counselling Farmers	- Agric. Capability Information - Soil Productivity Information - Soil Management Information - Agrometeorological Information - Engineering Properties
3. Advising Land Buyers	- Agric. Capability Information - Soil Productivity Information - Soil Management Information - Agrometeorological Information - Engineering Properties

4. Determining Soil Types
- Soil Productivity Information
- Agric. Capability Information
- Soil Management Information
- Agrometeorological Information
- Engineering Peoperties

5. Planning Tile Drainage
- Engineering Peoperties
- Agric. Capability Information
- Soil Productivity Information
- Soil Management Information
- Agrometeorological Information

The order in which the main reasons and the type of information required is listed reflects to some extent the significance of importance for the user. It appears that there is little difference in the ranking of the type of information required as far as the first four main reasons are concerned. The last main reason (planning tile drainage) may appear to be at the bottom of the list, but one should remember that the total number of agricultural engineers is only small in comparison to the total number of people polled.

The most accessible information for the user are the agricultral capability maps (either at a scale of 1:50 000 or 1:250 000). Soil capability ratings for various field crops were listed in the old survey reports, prior to the C.L.I. era. In the more recent reports, this practice has been abandoned. Soil Management information can be found in many cases in the map unit or soil descriptions in the report. Only in the most recent soil reports do we list the engineering properties of the most common soils in the area. All soil reports contain a short section on regional climate but what is understood by the term "Agrometeorological" information is not contained in all soil survey reports.

4. What individual soil characteristics are important for the different user groups?

This aspect of the surveys is difficult to assess, since it seems that it is closely tied to the occupation of the respondents. What seems to be very important for one group, is not necessarily important for another. The following table lists the top ten soil characteristics which are of importance for the different user groups and which can be found either on the soils map or in the soil report. The percentages listed, indicate how many of that group favour that type of information.

Table 2. Ten Soil Characteristics Ranked As "Important" By Occupation

Occupation	Soil Characteristics	% in favour
Agrologist	1. Soil Texture	78
	2. Topography	63
	3. Soil Wetness	63
	4. Rockiness	63
	5. Stoniness	63
	6. Soil Acidity	56
	7. Droughtiness	52
	8. Susceptibility to Erosion	48
	9. Wet Spots, Organic Soils	48
	10. Depth to Watertable	37
Engineer	1. Susceptibility to Erosion	65
	2. Depth to Watertable	60
	3. Wet Spots, Organic Soils	55
	4. Soil Texture	50
	5. Depth to Bedrock	50
	6. Soil Wetness	50
	7. Shrink and Swell Charac.	40
	8. Rockiness	35
	9. Bedrock Structure	35
	10. Soil Density	30
Urban Planner	1. Topography	85
	2. Soil Susceptibility to Erosion	43
	3. Wet Spots, Organic Soils	42
	4. Depth to Watertable	42
	5. Depth to Bedrock	30
	6. Soil Wetness	26
	7. Rockiness	26
	8. Soil Texture	23
	9. Stoniness	17
	10. Shrink and Swell Charac.	11
Other Planners	1. Topography	73
	2. Soil Susceptibility to Erosion	51
	3. Wet Spots, Organic Soils	51
	4. Depth to Watertable	46
	5. Soil Wetness	32
	6. Depth to Bedrock	24
	7. Soil Texture	19
	8. Rockiness	15
	9. Stoniness	15
	10. Soil Density	8
Resources Managers	1. Topography	82
	2. Susceptibility to Erosion	59
	3. Wet Spots, Organic Soils	59
	4. Depth to Watertable	59
	5. Soil Wetness	41
	6. Soil Texture	29
	7. Depth to Bedrock	24
	8. Rockiness	18
	9. Droughtiness	12
	10. Swell and Shrink Charac.	

If we disregard the occupational preference, and list the ten most desirable soil characteristics, the list is as follows:

Table 3 - Ten Soil Characteristics That Are Ranked As Important For General Use

Soil Characteristic	% In Favour
1. Topography	61
2. Susceptibility to Erosion	53
3. Wet Spots, Organic Soils	51
4. Depth of Watertable	49
5. Soil Wetness	42
6. Soil Texture	40
7. Rockiness	31
8. Depth of Bedrock	26
9. Stoniness	19
10. Droughtiness	13

A comparison of Table 2 and 3 shows that the individual preferences of planners and resource managers, match quite well with the general picture, closely followed by the preferences of agrologists. Although the engineers are interested also in the above mentioned soil characteristics, their ranking is quite different from the other user groups.

Commonly collected soil characteristics such as texture, rockiness, stoniness, and depth to bedrock rank low in priority. Characteristics like topography (questionable if this refers to the elevation or our slope classification system), susceptibility to erosion (interpretive information), wet spots (very localized in nature and sometimes indicated with symbols on the map) and depth to watertable (information that is rarely reported in soil survey reports), are ranked high in priority.

Degree Of Satistaction With Existing Soil Survey Information

A majority of the respondents in our second survey indicated that they were quite satisfied with the existing soil survey information. One of the most common complaints was the lack of availability of soil maps (out of print). This problem has now been at least partially resolved. About 23% of the respondents requested a larger map scale (preferably between 1:20,000 and 1:30,000). Most of the existing soil maps for Ontario are at a scale of 1:63,320, although the most recent maps are going to be published at a scale of 1:25,000 or 1:50,000. In later communications with the Agrologists, it was indicated that they want climatic information (e.g. corn heat units, degree days, length of frost free period) superimposed on the soil maps.

Is There A Need For More Soil Survey Extension Work?

Personally, I believe we are suffering from a credibility gap, especially with the Agrologists. Apparently, what we are intending to accomplish is not clear and users have difficulty in fully understanding the information. Over 30% of the respondents in our second survey indicated that they wanted a general overview of soil surveys, over 20% indicated that they want to know more about the particular methodologies, and about 12% want to know more about the soil capability system. Although it was not asked specifically in our first survey, it appears that all user groups want a section in the report explaining how to use the information presented. They emphasized that writing an understandable report and/or interpretation guide might help them significantly in understanding and digesting the information.

These are probably the six main questions that come to mind, when we start talking about feedback from users. We realize that this is only the beginning of effective interaction between users and producers. We would like to do more user surveys, for example with consulting agencies, conservation authorities, foresters and the like.

The results from these two surveys are in many ways optimistic. Our long term interaction with some individual users has helped to some extent to understand their problems, and yet, if we take the whole group into consideration, we came up with some suprising answers. One very positive aspect is that despite the variety of land resource information that is available, soil maps and reports are being used by many groups. One reason for this might be that survey information provides relatively detailed data for most of Southern Ontario, and is still being worked on and improved on.

Where Are We Going From Here?

This is not the time for complacency. I strongly believe that we now have to pursue this type of interaction more rigorously by polling other user groups, and responding to those polles already. Obviously, we cannot satisfy all our users 100% of the time, the demands are not always compatible. Other requests may not be reasonable, because the information requested cannot be collected in the time frame allowed or because certain requests fall outside our field of expertise.

Let me conclude, by listing the actions we have taken so far in response to these surveys:

1) The publication of "A Guide to the Use of Land Information". On many occasions, it became clear that the user is not always aware of what particular information is available or where to obtain it. With the publication of this handbook, we definitely fulfilled a need for this type of information. We did not restrict ourselves to soil survey information alone, but we also included information on Geology, Forestry, C.L.I. Interpretations, Climate, and Aerial Photography.
2) Soil Survey Advisory Committee. We felt a need for the existence of a committee (made up of users and survey staff) to help us to develop programs and/or provide us with feedback from their own ranks. Presently, we have a committee on which the Field Branches of the Ontario Ministry of Agriculture and Food are represented. Over time we hope to include more user groups in this Advisory Committee.
3) Soil Survey - Soil Management Interaction Group. Since the University of Guelph is embarking on a Land Use Evaluation Research project, it was felt that a close link between this research project and our soil survey program was required. More particularly, the function of this interaction group will be to plot out a course of action, whereby soil survey information can be used as the data base for extrapolating the results of the project.

These are some of the actions we have taken so far. No doubt, we hope to have a stronger working relationship with all our users, for our mutual benefit.

References

1. Hansen, John A.G., and N.R. Richards. "Professional Reaction to published Land Information in Southern Ontario". Journal of Soil and Water Conservation, (May-June, 1979).

2. McKnight, Murray D. (1979). Use of Ontario Soil Survey Reports by Selected User Groups. M.Sc. Thesis. University of Guelph.

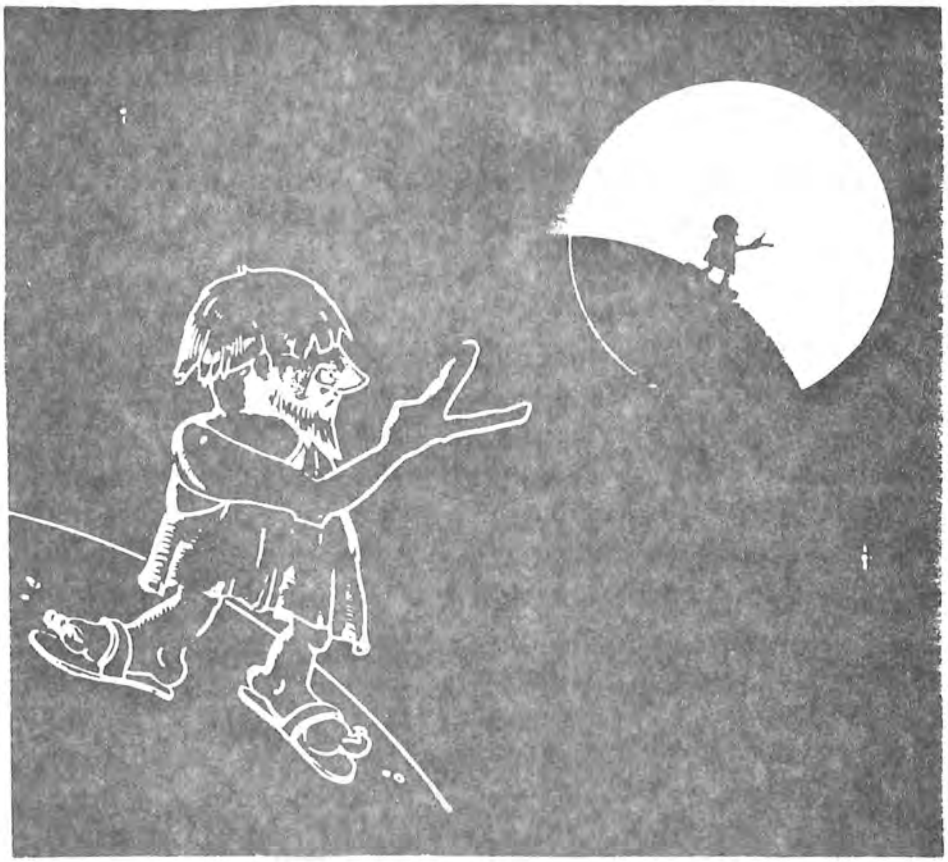
APPENDIX 4. WORKSHOP SESSION ON THE SOIL INFORMATION SYSTEM

CanSIS Cartogrpahic File:

Map Production Procedures, Scheduling and Costs

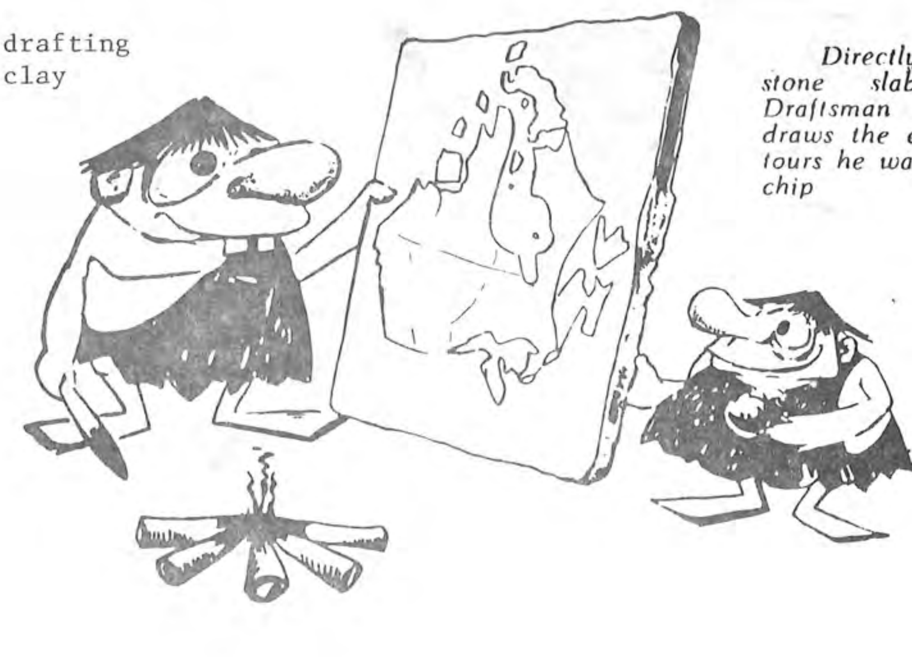
B. Edwards

It never ceases to amaze me that we have evolved in 3,000 years from proving the earth is round

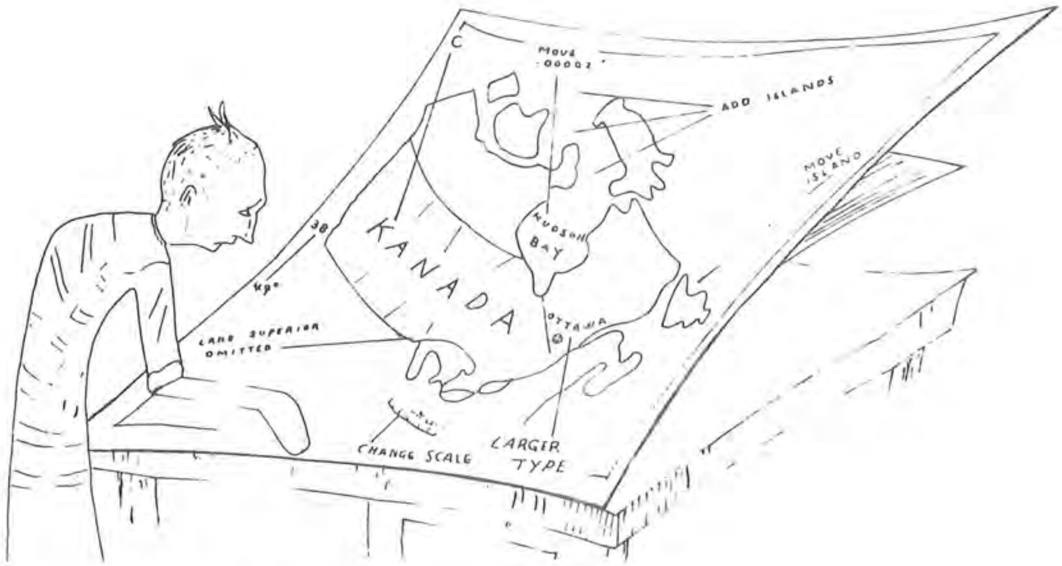


The earth is round!

to drafting on clay



Directly on the stone slab, Chief Draftsman Flinthead draws the exact contours he wants Joe to chip



labelling the features around us

producing maps by automation and compounding our errors

"....and in 1/10,000 of a second, it can compound
our error 87,500 times! "

Today, I can state that the CanSIS Cartographic file has become a completely operational and dependable tool.

I would like to take this opportunity to give credit to the cartographic Quality Control Unit of Stan Alward, Brian Davis, and Gary Labelle for their efforts and excellent ideas, and also to Dave Regan, our systems analyst and programmer who has done so much to debug and implement improvements to the system.

In discussing the topic map production procedures and costs, I have covered them together and by using a sample map which has gone through the various processes in the last year, will illustrate my findings. The map was chosen from last years production for the simple reason that it was only during this period that developmental costs have changed to production costs.

The map which we are about to discuss is at a scale of 1: 15280, the size is approx. 30 inches square, there are 303 soil areas consisting of 6482.85 hectares. Figure 1 shows the map and gives you some idea of the density, plus the complexity of the soil symbols.

Figure 1. Sample map area

I have broken down the production procedures into three areas. a) Data Collection, b) Error Correction and c) Retrievals.

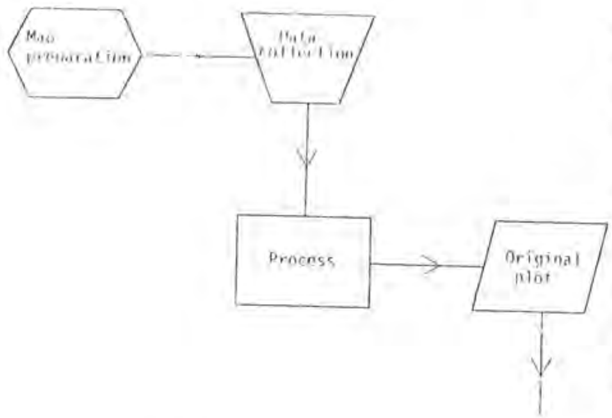


Figure 2.

Figure 2 shows the four operations of "Data Collection". "Map preparation" consists of checking the manuscript for completeness, that symbols agree with the legend and producing the scribecoat. "Data Collection" is the creating of the symbol and line files, better known perhaps as digitizing. "Process" is the editing and merging of data in the Toronto software. This same software also produces the plot tape from which we get are first graphic view of the digitized map and which we call the "original".

The cost of "Data Collection" is $566.69 broken down as follows: Map preparation $10.00, Data Collection $507.15, Processing $40.94, Original plot $8.60*.
* Includes cost of labour and materials

The "Error Correction" procedures can be broken into two parts. Figure 3 illustrates the main process of eliminating errors. These are errors which the computer can process and indicate, either on the original plot or by printout. This process normally takes three to four attempts before being complete.

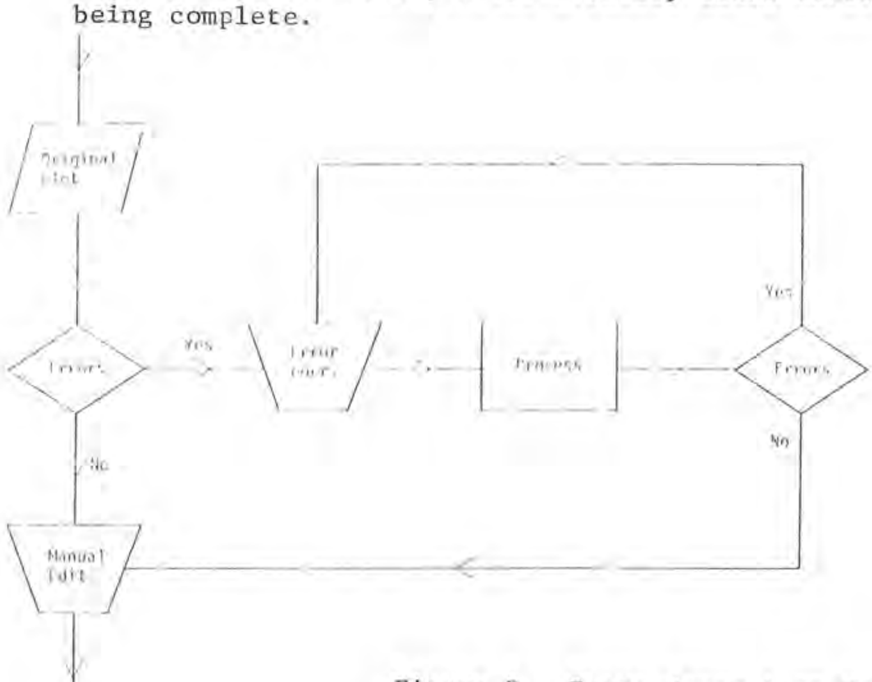
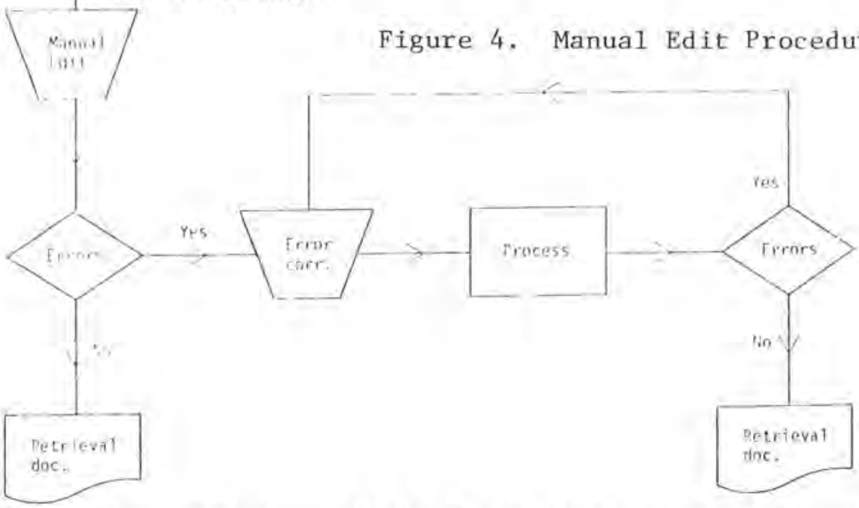


Figure 3. Error Correction Procedures

Figure 4 illustrates the second part of the error correction procedures. This is a manual comparison of the digitized lines and symbols to the original map manuscript. This is to eliminate any errors that the computer cannot recognize, e.g. spelling or incorrect location of symbol to related polygon

Figure 4. Manual Edit Procedures



The total cost of the Error Correction and Manual Edit procedures is $249,99 broken down as follows:

Error Corrections (5) $39.76, Error Processing (5) $119.78, Error Plots $69.75*, Manual Edit $20.70, Total $249.99. (*includes materials and labour)

Retrieval costs cover only those operations performed inhouse and do not take into consideration the author's cost. Total cost is $328.65 broken down by operation as follows:

Retrieval form $7.38, Keypunching $40.00, Processing - 8 maps $127.82, Retrieval plots $153.45*
*includes material and labour.

To date the total cost - $ of the three major operations is:

Data Collection	566.69
Error Correction	249.99
Retrievals	328.65
	1145.33

This total may be divided by the figure of 8 retrieval maps to give an approximate cost per map of $143.17. Those costs which are not available are salaries of data processing and technical assist persons, and all the quipment used. Our data processing person handles large numbers of peocessed maps each year which makes it extremely difficult to produce a per map cost. It is very difficult to assess the amounts of technical assistance required on a retrieval as it varies with each request.

The scheduling of CanSIS maps is becoming of prime importance. The requirements for data to be computerized quickly and become available for the production of derivative maps has received a great deal of attention by the cartography unit. The next table shows the actual time span for the Mill and Woodfibre Creek Project.

Time span - Actual

Operation	Date
Map preparation	March 8, 1979
Data collection started	March 28, 1979
Data collection completed	June 21, 1979
Processed	June 29, 1979
Error corrections completed	November 1, 1979
Retrieval plots completed	January 18, 1980

Total time span - $9\frac{1}{2}$ months

The total time spent was nine and one half months and I'm sure that someone will notice the large gap between the start and completion of data collection. This delay was a case by the realization that the computerized map symbolization would not agree with the legend as it was being digitized. This required complete revamping of the symbols for the cartographic procedures. The revamping was done by Cartography and then submitted to the author for his approval. Another minor delay was the lack of instruction on the style of retrieval plots.

The next table shows the estimated time span to produce this map under normal map production procedures and without delays as the system is performing at the present time.

Time Span - Estimated

- normal map production

Operation	Date
Map preparation	March 8, 1979
Data collection started	March 22, 1979
Data collection completed	March 30, 1979
Processed	April 7, 1979
Error corrections completed	August 31, 1979
Retrieval plots completed	October 18, 1979

Total time span - 7 months

As you can see we have managed to cut time by two and one half months. This figure should not be applied to all maps as the density of data plus the complexity of symbols can affect many of the factors. Examples taken from recent maps of the Avalon Peninsula area show the following statistics:

North Sheet	South Sheet
1972 areas	3107 areas
62 hours digitize	124 hours digitize
$117.64 process	$240.44 process
40 errors - 2.03% error rate	81 errors - 2.6% error rate

Returning to our original map and placing it on a priority production bases we have estimated that the time span could be cut to three and one half monghs (see table). It would be very difficult to improve on this time using the present system of being offline to the main computer. The physical handling of tapes and the sending of them from Ottawa to Toronto for processing are time delays which cannot be alerted. If at some future date the CanSIS Cartographic File should go on-line to a main computer then it is possible this time could be revised to a much lower level.

Time Span - Estimated for priority production

Operation	Date
Map preparation	March 8, 1979
Data collection started	March 15, 1979
Data collection completed	March 22, 1979
Processed	March 26, 1979
Error corrections completed	May 11, 1979
Retrieval plots completed	June 22, 1979

Total time span - $3\frac{1}{2}$ months

The derived map plots produced for the Mill and Woodfibre Creek area were simple wet ink plots. No enhancements were carried out either photomechanically or manually. Figure 5 shows a derivative map with some enhancement. The derived data has been combined with a topographic base map and some manual enhancement has been carried out.

Figure 5. Derivative Map

The estimated cost of producing a 1: 50K map in this manner is as follows:

Operation	Cost - $
Plotting time, 1 hour	10.37
Manual time, 2 hours	20.74
Photomechanical time, .75hr.	8.30
Materials	25.58
	64.99

Total time span (estimated) - 8 days

Figure 6 shows the same map which has been manually enhanced by the addition of the base and a screen delineating one specific area.

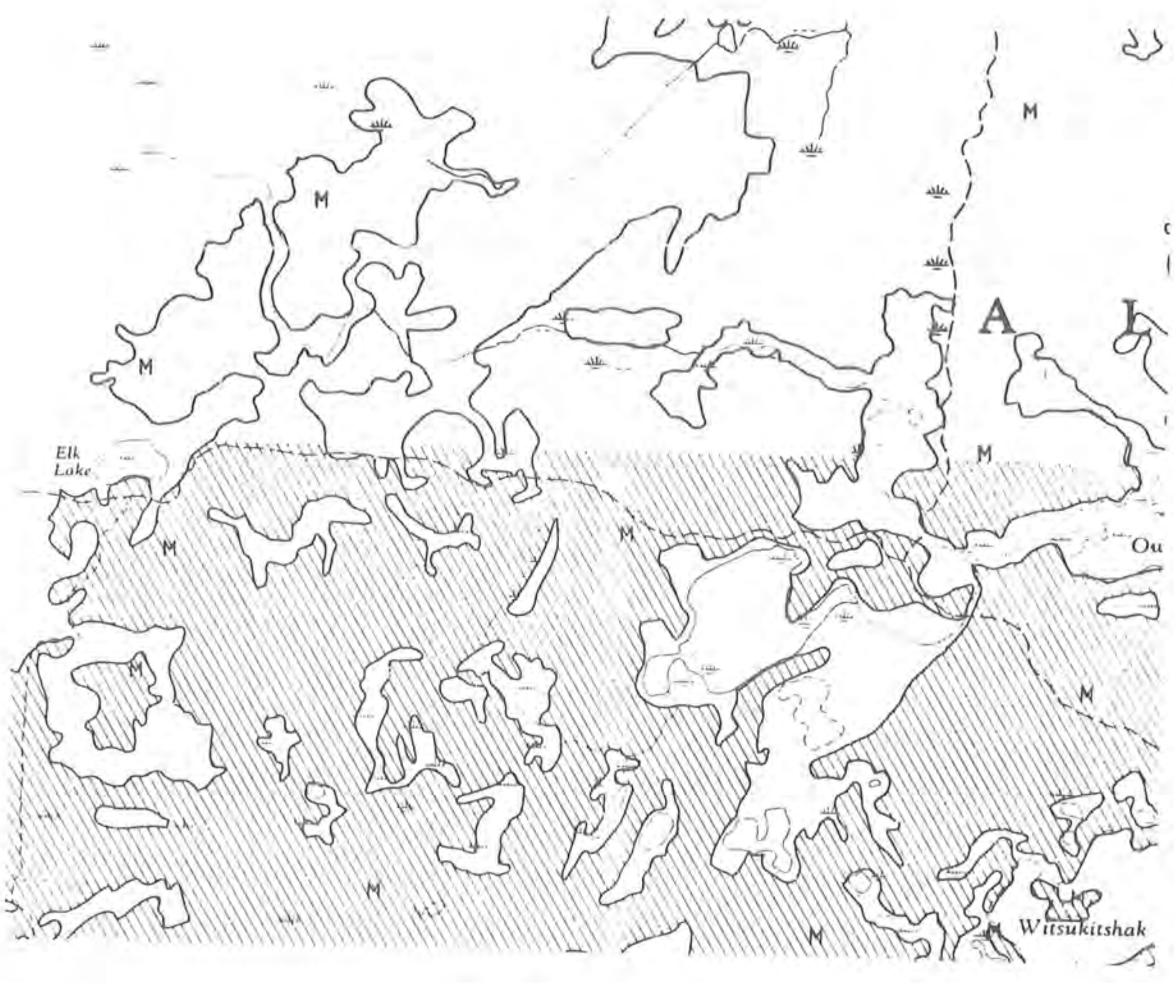


Figure 6.

The following table shows the cost and time span for a 1:50 K map similar to Figure 6.

Operation	Cost - $
Plotting time, 3 hours	31.11
Manual time, 7 hours	72.59
Photomechanical time, $1\frac{1}{2}$ hrs.	16.60
Materials	35.78
	155.78

Total time span (estimated) - 10 days

Before concluding my talk I have been asked to indicate a few of the new features which are or will be available from the Cartographic system. During the past year we have had requests to make available more detailed information in regard to hectares related to the individual polygons. The present printout only supplies an area total for all unique symbols. To satisfy this request, we now have a plot program which can give you any combination of soil boundaries, soil symbols and hectares for each unique ploygon.

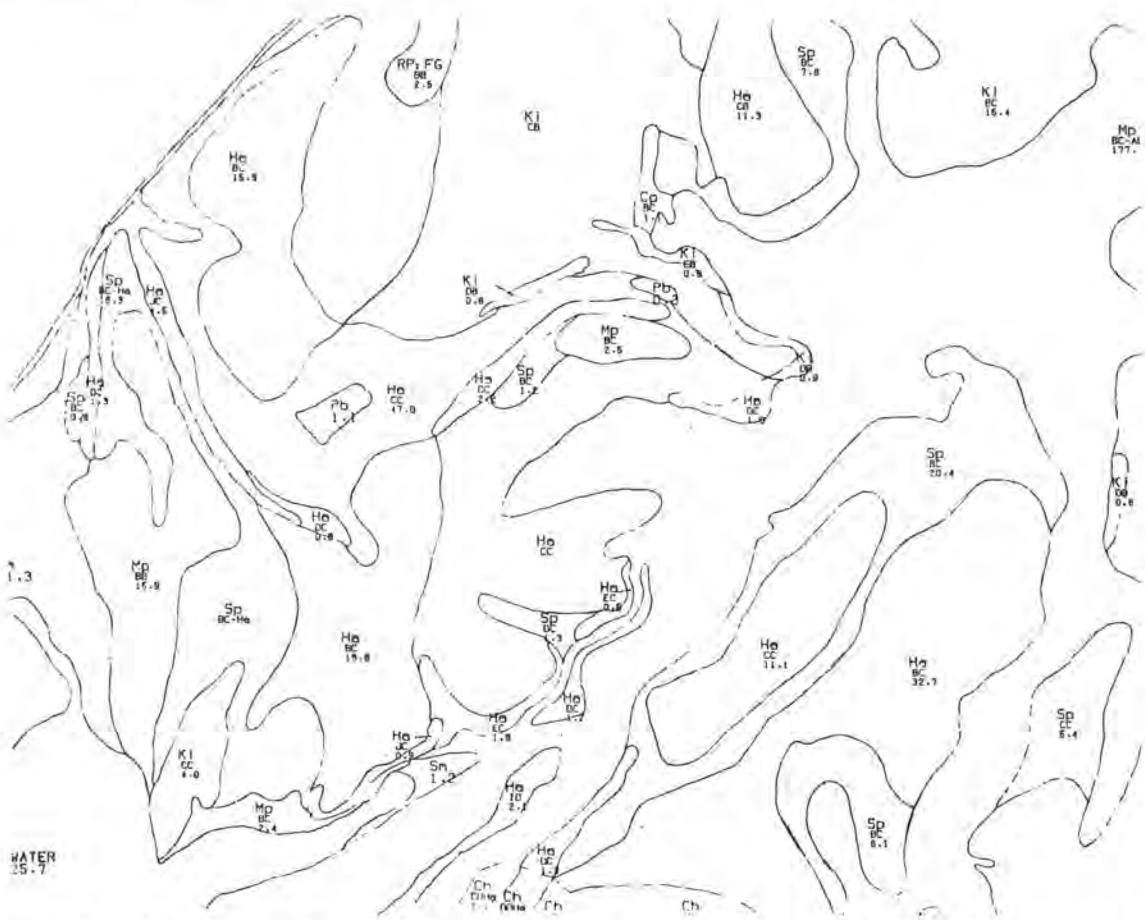


Figure 7. Plot of soil map showing boundaries, soil symbols and hectares.

Please note that only one symbol in each polygon has the area shown under it. Figure 7 illustrates the most expensive format we can produce.

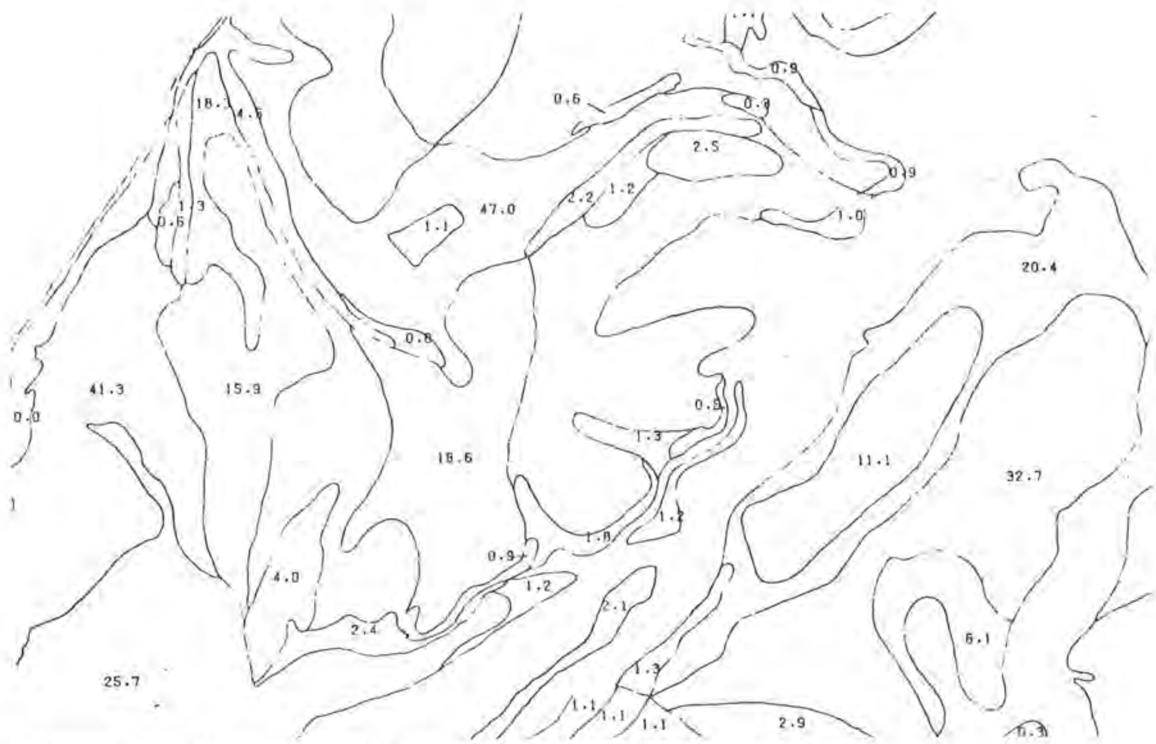


Figure 8. Plot of soil boundaries and hectares.

Figure 8 illustrates a second style of map which would have to be overlaid on a previously plotted soil map. This is of course cheaper to produce.

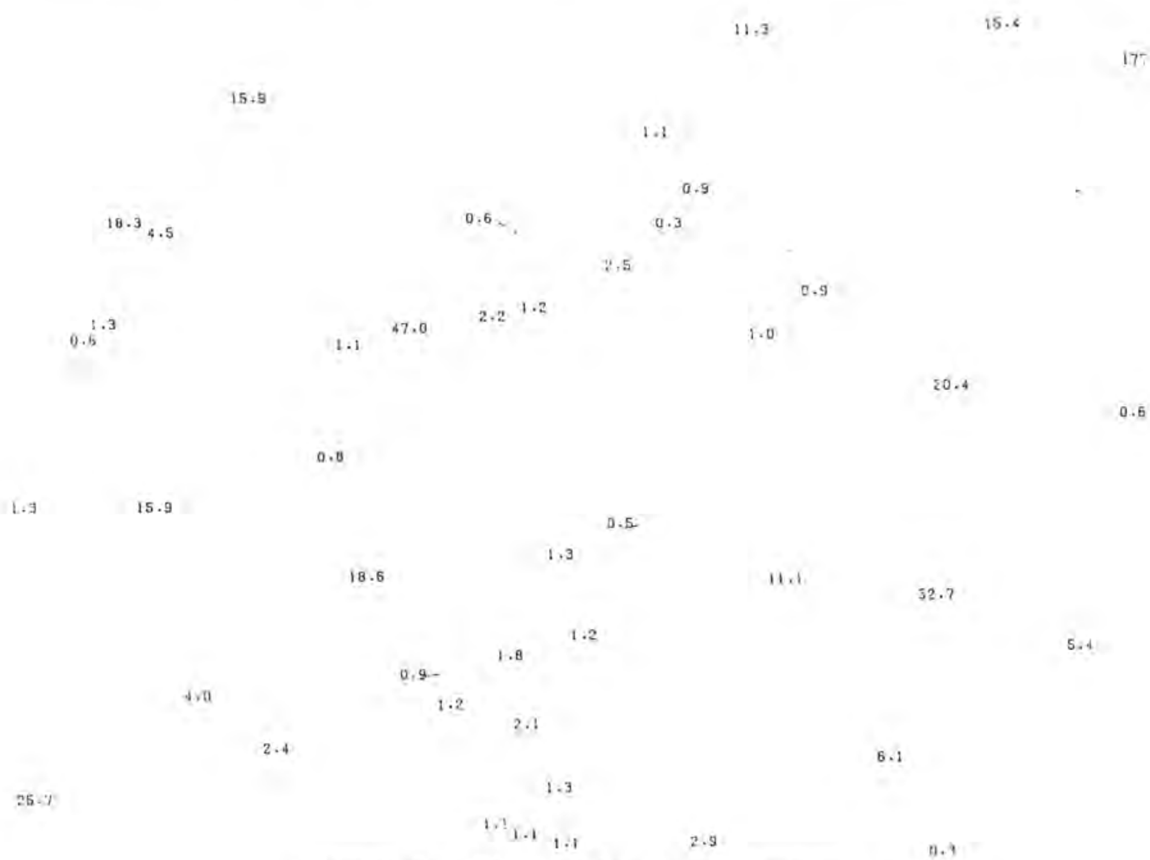


Figure 9. Plot of hectare figures.

Figure 9 shows the simplest and cheapest type of plot which we can produce. When making your request for this option please consider computer costs and choose the simplest format that will fill your needs. These three options are now available for any soil map digitized and error free (see monthly report).

Other operational enhancements are:

- the global symbol change
- 3 symbol size options for plots; these can also be used for derivative maps eg. "C" size for map symbols and "A" size for the legend.
- rectangular or square grids
- software to plot line graphs

Starting in April 1980, each soil survey will receive the new CanSIS Map status report (figure 10). It will be in the following format and I would like to quickly run through and explain what each column represents. Column one is the unique I.D. number given to each map. All correspondence regarding a project should quote this number.

The second column is the title of the map and the third is the map scale. The fourth column is the size of the map in inches (x-y). The fifth and sixth columns show the date of the last updates. The next two columns show the number of errors remaining and the last but one column indicates with the word "yes" if the data is ready for derived mapping. The last column is for the use of cartography only and indicates the storage location of a clean plot. Are there any questions?

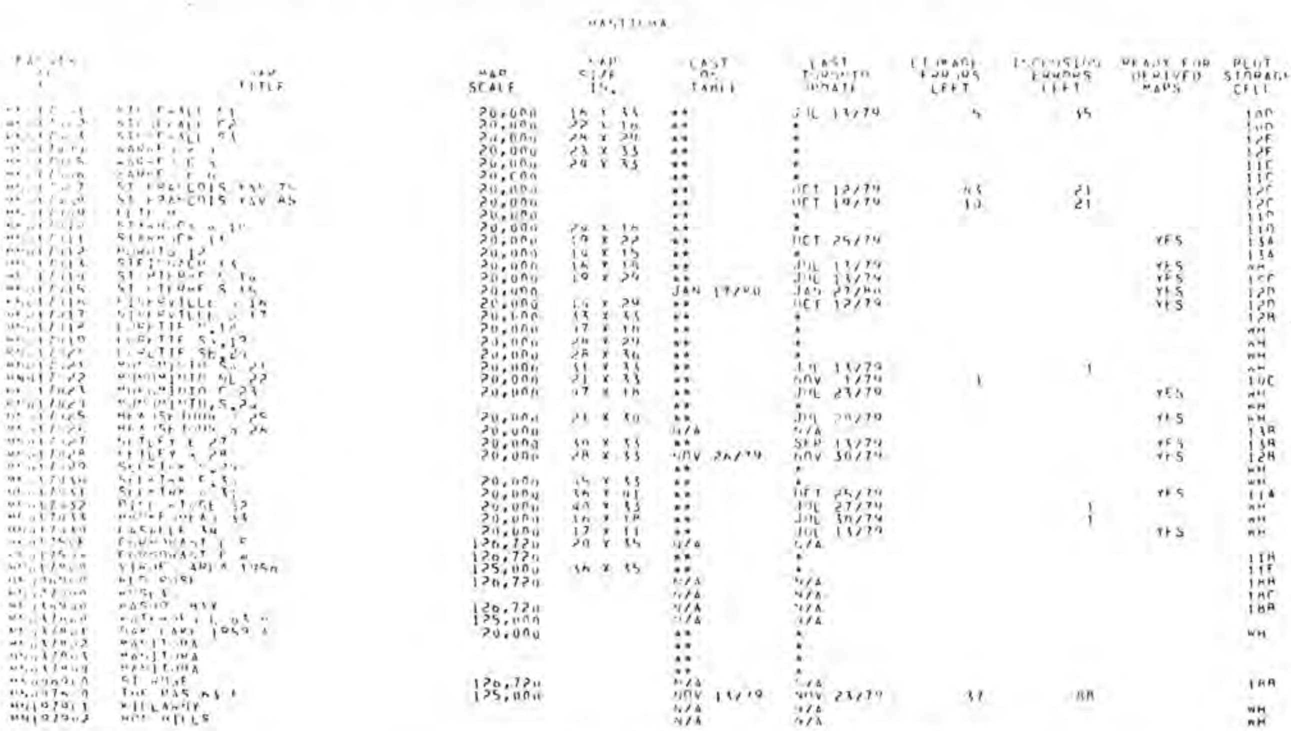


Figure 10. CanSIS Map Status Report

I would like to thank you for listening to me and leave you with this thought.

PARADOX OF DEADLINES

The reason for the rush is delay, and conversely
the reason for the delay is the rush.

When Cartography misses another deadline, perhaps this paradox will explain the circumstances.

Map Interpretations and Computerized Extended Legends

K.B. MacDonald and R. Leuty

Introduction

Recent soil inventories have collected ever increasing quantities of information and compiled it on large scale maps which are quite detailed and often complex. In many cases, the use of information represented on these soils maps is facilitated if simplified interpretations are prepared. Consequently (i) increasing numbers of interpretations are required, (ii) many people, other than the original surveyor, are making interpretations and generally their understanding of the basis of the survey is much less than the author's, (iii) the purpose for which the soil maps are interpreted have become increasingly diverse, (iv) because of the increasing levels of planning activities and resulation, the rigour with which an interpretation must be specified is increasing, as is its expected reliability.

The interpretations of a soil survey for a specific purpose often take the form of maps which display only the data directly related to specific purposes. Interpretive maps prepared from published information must be drawn by hand, but if the data is stored in CanSIS it can be accessed and prepared more simply by using the capabilities of the computer.

The current techniques for preparing an interpretive map from CanSIS consist of interpreting each map symbol and coding the interpretation on a computer input document. The computer has been programed to select the appropriate map units, to assign to them the intended interpretation, and to prepare a map showing the interpretive classes and their boundaries. The task of coding the interpretations of the map symbols is straight-forward for a soil surveyor albeit somewhat tedious and time-consuming. The coding becomes more difficult and probably less reliable if it is done by people less closely associated with the soil survey.

As the input of soil inventory information into CanSIS become a routine procedure and as increasing numbers and types of interpretations are required, there will be a need to develop techniques which are generalized and efficient for preparing interpretations of the data contained on or associated with soil survey maps. The basic requirement is for a standard procedure whereby criteria specifying an interpretation can be applied to a soil survey map with a minimum of time and effort.

While it is not possible to present a complete system and approach at this time, preliminary capabilities have been developed on the computer for handling map interpretations. The basis of the approach consists of computerizing information contained in the map symbol, legend, survey report etc. and using the data handling capabilities of the computer to select, combine, and manipulate these data to arrive at specific interpretations.

Definition and Requirements of Computerized Extended Legends

The computerized extended legend may be thought of as a table of data containing a series of attributes for interpretation and a listing of the value of each attribute, map symbol by map symbol for a single map or a series of maps.

Computerized Legend: Map XYZ

May symbol /	Slope	Texture	Drainage	Suitability #1	ETC
ABC/1	1	L	Good	Good	---
ABC/2	2	CL	Imperfect	Fair	---
ABD/1	1	L	Good	Good	---
FKE/3	3	SL	Rapid	Poor	---
etc					

A computerized extended legend must meet a series of requirements including:

- the array of attributes must be sufficiently complete and comprehensive that most interpretations can be done from it.

- the values of each attribute should be listed as distinct classes rather than as a continuum so that the basic classification is done by the author of the map at the time when the legend is prepared. Interpretations simply assign classes to various interpretive categories.

- information for interpretation may potentially be obtained from the map symbol, or from other CanSIS files in an automated fashion e.g. soil names file, the detail or daily files, the map unit description file or possibly the performance management file. This is one area where the extended legend provided a more powerful interpretive tool than the partial symbol retrieval concept; it is not restricted to information directly from the map symbol.

- map symbols which have information on percentiles of the area occupied by soils with various properties will have the legend attributes specified on the same percentile basis. Symbols containing dominant and significant soil areas will retain information in the legend on the dominant area separate from the significant one.

- extended legends deal with lists of map symbols which have the same level of detail and information associated with them. As such, the list may refer to one map or to a series of maps which, from a map symbol and interpretation standpoint, constitute a logical unit. Where the legend applies to more than one map, interpretations may be done on any portion or all of the legend, and retrievals will generally be done on an individual map basis.

Preparation of a Computerized Extended Legend

One of the principal distinguishing features of all map symbols is that over a map sheet they are variable in form. This variation may well be acceptable and useful when the map is interpreted by eye; however, it is an unacceptable form for computer-assisted interpretation. The main objective of the computerized legend technique is to format the characteristics and properties to be associated with the map symbol into a standard form for easy access by computer. In this form, selected variables can be readily manipulated and summarized with the aid of a computer to allow a rapid, interactive interpretation of the important properties associated with the delineations of a soils map.

The steps involved in preparing a computerized extended legend include (i) make all components of the map symbol completely accessible for selection and manipulation by computer, (ii) explicitly specify any characteristics embedded in the nonconnotative parts of the map symbols, (iii) add additional characteristics and information as required either from reports, by making specific interpretations, or by manipulating the data existing within the various CanSIS files.

From the standpoint of computerization there are a variety of forms of map symbol.

(a) There is the map symbol type in which each of the symbol components is completely explicit and this type requires only a fixed format presentation to facilitate computer manipulation. An example of this type of symbolization is found on the forest cover maps of Prince Albert National Park.

For these maps the map symbol contains a separate component to specify each of the properties; height, species, species density, species condition, percent coverage. This information can be repeated up to three times in the symbol to specify three cover and additional space is provided to code similar characteristics for the understory. Obviously, on a map this symbol is large and cumbersome, in fact it is too large to be plotted on the computer drawn maps. It does, however, provide all the relevant information from which to prepare a computerized legend and from this legend, derived maps with simplified symbols can be prepared to illustrate specific festures of the coverage.

(b) Alternatively, the map symbol may be completely nonconnotative; it may take the form of a number of letter-number combination such as the symbols on the Soils of Canada map. For symbols of this type, the symbol provides only the key to the map delineation and to the information. In computerizing a legend for this type of map, each property or characteristic to be associated with a symbol must be taken from a report or associated documentation and specified in the legend table. For the Soils of Canada a computerized legend has been prepared which has approximately 1000 properties associated with each symbol.

(c) These two types of map symbol tend to represent extremes and, in general, the symbols on the soils maps consist of a combination of connotative and nonconnotative elements. Generally a part of the map symbol represents the soil unit and as such it implies the soil name (or series, association, map unit etc.) and a range of properties such as profile development, reaction class, depth, etc. to be associated with that symbol. In another part of the symbol various properties may be recorded in a connotative fashion e.g. texture, slope, phase, etc. which may well have a specific component in the symbol to represent their value. In computerizing this type of symbol into a legend, both the explicit properties from the connotative portion of the symbol and the implied properties must be specified into a fixed format.

Selection of Soil Properties and Characteristics for Inclusion in a Computerized Extended Legend

In the example being used to develop the computer capabilities, many of the common characteristics require for map interpretations have been selected from the suggested rating and interpretation guides used in both the U.S. and Canada. Class limits have been chosen for each characteristic again after reviewing the classes and class limits used in existing interpretation schemes.

Classes and class limits may be set for each interpretation or may be fixed by the level of resolution of the original map data. For illustration purposes, the map symbols have been assigned to classes at the time they are entered into the computerized legend and will remain in those classes or an aggregation of them for all interpretations. This places the onus for interpreting and classifying the basic data on the person preparing the legend; this is desirable because he should be closer to the assumptions underlying the data and also because the classification will be made in a consistent fashion.

A variety of soil interpretive rating schemes exist in the literature for almost every land use. There is little consistency amongst them and frequently schemes for the same purpose but from more than one source are dissimilar. Discrepancies like these occur for various reasons e.g. differences in the definition of the use, lack of correspondence in the class limits, etc. One way to achieve some consistency among the various interpretive schemes was to compare the existing class limits for the various kinds of interpretations and attempts to average them. This was accomplished by preparing histograms for each property and subjectively assessing the values at which the class limits occured which were common to all interpretations.

Figure 1. Slope Histograms for Derivation of Generalized Slope Classes

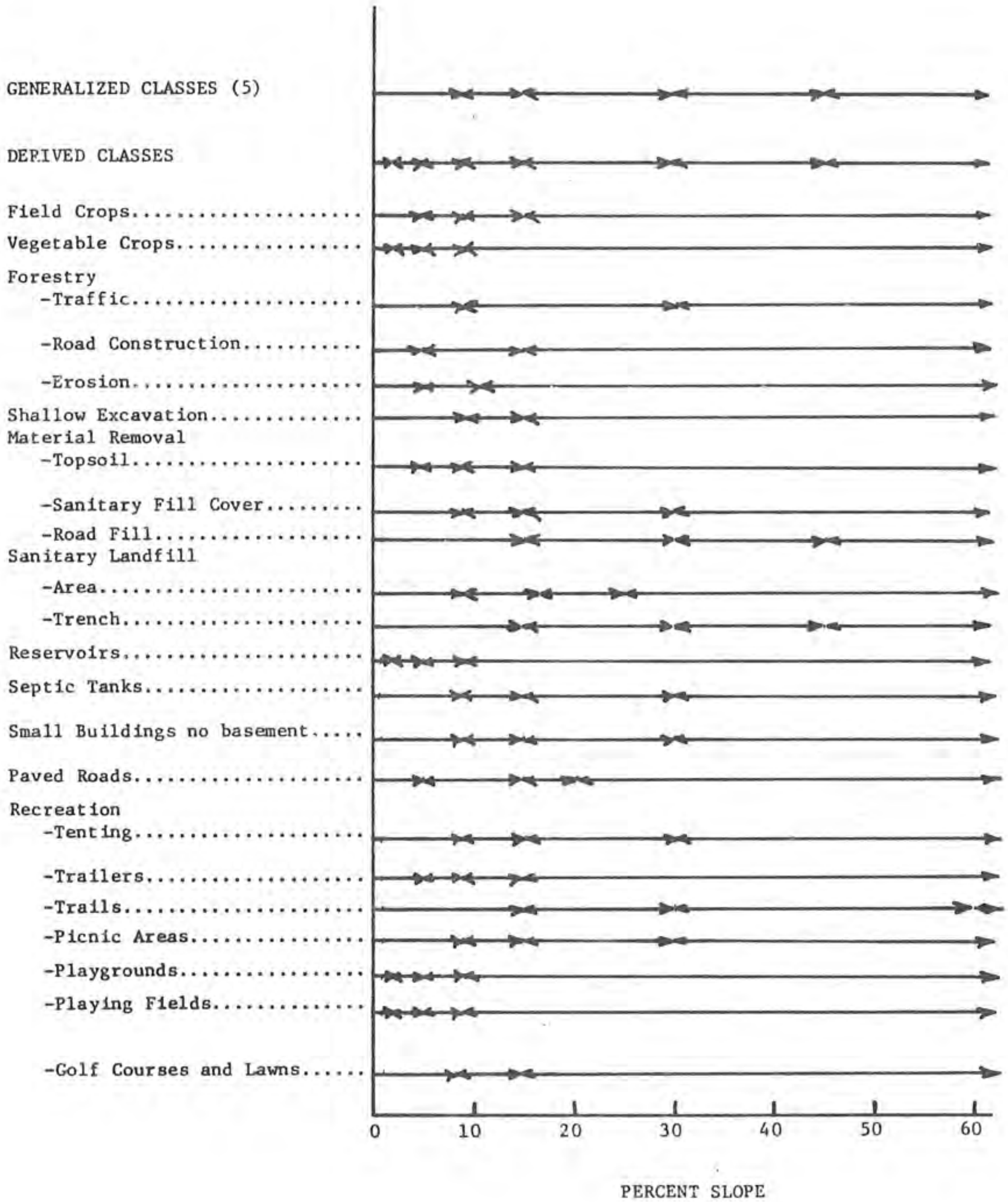


Table 1. Generalized Class Limits For Soil Interpretations from a survey of 22 land use rating schemes*

Property	Units	Generalized Class Limits 1.	2.	3.	4.	5.
Slope	%	0	9	15	30	45
pH		3.6	5.5	6.5	7.5	9.0
Bulk Density	g/cm^3	0.5	1.0	1.4	1.8	2.0
Stoniness	m apart	50	30	10	1	0.1
Rockiness	m apart		100	30	10	2
	% cover		2	10	25	50
	class	0	1	2	3	4
Cobbles	%	0	5	15	25	50
Gravel	%	0	3	20	40	50
Hydraulic Conductivity	cm/hr			2.5	1.5	0
Permeability	cm/hr	0	0.5	2	15	50
Available Moisture	cm		9	5	5	
Drainage	class	well	mod-well	imperf	poorly	v. poorly
Depth to Watertable	m	1.5	1.0	0.75	0.5	0.2
Flooding	yrs^{-1}	1/100	1/20	1/5	1/1	prolonged
See page	freq.		none	occasional	subject to	
Need for Irrigation	class	none	some	mod	definite	essential
Erosion Susceptibility		high		mod		low
Shrink-Swell Potential		high		mod		low
Salinity	$\frac{mmhos}{cm}$	0	2	4	8	14
Sodium Adsorption Ratio			4	8	12	
Depth of Solum	m	1.2		0.5		0.2
Depth to Bedrock	m	1.8	1.5	1.0	0.5	0.2
Depth to Compact layer	m	1.8	1.5	1.0	0.5	0.2
Depth to Deposit	m	0	0.25	0.5	0.75	1.0
Deposit Thickness	m	1.5	1.0	0.5	0.25	0
Structure	class					
Consistence	class	loose	v.friable	friable	firm	v. firm
Aashto Classification		A3	A5	A7		
Frost Action						
Texture	Could not be grouped, actual values were retained.					
Unified Soil Group						

* Compiled by Rod Leuty

In figure 1 the individual histograms and the final subjective average are shown for slope classes. For this property, the class limits which were common to most interpretations occured at 9, 15, and 30% slopes and many also used class limits at 2, 5, and 45% slope. A total of 7 classes could be specified to accomodate 22 separate interpretations. One of the guiding criteria in carrying out the analysis was the fact that classes can always be combined to form broader categories but it is impossible to subdivide a class without recoding the original data.

This procedure was repeated for all numeric characteristics found in the interpretive schemes reviewed. After the class limits were subjectively averaged to arrive at a limited number of classes this final number was further arbitrarily reduced to five. In retrospect, this standardization was probably unnecessary and the actual number of classes arrived at by the subjective average should have been used. For the classification used for the demonstration legend the number of classes for each property have been standardized to five or less.

The same methods were applied to derive generalized classifications for nonnumeric properties. The method was successful when the property was based on only one feature, for example drainage, which could be arranged on a graduated scale from rapid to ponded.

With properties that expressed more than one component such as texture it was impossible to develop any generalized groupings. For properties of this nature the information was not grouped into classes but rather coded into the legend as actual values. Even in using the property as it exists on soil delineations there is the problem of handling a range of textural groups and comparing these to the range of textures required for the interpretation when these ranges do not coincide. The soil properties which were handled in this manner include unified soil group, frost action (which uses the unified soil group) and texture.

Generalized classifications were developed for a total of 30 properties by comparing the classification schemes used from 22 different land use schemes. The final classifications are summarized in table 1.

This generalized classification of soil properties into classes provided the basis of coding the demonstration extended legend for the PEI map series. Its application to the PEI legend required only a few minor adjustments and otherwise the information fitted directly into the classes. It is left to the working group on map interpretations and rating schemes to define a standard set of properties and class limits for use in extended legends of this sort.

Example Computerized Extended Legend

For demonstration of the capabilities of the computerized extended legend concept, an area of PEI was selected for which the soils maps were already digitized and the data was "clean". The map symbols and legend concepts used in the PEI project are relatively simple and contain some connotative portions such as phase slope and surface texture and some nonconnotative portions namely the soil series (dominant, subdominant and inclusions) which carry with them many properties characteristic of the soil series. The PEI map series was of interest for demonstration purposes because it represents a large series of maps (approximately 100) all of which use the same legend. This provided an opportunity to show how the computerized legend could facilitate user access to interpretive information relating to several maps at the same time and also allow examination of the areal extent of particular delineations on a map sheet by map sheet basis.

The information on the map symbols, legend and soil series was provided by J.I. MacDonald.

The information for the computerized legend was input into the computer in three phases:

In phase 1, the map symbol was coded in a fixed format fashion whereby each component of the symbol was coded in a specific location on a computer card, (figure 2a). This merely allowed the computer to find any particular component of the map symbol in an efficient fashion.

In phase 2, the soil series were coded for input into the computer. At this stage a specific fixed format was developed to allow to be recorded all the properties and characteristics associated with the series code (figure 2b). From a computer standpoint this meant that the information about the soil series was contained in a large table with soil series designation noted in the left-hand column and a separate column for each property associated with the series. For each soil series, information was input giving values for 30 properties and uses.

In the third phase, the information on each soil series was added into the computerized map symbol so that each series which was noted in the map symbol (whether dominant, subdominant or inclusion) could be completely described as to its 30 characteristics and uses (figure 2c). This wad done by computer manipulation of the data and required no additional coding.

At the same time data from the cartographic files was searched to extract the information on the number of times each map symbol occured on each of 5 map sheets and the area in hectares represented by each map symbol on each of the map sheets. These data were added to the legend information. The final computerized extended legend consisted of a

Figure 2. Phases of Coding - Demonstration Computerized Extended Legend

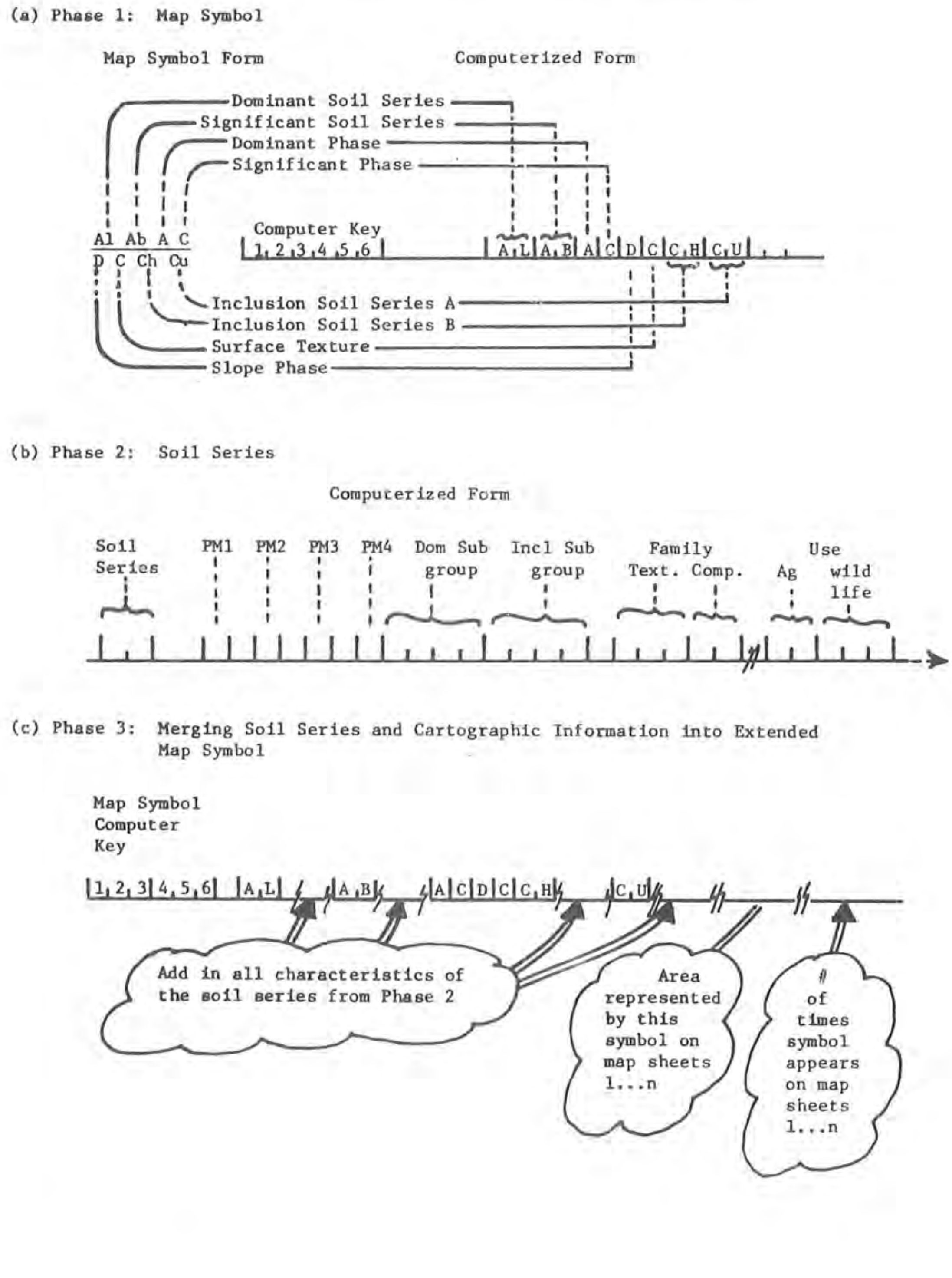


table of data which contained approximately 140 columns. It contained about 65,000 separate pieces of data to describe 508 symbols which occured on 5 maps. The process of coding this information had required coding of the characteristics of the soil series - some 1550 pieces of data, and the components of the 508 map symbols - some 4572 elements of data. The remaining 59,000 elements of data have been generated by data manipulation using the computer.

In using these data to assist in carrying out an interpretation it is a simple matter to select and classify (group) any property in the legend (this includes any characteristic of the dominant, subdominant or inclusion series, any of the connotative properties or any of the information about the number of area of delineations).

Interpretations Assisted by Computerized Extended Legend

Once a computerized legend has been prepared for a map or a series of maps, there should be no requirement to code up individual interpretations on computer input documents. This capability will still exist if it is desired. It is envisaged that most interpretations will be developed through an interactive process whereby the user accesses the extended legend and applies selections and data manipulations to develop the selection criteria which constitute the desired interpretation.

An interpretation and retrieval of information in map form is carried out by specifying:

(i) which attributes are to be examined.

(ii) which classes of each attribute are assigned to various interpretive classes.

(iii) how the attributes are to be combined to give the final interpretive classes. In cases where soil area percentiles have been mapped or where dominant and significant soil types are noted, the interpretation request must specify how this information is to be combined to give one areal interpretation of whether the percentiles or dominant/significant area information is to be retained. The default will be that the interpretive symbol will contain the same degree of area specificity as is found in the computerized legend.

(iv) which map(s) the interpretation is to be applied to, and what format (balular, map, or both) the interpretation should take.

Forms of Interpretation

The most tangible products of many interpretations of soil inventories have been derived maps which highlight properties important to the proposed application. There are, however, other types of presentations of the information which can constitute interpretations or provide assistance in developing the final interpretation.

These forms of interpretation consist of tabular summaries of the data after some or all of the selection, manipulation and grouping has been carried out. In this way, the user can determine what effect the various selection criteria have had and can understand how severe the rating scheme is in terms of the extent of an area meeting specific ratings. In many cases also he should be able to detect occurances where the selection and data manipulation being carried out by the computer is not producing the results to be expected on the basis of other knowledge or intuitive feelings. In these cases he can examine the data and the selection process and either accept the interpretation as specified or make appropriate modifications to the criteria in order to bring the results more in line with his expectations.

Some of the types of tables which may be of interest in developing an interpretation are (i) the number of map symbols which meet specified criteria probably done in an iterative fashion as the criteria become more and more restrictive, (ii) a list of the symbols which meet the criteria so that the user can determine if the grouping is logical from his subjective integration of the information, (iii) if more than one map sheet is involved in the legend he can examine the number of delineations on specific map sheets which have been selected and also tabulate the hectarage meetings the rating criteria on a map sheet by map sheet basis.

Once he has carried out this assessment of the data he may decide simply to use the tables if only a few areas have been selected and to locate the areas on a soil map. In cases where there are significant numbers of areas or where the interpretation is sufficiently important to warrant the preparation of a map he would use the selection criteria developed through the interactive process to specify a computer generated map displaying the interpretation with interpretive classes on it and an accompanying legend to list the criteria underlying each interpretive classification as well as the assumptions and conditions for applying the interpreted information.

Conclusion

In developing the capabilities for a computerized extended legend it was considered important that the initial data selection and manipulation procedures for the analysis of the information should be simple enough that they could be carried out by users with no prior computer experience. The computer programs which have been implemented to manipulate the demonstration legend information meet this requirement. The computerized extended legend capability of CanSIS now requires a period of trial and refinement by a wide range of users and for a variety of soil maps.

APPENDIX 5 WORKSHOP SESSION ON LAND EVALUATION

A Multicategorical Classification of Agricultural Land In Saskatchewan : A Base for Land Evaluation

S.E. Kraft, D.F. Acton, and G.A. Padbury*

*The authors would like to acknowledge the contribution of E.H. Halstead and other members of the Saskatchewan Institute of Pedology staff in developing the ideas in this paper.

We are developing a framework for land evaluation based on agro-ecological units of land specified using climate, edaphic, and physiographic data. These data ideally reflect expected differences in crop response and/or land management relevant to rainfed agriculture in Saskatchewan. The units are being defined at different categorical levels. However, the units are not part of a formal, multicategorical, hierarchical taxonomy. Rather, each categorical level and its component classes represent distinct levels of spatial generality. The categorical levels and their classes are accompanied by a set of corresponding cartographic units. The categorical levels and their component classes ideally will match the spatial concerns of people making land-use decisions or formulating policies encompassing land use. The purpose of our classification system is to facilitate the dissemination of information about land that can be used evaluatively by these people. Since the spatial concerns of these people will vary given their economic and political activities, the classification system is designed so that economic, political, and natural phenomona or their indicators are "relatively" homogenous within each class. Consequently, we envision a number of approximations in developing our framework. Given this general introduction, we will present the concepts and procedures underlying our work in more detail. We also include examples of how the framework might be used at the lower categorical levels.

The need to develop a classification of agricultural land in Saskatchewan derives from our realization that inventory information about land and soil in the province as well as productivity data on the agronomic use of the land are collected on spatial levels that do not correspond to the spatial focus of the potential users of the information. There are few a priori reasons to assume that the logic of soil maps and data available on them and in productivity data banks are accessible or understandable to individuals desiring to evaluate land for public or private purposes. Hence, in Saskatchewan, we decided that we required a format of data organization and presentation that would increase the accessibility of land information for users who frequently lack formal pedological or edaphical training and who have different temporal and spatial interests. The thrust of our effort is not to change necessarily the ways in which inventories and data collections are presently conducted, but to focus on how to transfer this information to potential users in forms that they can readily apply to their particular applications. Where possible, we see the framework as facilitating the interpretation of inventory and production data as these data become available. Our experience has taught us that we presently lack the capability to make technical evaluations of, or technical classifications of land[1] for a broad spectrum of users with diverse needs. While we cannot hope to meet the needs of all potential users in one classificational system, we can at least begin to facilitate the access of larger numbers of users to the diverse land, soil, productivity, and managerial information that is available.

Our overall goal in this study is to develop a multicategorical classification of land. Ideally, through the different levels of generality, i.e., categorical levels, we will present land related information relevant to different types of decision makers (Figure 1).

Figure 1. Role of Land Classification in Evaluative Question of Land Use, Land Management, and Land Policy

Physical Resource and Useage Aspects of Land

edaphic

topographic

climatic

past investment, e.g.,
irrigation
drainage
land use, e.g.
past
present

productivity

land-use technologies

MULTICATEGORICAL CLASSIFICATION OF LAND IN AGRICULTURAL SASKATCHEWAN

(organization and dissemination of land information relevent for agriculture)

Political Economy of Land: Socio-economic Aspects of Land Use and Land-Use Policy

federal planners and policy makers

provincial planners and policy makers

officials or rural municipalities

private developers

agrologists

extension agents

farmers

professional land specialists

eg., pedologists, agrologists, economists

Some Problems that Could be Addressed by Information Processed Through the Classification Scheme

land degradation and renewal

land ownership

land productivity;
biological yield
economic yield

land evaluation

productivity modelling

land-use patterns

regional-yield prediction by crop

moisture and precipitation management

land management

land assessment - taxation

land-use controls

farm level planning

land base policy

Each level of generality will contain classes of land based on physical aspects of land relevant to agricultural use. In addition, the categorical levels and their classes will convey information on the physical features of land and land use to decision makers who either use land or affect policies influencing its use. The decision makers for whom we are designing the classification system are farmers, agrologists, extension agents, officials of rural municipalities, provincial officials, and public decision makers or planners concerned with regional, i.e. prairie, agricultural interests. Furthermore, since relevant evaluative questions change with the extent of spatial generality, our different categorical levels should aid us in addressing the spatial dependent aspects of land use. Frequently, policy changes or changes in factors effecting supply and demand have different implications for the decision makers as the level of generality moves from the most specific to the broadest.

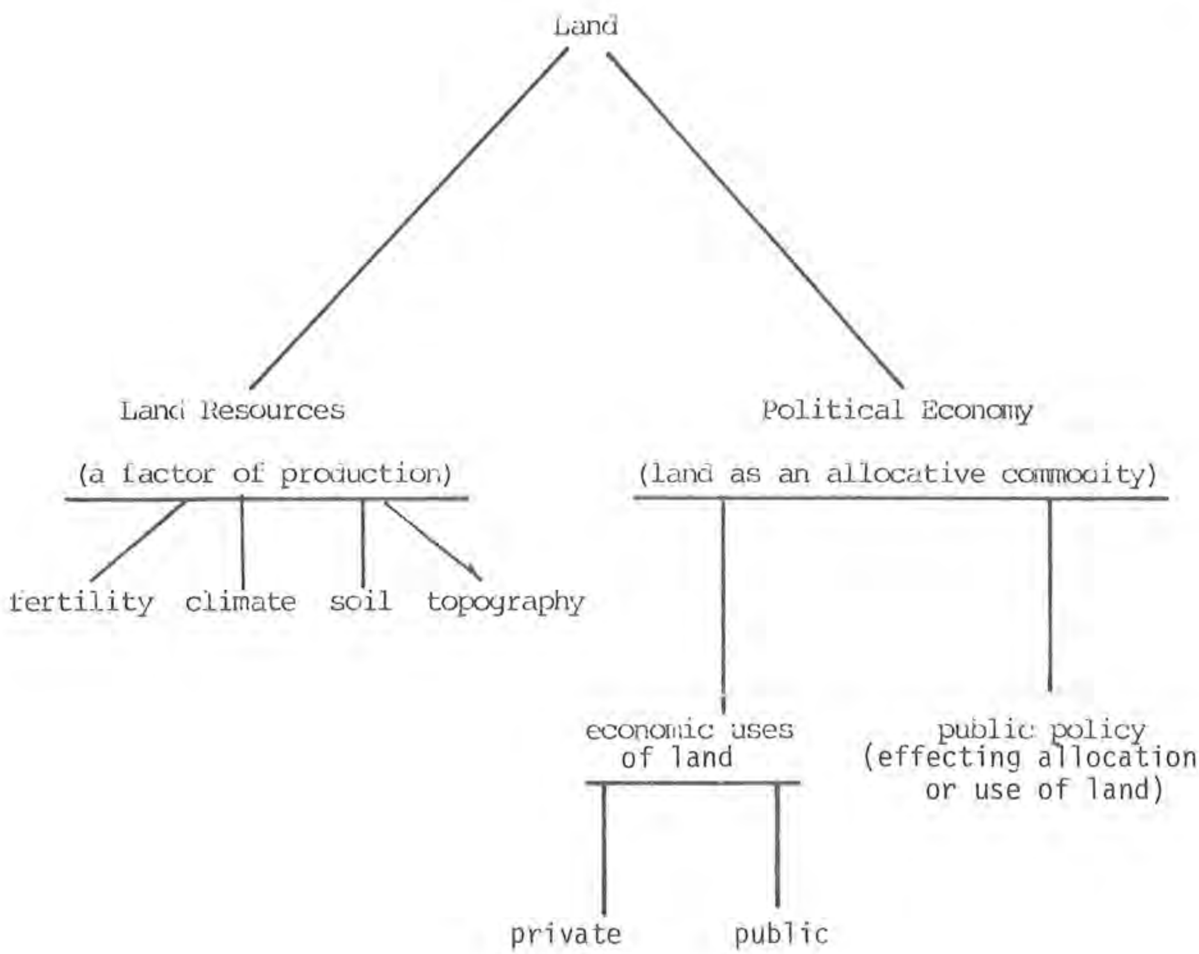
The terms of land, land evaluation, and land-use are often fraught with confusion. Consequently, we want to clarify a number of concepts supporting this research. First, land is considered a physical resource used in processes of production, e.g., agriculture, transportation, housing, etc.:

> A tract of land is defined geographically as a specific area of the earth's surface; its characteristics embrace all reasonable stable, or predictable cyclic attributes of the biosphere vertically above and below this and including those of the atmosphere, the soil and underlying rocks, the topography, the water, the plant and animal populations and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man (sic)[2].

Land is an n-dimensional entity occupying space and changing through time. Edaphic, topographic, and climatic features are aspects of land. In addition to the physical aspects of land, the nature of land changes due to the cumulative actions of man[3]. The inclusion of land in many and varied productive processes underscores land as a bundle of resources. The resource aspect of land cannot be limited to one of its natural components. Rather, land as a productive resource represents an intricate combination of resource funds and flows[4] that determine its response to and contribution to many forms of productive activity. Hence, the actual response of a unit of land in a productive activity depends upon which of its resource aspects are being tapped and how they combine with the other inputs and the technology used in the production process.

In addition to the natural resource side of land, there is the political economic side of land i.e., the processes through which land is allocated by resource managers to specific uses at a particular time. (Figure 2). This involves land as a commodity to be allocated by resource managers among alternative productive activities. The political economy of land has two facets: the economic and political[5]. The economic facet encompasses allocative decision making by private or

Figure 2. Aspects of Land



Note: there is some circularity implicit in the diagram, since private and public uses of land in economic activity can alter its physical nature. Similarly, public policy influences the range of allocative and use options open to private and public users of land.

public individuals whereby land is allocated among uses in order to further the advancement towards some goal. The political facet focuses on decisions made by public groups at different levels of public administration that change the framework in which private and public land-use decisions are made. Of concern to participants in both the economic and political realms is the performance nature of land: the facility with which land combines with other resources and contributes to the attainment of some goal.

The significance of the political economy of land derives from the scarcity of many types of land vis-a-vis the multiplicity of mutually exclusive uses competing for it. The political economy of land includes the influence of allocative decisions upon the agricultural economy, the effect of policies designed to influence land use, and the effect of land allocation among different uses on the physical nature of land.

On a macroscale,the political economy of land reflects societal forces determining the supply and demand of land for different uses. These societal forces are composed of social goals and changes in secular and political aspects of the economy. On a microscale, the political economy of land reflects the decisions made by individuals with respect to land use given their economic enterprises and their expectations of costs, revenues and risk.

We hope in our land classification to convey information currently available and being collected on land as a physical resource and land in use to participants in the political economy of land. Ideally the information we provide will facilitate the evaluation of land made by public and private agents. The availability of land information should ease the making of allocative and policy decisions and result in better utilization of our land resources.

Land evaluation is the second concept we must clarify. Land evaluation is a vague concept covering at least three distinct processes: description, assessment of capability, and assessment of land-use capacity. Implicitly, efforts in land evaluation assume the designation of the unit(s) to be evaluated. Heady and Jensen point out that studies dealing with a single productive factor, i,e, land or labor involve only the physical or intrinsic aspects of the particular factor[6]. With respect to land, description involves the inventorying and classifying of identifiable morphological and performance features of land as entities or phenomenon in and of themselves. Examples of descriptive studies of land include pedological analyses and classification, topographic descriptions, and vegetative or climatological maps.

Assessment of capability refers to the absolute capacity of land to support a particular use given present or expected technology. This assessment is a yes or no evaluation of the capacity of land to sustain the use: either the land can or cannot sustain it. From the perspective of land as a resource, capacity implies that a unit of land being evaluated can or cannot be combined with other factors of production to attain a given end.

A shift of emphasis from the absolute capacity to the relative capacity of a unit of land to perform a particular function results in the consideration of land-use capability[7]. This form of evaluation requires the selection of goals, standards of comparisons (criteria), and time horizons for use in judging relative, land-use capacity. In evaluating the land-use capacity of a unit of land the evaluator has a number of procedural options. First, the evaluator can elect to use either physical or economic criteria in the evaluation. Physical criteria include yield or agronomic performance. Economic criteria include gross income, net income, or dollars earned per dollar spent. A second option open to the evaluator is to include constraints or side conditions on the performance of the unit. The constraints encompass such things as specified level of management, evaluation based on net performance (gross performance minus cost), or maintenance of some level of environmental quality. These are not all the possible options an evaluator might elect to make; however, these examples point out the complexity and diversity of the evaluative process. The pivots in any evaluation, however, are the goal(s)[8] against which the land is judged and the criteria used to determine the "value" of the land vis-a-vis the goal. Land evaluation is first and foremost an end directed activity involving one or more decision makers or policy planners.

Our discussion of land evaluation has three caveats that need to be stressed. First, the nature of the evaluation process will change dramatically with the spatial scale at which the land is evaluated, e.g., field, farm, municipality, or province. Second, the criteria used by evaluators will change given their goals and time horizons. Third, the form of land evaluation changes with the physical and economic criteria used in the evaluative process. The form will also change based on how physical relationships underlying land uses are translated into values useful in economic analyses.

Land use and land management are the last concepts we want to clarify. Land uses are those productive enterprises that employ land as a factor of production. In addition, land use encompasses uses of land in which land or its attributes are "consumed" as end in and of themselves, i.e., scenic landscapes. Frequently, land-use patterns are used to describe combinations of particular land uses over an area and over time. The description of land-use patterns will change given either the level of spatial generality and/or the aspect(s) of land use being highlighted through pattern analysis[9]. Land management is the production technique through which land is actually combined with capital and labor. If different time periods are used to assess land use and land management, then some facets of use and management may combine, i.e., crop rotations.

Given these concepts of land, land evaluation, land use, and land management, we visualize a system of land classification that will facilitate the uncovering and studying of the spatial dimension of these concepts. We do not foresee the classification encompassing the dynamic aspects of land. This dynamic aspect can be approached through techniques of comparative statics, updating the data in the classificational scheme over time, and conducting trend analyses on data that are appropriate for these kind of analyses. In short, our classificational scheme is a process whereby available land information is processed to increase its availability to decision makers with a range of spatial, temporal, and use interests.

Generally, we view classification as a process through which individuals of a population are placed in one of various groups or classes according to some predetermined criteria. Classifiers specify the population to be classified. They prepare statements detailing the characteristics to be used as criteria in defining the classes, the range of the criteria within each class, and the number of classes. The classes at any categorical level are usually mutually exclusive and comprehensive. Classifiers then describe individuals of the population in terms of the criteria and indicators thereof and place them in the appropriate class. However, if the phenomenon being classified is not a population of individuals but is continuous (land, soil, time), then classifiers must divide the phenomenon into "individuals" according to other criteria. These "individuals" are then classified like natural ones.

Classification is a pragmatic, some might say a political, process; there are no universal answers to the questions of how to define a population, to individuate a continuous phenomenon for classificational purposes, or to select criteria used in constructing classes. Ultimately, these questions are answered by classifiers with particular goals, research orientations, and philosophies. The usefulness of a classification depends on the user's comprehension of its designer's goals and how these coincide with his own.

The Rudiment of a System for the Classification of Agricultural Land in Saskatchewan

The area covered by the classification system lies south of 55^{0} N latitude. It includes all of the agricultural region of the province and parts of the northern provincial forest. Although the latter is not presently used agriculturally, it is included because it has at least some agricultural potential.

In our classification, we have specified five categorical levels. We will focus on the four highest levels, referred to as the land region, the land system, the land type and the land unit and the process of classification used for these four levels. The lowest, or most detailed level includes detailed reconnaissance soil maps, published at a scale of 1:125,000 on a national topographic map sheet basis[10], semi-detailed soil maps published at a scale of 1:50,000 for each rural municipality[11] and the individual township field sheets at a scale of 1:30,000.

Figure 3. Land Classification Concepts

MULTICATEGORICAL CLASSSIFICATION OF LAND
IN AGRICULTURAL SASKATCHEWAN

	CATEGORICAL LEVEL	POSSIBLE MAPPING SCALES AND COMMENTS
□	1	1:5,000,000 (land regions)
□□	2	1:1,000,000 to 1:5,000,000 (land systems)
□□□	3	1:250,000 to 1:250,000 (land units)
□□□□	4	1:125,000 to 1:250,000 (land units)
□□□□□□		1:125,000 (N.T.S. Soil Maps)
□□□□□□□□	5	1:50,000 (Rural Municipality Soil Maps)
□□□□□□□□□□□□		1:30,000 (Field Sheets)

RESEARCH QUESTIONS AND OBJECTIVES BASED ON CLASSIFICATION SCHEME

1. Who uses and can supply data for each categorical level?

2. What types of information to collect andpresent for each categorical level?

OBJECTIVES

a. Interpretation of relevant data on each level, (ie. What are the common denominators?)

b. Use of central concepts or boundary conditions to specify categorical levels and their classes?

c. Minimum-area and maximum-complexity criteria for categorical levels and their classes?

FURTHER CONSIDERATIONS

i) procedures for updating and modifying the classification.

ii) data to use in designing and validating the classification.

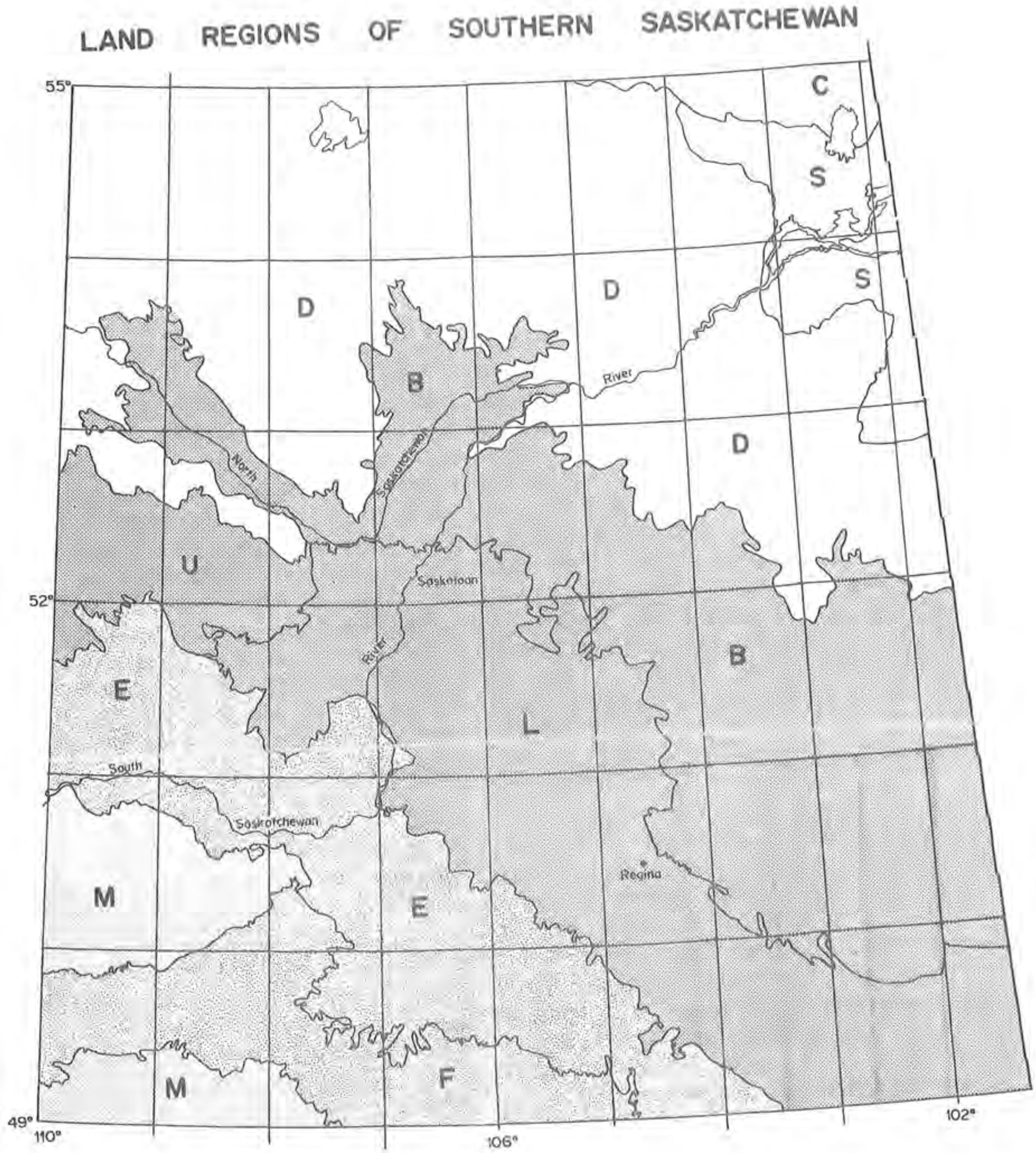
The most general category is the land region. The area is divided into nine regions. (Figure 4). The average size of each region is approximately 10 million acres. The differentiating criteria for the land regions are major geological structures and regional soil climate. In our first approximation of the classification scheme, physiographic provinces of the physiographic divisions of Saskatchewan [12] are used in conjunction with soil temperature and moisture classes from the Soils of Canada[13]. The land region, we believe, will be appropriate for land-use concerns which encompass the entire province on a small scale[14]. Our first approximation of the land regions and their definitive characteristics are summarized in Figure 4 and Table 1.

The next lower level of categorical generality is the land system. Each land system is contained within a particular land region, i.e., they are subdivisions of the land regions. In our first iteration, there are 34 land systems ranging in size from 500,000 to 6 million acres with an average size of approximately 3 million acres(Figure 5). The land systems, like the land regions,are differentiated on the basis of geology and climate but, unlike the land region, the geologic and climatic criteria of the land system are less broadly based. The geologic criteria are regional geology, topography, and river drainage basins. For example, an upland, dominated by hilly morainal landforms would be separated from a lower plain with an assemblage of fluvial and lacustrine landforms on gentle slopes. In addition, climatic criteria congruent with soil zonality are used to differentiate land systems. We anticipate that the land system will serve as a basis for broad agricultural planning within the province. The land systems, definitive criteria, and accessory characteristics for two land regions in the province are presented in Table 2.

A more specific categorical level than the land system is the land type. Each land type is a subdivision of a land system. While the land region and land system are differentiated using regional geology and climate, the land types are differentiated on the basis of surface geological deposits, surface expression or landform, and soils. Land types range in size from approximately 50,000 to 1 million acres. On the average, they are approximately 250,000 acres in size. The land types separated for the Big Stick Lake land system and the criteria used for their separation are presented in Figure 6 and Table 3. We believe that the land type will be useful in agronomic planning at the sub-provincial or rural-municipality level.

The categorical level beneath the land type is the land unit. The land unit represents an interface between the soil mapping units of published soil survey map sheets and the land type. Land units range in size from 5,000 to 50,000 acres or more. The average size of the land unit is 20,000 acres. The land unit represents either a homogeneous area comprised of similar genetic materials, landforms, and soils or a heterogeneous mixture of genetic materials, slopes and soils that cannot be separated at a scale of 1:250,000. Every land unit is unique to a land type, although the unit can occur more than once spatially within its land type. Consequently, two land units having similar characteristics, but located in different land types are considered unique and would be classified differently. The land unit will be

Figure 4. Land Regions



SYMBOL	REGION
B	Batoche
C	Churchill River
D	Doré Lake
E	Eston
F	Fort Walsh
L	Last Mountain Lake
M	Milk River
S	Suggi Lake
U	Unity

Table 1. Land regions of Saskatchewan, their definitive criteria and accessory characteristics

Region Name	Soil Climate: Temperature	Soil Climate: Moisture	Physiographic Province	Geology	Elevation
Wollaston	Subarctic	Humid	Churchill	Precambrian Shield, thin drift	
Churchill River	Cold cryoboreal	Humid	Churchill	Precambrian Shield, thin drift	1000-1800
Athabasca	Cold cryoboreal	Subhumid to humid	Athabasca	Precambrian sandstone, thin drift	600-1600
Suggi Lake	Cold to moderately cold cryoboreal	Subhumid to humid	Manitoba Lowlands	Paleozoic limestone, Cretaceous sandstone and shale, thin drift	850-1200
Doré Lake	Cold to moderately cold cryoboreal	Humid to subhumid	Great Plains	Upper Cretaceous shale, drift covered	1000-2500
Batoche	Moderately cold cryoboreal	Subhumid	Great Plains	Upper Cretaceous shale, drift covered	1500-2650
Unity	Moderately cold cryoboreal	Semi arid	Great Plains	Upper Cretaceous shale, drift covered	2000-2300
Last Mountain Lake	Cool boreal	Semi arid	Great Plains	Upper Cretaceous shale, drift covered	1500-2150
Eston	Cool boreal	Subarid	Great Plains	Upper Cretaceous shale, drift covered	1900-2900
Fort Walsh	Moderately cool to cool boreal	Subarid to subhumid	Great Plains	Upper Cretaceous and Tertiary shale, quertzite, thin to thick drift cover	2500-4567
Milk River	Moderately cool boreal	Subarid	Great Plains	Upper Cretaceous shale, drift covered	2250-3500

useful in sub-provincial planning as well as in studying aspects of degradation, conservation, and productivity.

Since the land unit represents the interface between the higher categorical levels and the traditional mapping units of the soil survey, we will present a more detailed explanation of it.

The way in which named soil series are combined into soil mapping units on R.M. soil maps and recombined on the more general N.T.S. soil maps is illustrated in Figure 7. Also depicted is the interface between the soil mapping units and the land units of the land classification system.

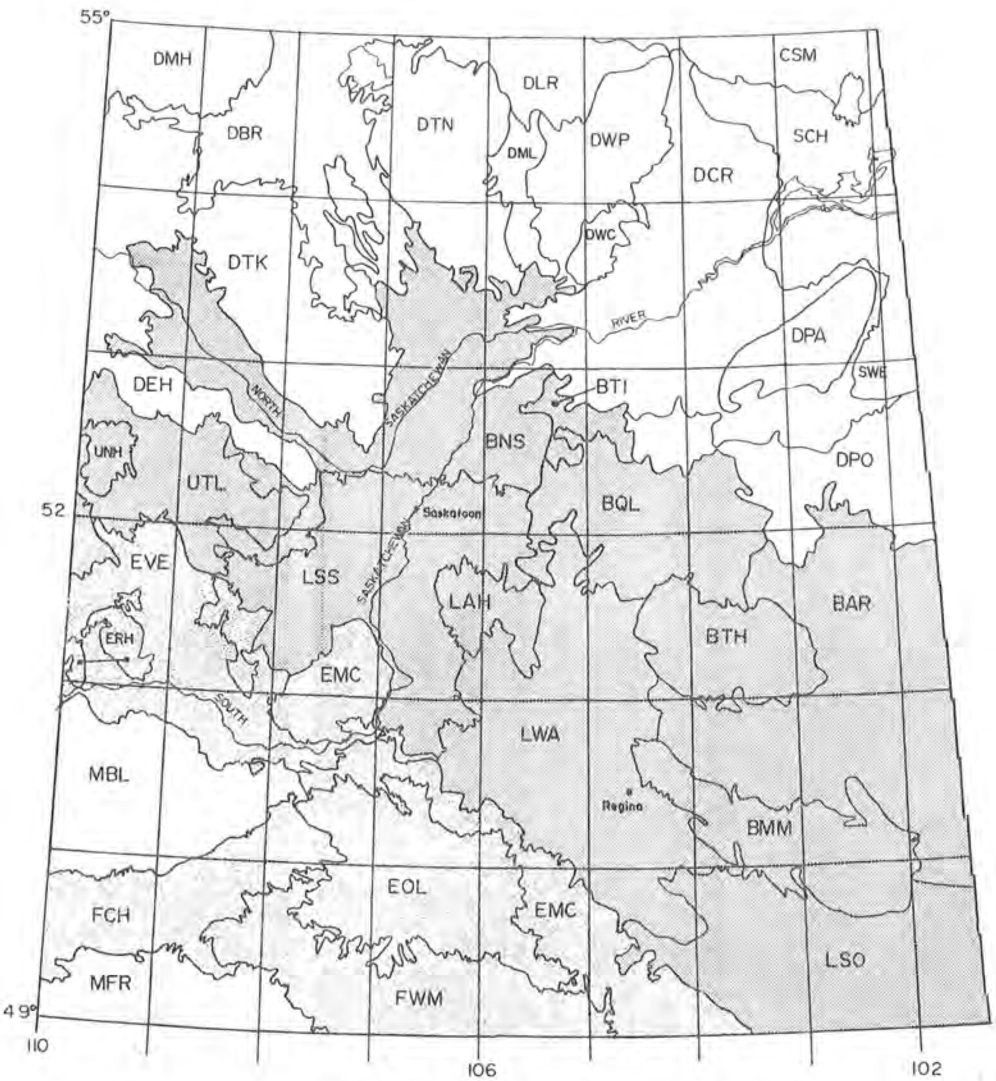
The map edit used to designate a land unit has five parts corresponding to the criteria characterizing the unit (Figure 8). The two elements of the numerator correspond to the dominant taxomonic unit of the soil and the soil parent material. The three elements of the denominator correspond to the surface expression, slope class, and erosional characteristics. Examples of land units and their map edit for some of the land types of the Bigstick Lake land system are presented in Table 3 and Figure 6. Because of the potentialy large number of land units, we found the description of each one individually to be impractical consequently we adopted the use of an open legend which enables a user to obtain an abbreviated description of the land unit. For example, a land unit identified by the symbols $\frac{\text{Ac}}{\text{U3v}}$ is defined as a Brown Chernozemic soil (A), developed in glaciolacustrine clay (c) with an undulating surface expression (U), slopes ranging from 2-5 percent (3), and undergoing erosion by gullying (v).

We are currently working out the interrelationship among the categorical levels and their constituent classes. Ideally, we want to be able to describe the degree of homogeniety of each categorical level in light of the kinds and extent of classes occurring in the next lowest level of the classification. We are designing the classification so that the land regions can be described in terms of the kinds of land systems occurring within them. Similarly, the land systems are being designed to be described based on their constitutent land types. Finally, on the level of the land unit, the land unit can be described in terms of the kind of soil mapping units identified and mapped in soil surveys.

The general methodology used to construct the four categorical levels begins by concentrating on the lowest categorical level, the land unit, and the highest categorical level, the land region, simultaneously, and then proceeding to the two intervening categorical levels, the land system and land type. Specifically, we began by generalizing soil survey mapping units into land units using the criteria mentioned above. In most instances land units were comprised of several similar soil mapping units, but occasionally the land unit may represent a very complex tract of land comprised of several highly contrasting soil mapping units that were combined due to scale limitations. (See Appendix for a detailed description of this procedure). At the land region and land system levels, a number of

Figure 5. Land Systems

LAND SYSTEMS OF SOUTHERN SASKATCHEWAN



REGION SYMBOL SYSTEM

REGION	SYMBOL	SYSTEM
BATOCHE	BAR	Assiniboine River
	BMM	Moose Mountain
	BNS	North Sask River
	BQL	Quill Lake
	BTI	Tiger Hills
	BTH	Touchwood Hills
CHURCHILL RIVER	CSM	Stanley Mission
DORÉ LAKE	DBR	Beaver Hills
	DCR	Carrot River
	DEH	Eagle Hills
	DLR	La Ronge
	DML	Montreal Lake
	DMH	Mostoo s Hills
	DPA	Pasquia Hills
	DPO	Porcupine Hills
	DTK	Thickwood Hills
	DTN	Thunder Hills
	DWC	White Gull Creek
	DWP	Wapawekka Hills
ESTON	EMC	Missouri Coteau
	EOL	Old Wives Lake
	ERH	Rainy Hills
	EVE	Verendrye

REGION	SYMBOL	SYSTEM
FT WALSH	FCH	Cypress Hills
	FWM	Wood Mountain
LAST MTN. LAKE	LAH	Allan Hills
	LSO	Souris River
	LSS	South Sask River
	LWA	Wascana
MILK RIVER	MBL	Bigstick Lake
	MFR	Frenchman River
SUGGI LAKE	SCH	Cumberland House
	SWE	Westlake
UNITY	UBH	Bear Hills
	UNH	Neutral Hills
	UTL	Tramping Lake

Table 2. Land systems in the Last Mountain and Eston land regions, their definitive criteria and accessory characteristics

Region	System Name	Elevation	Geology	Drainage	Soil Zone
Last Mountain Lake	Allan Hills	2100-2200	Morainal upland, moderate to steep slopes	Limited	Dark Brown
	South Saskatchewan River	1600-2000	Fluvial and lacustrine plain, gentle slopes	Saskatchewan River	Dark Brown
	Wascana	1850-2400	Fluvial and lacustrine plain, gentle slopes	Assiniboine River	Dark Brown
	Souris	---------	Till plain, gentle slopes	Red River	Dark Brown
Eston	Missouri Coteau	2000-2900	Morainal upland, moderate to steep slopes	Limited	Brown and Dark Brown
	Old Wives Lake	2200-2800	Fluvial, lacustrine and till plains, gentle slopes	Limited	Brown
	Rainy Hills	2250-2750	Morainal upland, moderate to steep slopes	Limited	Brown
	Verendrye	1875-2400	Fluvial, lacustrine and till plains, gentle slopes	Saskatchewan River	Brown

Figure 6. Land Types in the Bigstick Lake Land System

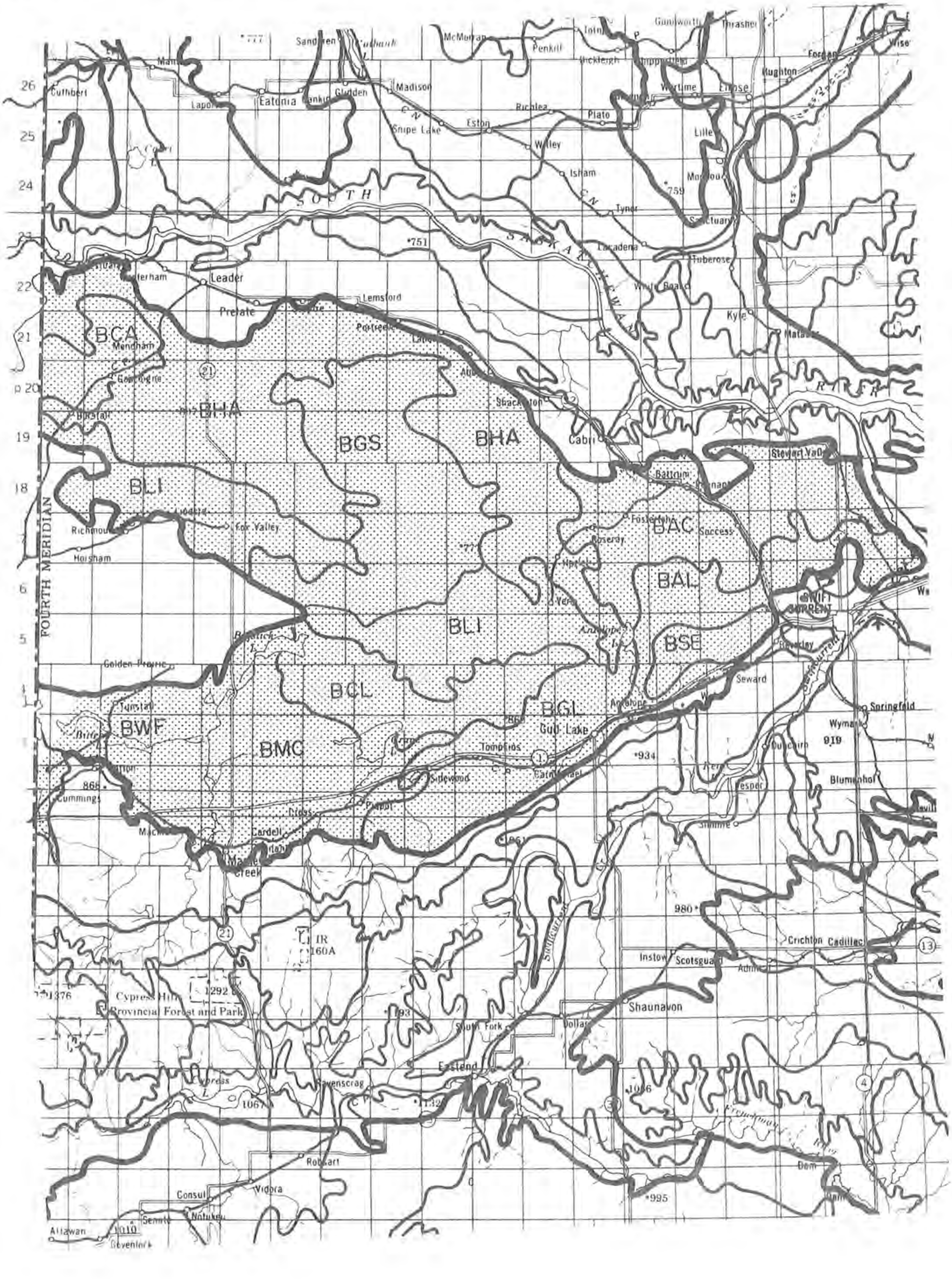


Table 3. Land types in the Bigstick Lake System, their definitive criteria and accessory characteristics

Type Name	Genetic Material	Topography	Elevation (ft)	Soils
Antelope Creek	Lacustrine silt, glacial till	Gentle	2250-2475	Brown Chernozemic
Antelope Lake	Lacustrine sand	Gentle	2300-2400	Brown Chernozemic
Cascoigne	Eolian sand	Gentle	2300-2400	Brown Chernozemic, Regosol
Crane Lake	Eolian sand	Moderate	2400-2650	Brown Chernozemic, Regosol
Great Sand Hills	Eolian sand	Strong	2300-2400	Regosol
Gull Lake	Lacustrine silt	Gentle	2500-2800	Brown Chernozemic
Hazlet	Lacustrine silt	Gentle	2300-2400	Brown Chernozemic
Linacre	Lacustrine silt, glacial till	Moderate	2500-2600	Brown Chernozemic
Maple Creek	Fluvial sand and gravel	Moderate	2350-2700	Brown Chernozemic
Seward	Eolian sand	Moderate	2500	Regosolic, Brown Chernozemic
Walsh Flats	Fluvial clay	Level	2400	Regosol

Figure 7. Relationship between the mapping units of soil surveys and the land unit.

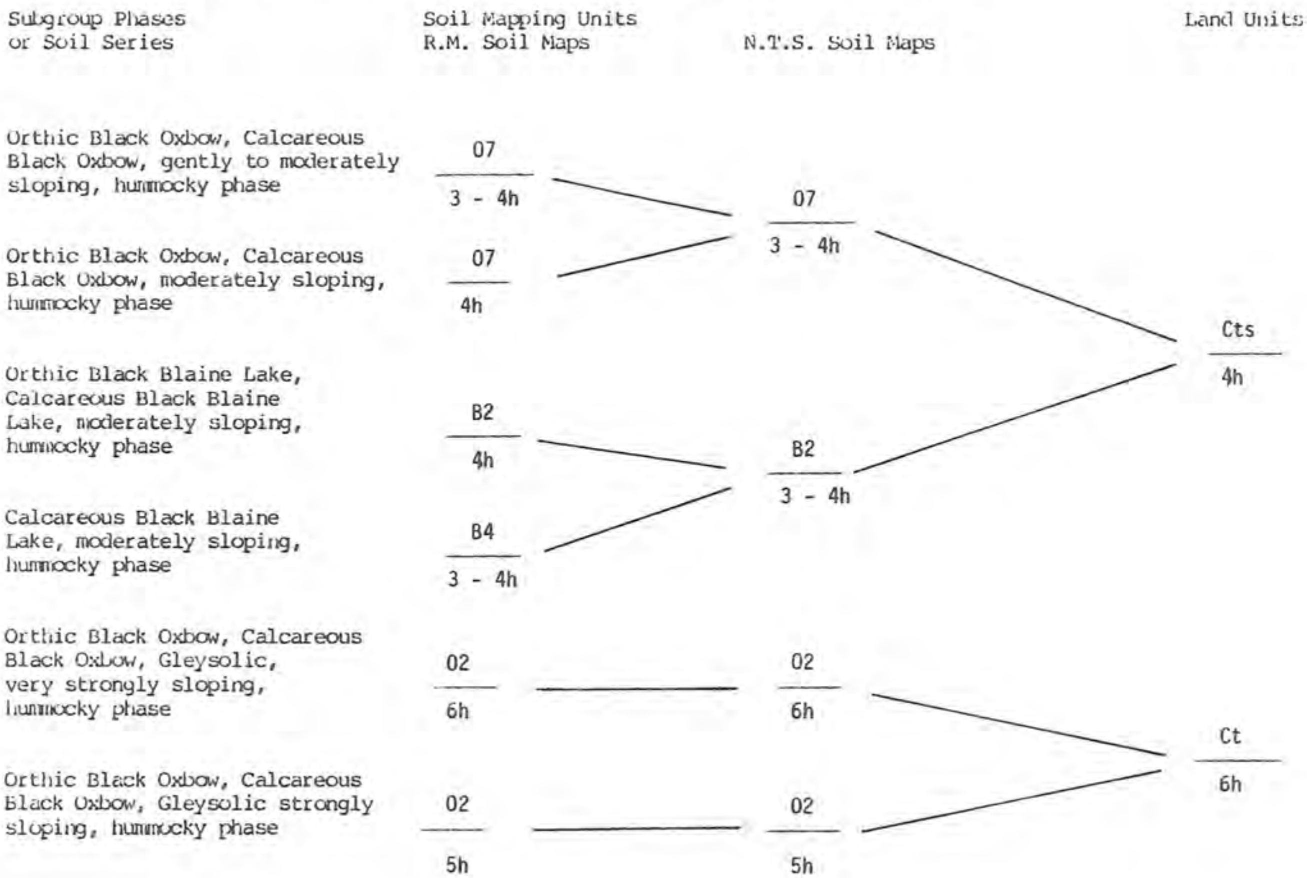


Figure 8. Land Units within the Bigstick Lake Land System

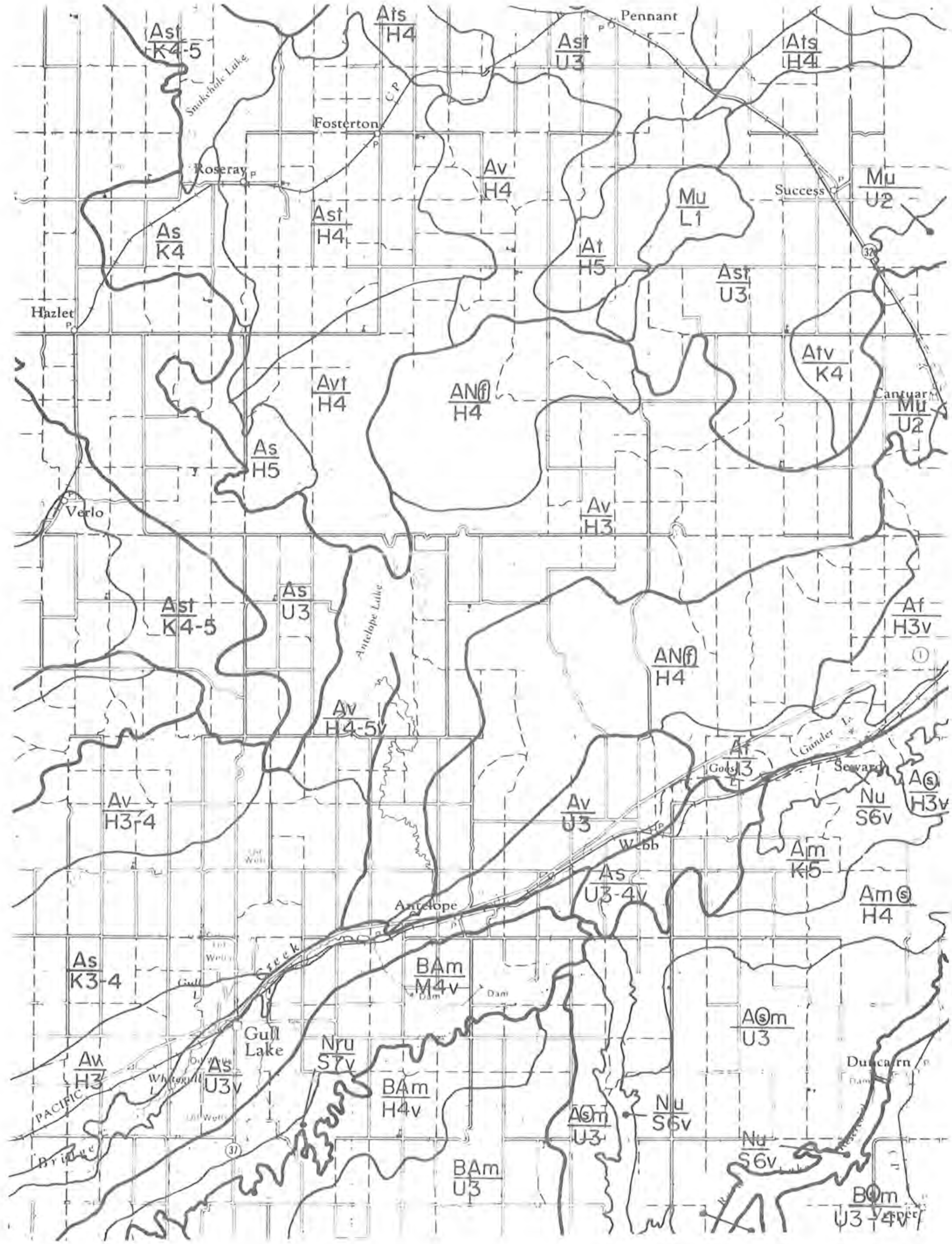


Figure 8. Continued

LEGEND

SOIL TAXONOMIC UNITS

Symbol	Description
A	Brown Chernozemic – Well to imperfectly drained soils with brown surface horizons formed under a grassland vegetation in a semiarid climate.
B	Dark Brown Chernozemic - Well to imperfectly drained soils with dark brown surface horizons formed under a grassland vegetation in a semiarid climate.
C	Black Chernozemic - Well to imperfectly drained soils with black surface horizons formed under a grassland vegetation in a subhumid climate.
D	Thick Black Chernozemic - Well to imperfectly drained soils with thick, black surface horizons formed under a grassland vegetation in a subhumid climate.
E	Dark Gray Chernozemic - Well to imperfectly drained soils with dark gray surface colors formed under an aspen forest and grassland vegetation in a subhumid climate.
F	Gray Luvisolic - Well to imperfectly drained soils with light colored, leached surface and brownish, clay-rich subsurface horizons formed under a forest vegetation in a subhumid climate.
G	Brown Solonetzic - Well to imperfectly drained soils with brown surface horizons and hard, blocky subsurface horizons associated with saline parent materials under a grassland vegetation in a semiarid climate.
H	Dark Brown Solonetzic - Well to imperfectly drained soils with dark brown surface horizons and hard, blocky subsurface horizons associated with saline parent materials, under a grassland vegetation in a semiarid climate.
J	Black Solonetzic - Well to imperfectly drained soils with black surface horizons and hard, blocky subsurface horizons associated with saline parent materials, under a grassland vegetation in a subhumid climate.
K	Gray Solonetzic - Well to imperfectly drained soils with gray surface horizons and hard, blocky subsurface horizons associated with saline parent materials, under a forest vegetation in a subhumid climate.
L	Eutric Brunisol - Well to imperfectly drained soils with light colored, leached surface horizons and brownish subsurface horizons formed under forest vegetation in a subhumid climate.
M	Gleysolic - Poorly drained mineral soils formed under hydrophytic vegetation in all climatic regions.
N	Regosolic – Weakly developed soils, lacking horizon development as a result of youthfulness, or the instability of the deposits on which they form. They occur in all climatic regions.
O	Organic - Poorly drained soils composed dominantly of organic residues resulting from the cyclic growth and decay of hydrophytic vegetation. They occur in poorly drained depressions and level areas in the forest-grassland transition and forest regions in a subhumid climate.
P	Fibrisol – Organic soils containing an abundance of essentially undecomposed organic residues.
Q	Mesisol - Organic soils containing an abundance of partially decomposed organic residues.
R	Humisol - Organic soils containing an abundance of well decomposed organic residues.

PARENT MATERIAL UNITS

Symbol	Description
a	Fen - sedge peat materials
b	Bog - sphagum or forest peat materials
c	Glaciolacustrine clay - glacial lake deposits comprised primarily of clay-size particles.
©	Fluvial clay - recent (post-glacial) river or stream deposits comprised primarily of clay and silt-size particles (alluvium).
f	Glacialfluvial fine sands - glacial river and stream deposits comprised primarily of particles of fine sand.
Ⓕ	Eolian fine sands - wind deposits comprised of particles of fine sand.
g	Glacialfluvial coarse sands and gravels - glacial river and stream deposits comprised of coarse sands and gravels.
m	Morainal clay loams – modified glacial till consisting of large amounts of bedrock-derived clay-shales or glacial lake clays.
n	Morainal sandy loams - modified glacial till consisting of large amounts of sandy glaciolacustrine and sandy modified till deposits.
r	Bedrock – preglacial deposits such as sandstones, shales, and limestone.
s	Glaciolacustrine silt - glacial lake deposits comprised primarily of silt - size particles.
Ⓢ	Eolian silt - wind deposits comprised primarily of silt-size particles.
t	Morainal loams - unsorted glacial till comprised of nearly equal amounts of sand, silt and clay deposited directly from glaciers.
u	Undifferentiated - a complex of glacial or post-glacial deposits of variable texture and different origins.
v	Glaciolacustrine very fine sand - glacial lake deposits comprised primarily of very fine sand.

Figure 8. Continued

GEOMORPHIC UNITS

Symbol	Description
H	Hummocky - a landform with a chaotic or haphazzard sequence of pronounced knolls or knobs and occasional depressions or sloughs.
K	Kettled - a landform with a chaotic or haphazzard sequence of pronounced knolls or knobs and with numerous, pronounced depressions or sloughs.
L	Flat or Level - a landform with a featureless, level surface.
M	Rolling - a landform with a regular sequence of moderately steep but subdued slopes.
R	Ridged - a landform with a series of ridges and accompanying swales.
S	Steep sloping - a landform with rough broken, steep slopes, usually along coulees, valley sides and escarpments.
T	Terrace - landforms with a steep, scarp face and an accompanying nearly level area above it.
U	Undulating - a landform with a regular sequence of gentle, subdued slopes of low relief.

SURFACE TEXTURE UNITS

Symbol	Texture Classes
1	Sand, loamy sand, gravelly sand and loamy sand.
2	Sandy loam, fine sandy loam, gravelly sandy loam.
3	Very fine sandy loam, loam, silt loam.
4	Silty clay loam, clay loam, very fine sandy clay loam.
5	Silty clay, sandy clay, clay
6	Heavy clay

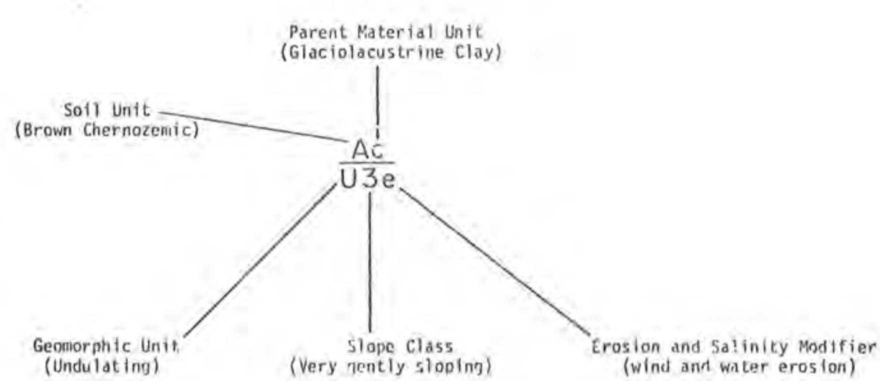
SLOPE CLASS

Symbol	Slope Classes	
1	0 - 0.5	Level
2	0.5 - 2	Nearly level
3	2 - 5	Very gently sloping
4	6 - 9	Gently sloping
5	10 - 15	Moderately sloping
6	16 - 30	Strongly sloping
7	31 - 40	Very strongly sloping

EROSION AND SALINITY

Symbol	Description
b	Bevelled - surface cut or planed by running water, but not underlain by fluvial materials.
c	Channelled - surface crossed by a series of abandoned river channels.
d	Deflated - surfaces modified by the sorting out, lifting and removal of loose, dry, fine-grained particles by the turbulent, eddy action of wind.
e	Wind and water eroded - extensive occurrences of wind and water eroded soils (e^+ signifies a severe condition).
f	Failing - surfaces modified by the formation of tension fractures or by large masses moving downslope.
n	Saline - extensive occurrences of saline soils (n^+ signifies a severe condition).
v	Gullied - The modification of surface by fluvial erosion, resulting in the development of parallel and sub-parallel, steep-sided and narrow ravines in both consolidated and unconsolidated materials.
w	Wind eroded - extensive occurrences of wind eroded soils (w^+ signifies a severe condition).

SEQUENCE OF MAP SYMBOLS



overlays of climatic and physiographic information were used to delineate the actual areas each region and system encompassed. Finally, the areas of the land unit and land systems were merged in the derivation of the land types. Throughout the procedure, our goal was to specify units that would be significant agronomically and that would lend themselves to analysis from either the natural resource perspective of land or the political economic perspective of land.

The lowest elements of the classification system correspond to soil mapping unit used in the soil survey of the province. These soil mapping units are presented at differing scales depending upon the objective of the soil survey publication. They may present information on a subprovincial basis useful for regional interpretation or at a scale relevent for areas within rural municipalities, as well the field sheets from the actual soil survey work which may be useful for site interpretations. These lower categorical levels, we believe, are useful in farm level planning, for the work of rural land assessment and the administration of crop insurance programs. Consequently, we view interpretative work on these categorical levels to encompass areas of crop productivity and response, recommendations for crop and land management, and development of plans for farm operations. We also believe that most private users of land will desire evaluative information about land on these levels. Consequently, we will provide examples of this type of interpretive and evaluative information we want to provide at these levels of generality.

One of the most specific categorical levels corresponds to the maps the Saskatchewan Institute of Pedology is compiling for rural municipalities. These maps, at a scale of 1:50,000, represent a level of detail relevant for farm level planning. At this detail, the Institute is interpreting pedological information to aid decision makers in making allocative and managerial decisions. The expected clientele for interpretative information at this scale is farmers, agricultural extension personnel, land assessors, and other land users or land administrators concerned with the use and management of specific parcels of land.

Given this diverse clientele, we believe that two types of interpretative information can be provided. First, information must be made available that aids farmers and agrologists in determining how the land should be managed. Information that aids in the making of decisions to increase production, change tillage practices, decrease cost of production, reduce risk, or improve land conservation should be provided at this scale of reference. The objective is not to give the users of the information detailed pedological data about the land, but to give them information that is conqruent with their knowledge of their land and which can help them manage it efficiently. Criteria for efficient management derive from individual concerns of profit maximization and social concerns for conservation of land resources. The second type of interpretative information that should be provided is productivity ratings that can be used in the area of assessment outlined above. Productivity information must incorporate measures of productive capacity relative to cost and locational factors affecting the use-value of agricultural land.

With both kinds of information, the objective is not to make recommendations to users of the information. Rather, the objective is to provide information to decision makers so that they can select their level of management and forms of land use vis-a-vis their goals. In short, information provided to users at this level involves the utilizaion of data obtained through the soil survey and research. Implicit are the functions of information transfer and interpretation. These functions, ideally render the scientific information accessible to the nonpedologist.

Specifically, we believe that we have or ought to have the capability to provide users with data on climatic variables such as: (1) monthly minimum, maximum, and mean precipitations; (2) probability of hail damage, by month, and degree of damage; (3) moisture status at planting in relation to expected yields and yield potential for different crops on soils of different textures; and (4) occurence of last fall frost in spring and first frost in fall. In terms of soil fertility we should be able to provide information on the general level of different nutrients under stubble or fallow conditions for different soil types. Information on expected yield increases, with fertilization, fertilizer selection and applications, and potential problems in soil sampling and testing could be provided by soil type. Additional areas on which information could be provided include changes in tillage operatons given different weather patterns and soil type, potentials for salinity or erosion, and strategies of conservation. While this list is not all inclusive, it indicates the kinds of land information we could provide to land users and managers if we were able to organize and interpret the soil information that is available or that is being collected.

In summary, we have attempted to show how the dual nature of land as resources and land as a commodity gives rise to a need to process and disseminate land information. One strategy for accomplishing this is a multicategorical classification of land. In such a classification, the categorical levels, the classes in each categorical level, and the information conveyed at each categorical level are designed to correspond to units that are meaningful from a natural resource perspective and a political economic perspective.

In this article, we have outlined the first approximation of such a classificational system. We have stressed the need to interpret and transfer land information in a nonpedological manner to users of the information. We envision a number of approximations and changes in the system as we test it and obtain responses from users.

Appendix : Derivation of the Land Units

The following procedure was used to formulate the land units used in the classification:

(1) Selected an appropriate scale and size of the map unit
  (a) scale of 1:250,000
  (b) minimum map delineation of 2,000 acres.

(2) Selected criteria for generalizing the soil survey maps
   (a) taxonomic unit of the dominant soil
   (b) soil parent material
   (c) surface expression
   (d) slope class
   (e) erosional features

(3) Established a procedure for deriving land units from the soil mapping units, using the map legend.
   (a) where detailed reconnaissance data were available
      (1) information grouped by overlying a blank mylar sheet and a clear mylar sheet containing elevation contours with 25 feet intervals on the printed soil map.
      (2) separations were then made based on elevation and the mapping criteria

   (b) where broad reconnaissance data on soil were available

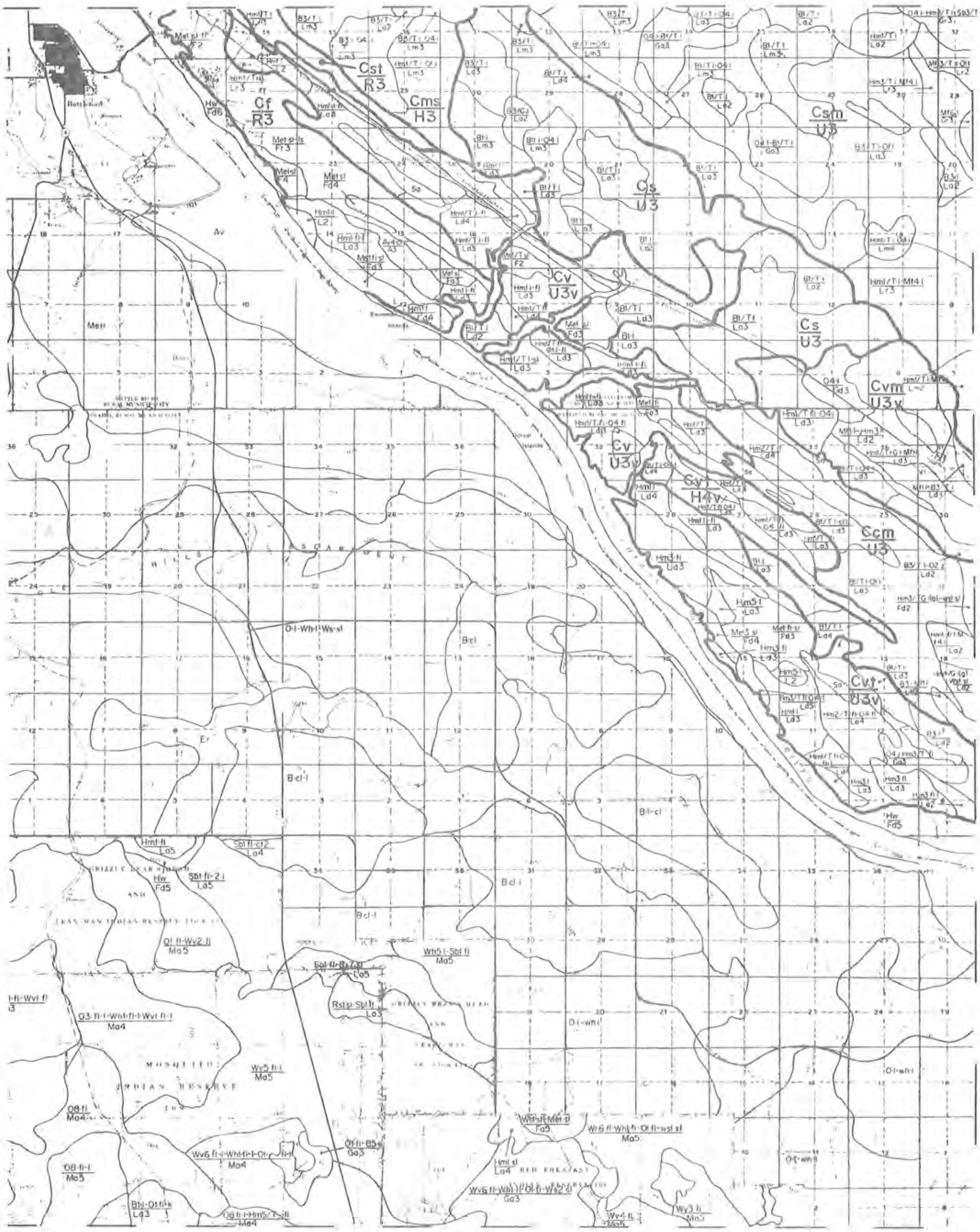
      (1) a mosaic of aerial photography was prepared at a scale of 1:125,000
      (2) elevation contours at 25 foot intervals and soil information from the reconnaissance surveys were produced at the same scale on clear mylar
      (3) mylar was overlayed on the mosaic
      (4) land units were separated using the criteria of the map legend.

(4) land units were transferred from overlays to appropriate base maps.

(5) legends compiled for each map of land unit.

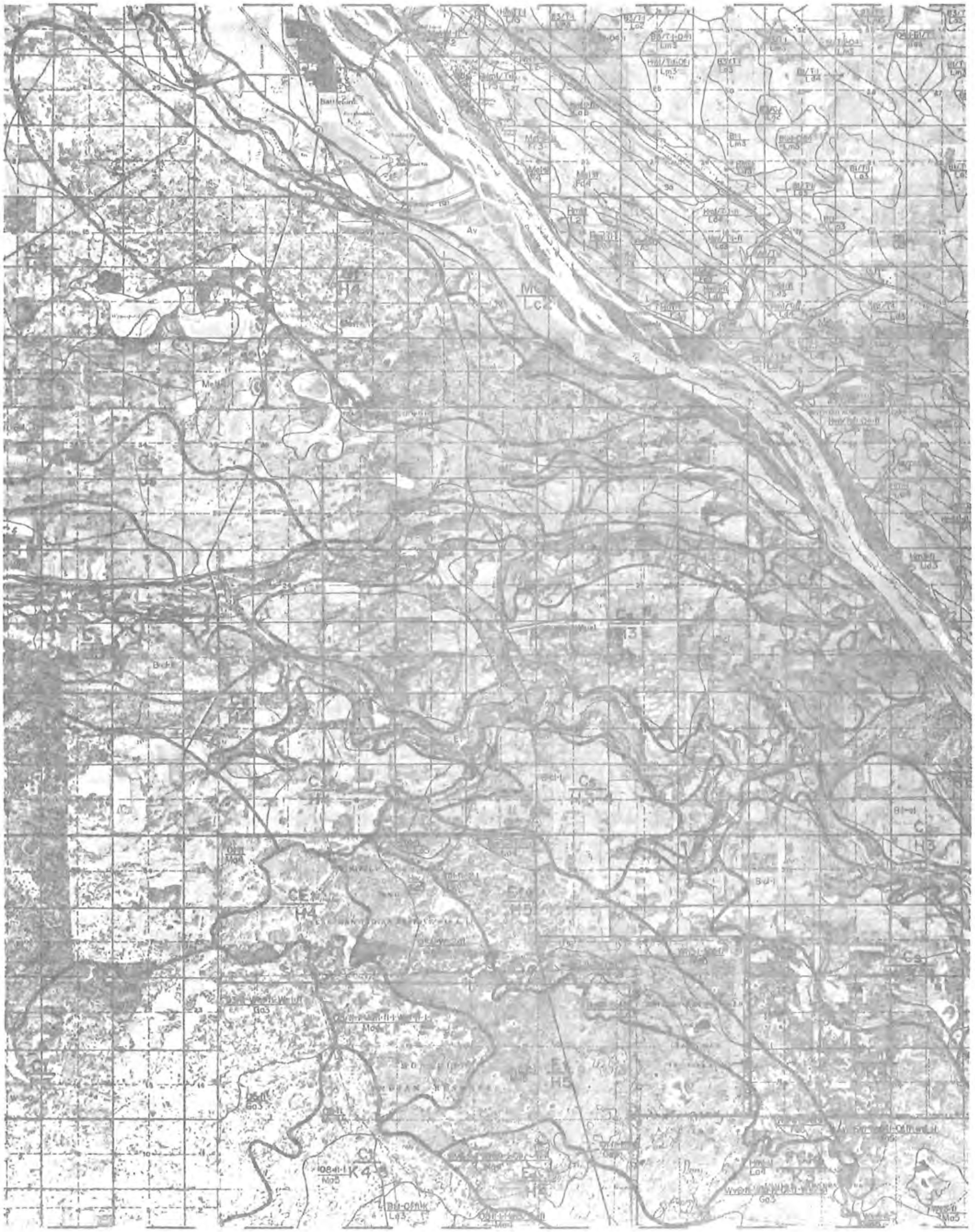
An example of this procedure is presented in the North Battleford N.T.S. map sheet (Figures 9 and 10). The reconnaissance soil information has been collected partially at the detailed level and particularly at the general level. Where appropriate, the detailed soils information was used as indicated above. The procedure used for the general information involved the following. First, mosaics of aerial photographs compiled by the Saskatchewan Research Council at 1:50,000 were reduced to matte positives at a scale of 1:125,000. Second, topographic maps at a scale of 1:50,000 were reduced to the 1:125,000 scale. Available information about the soil mapped at a scale of 1:30,000 was recomplied at a scale of 1:50,000 and subsequently reduced to the 1:125,000 scale. These sets of topographic and soils data in conjunction with the information from the aerial photographs were used to separate land units according to the legend criteria. These land units were then transferred to a comprehensive map at a scale of 1:250,000.

Figure 9. Overlay of topographic and soil information to serve as basis for compiling land units in areas where more detailed information is available.



BATTLEFORD

Figure 10. Overlay of aerial photo, topographic and soil information as a basis for compiling land units in areas where detailed information is not available.



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FOOTNOTES

[1]Our use of technical evaluations and classifications corresponds to the approach set our by Marline Cline, see Marline G. Cline, "Basic Principles of Soil Classification". Soil Science 67 (1949) 81-91.

[2]R. Brinkman and A.J. Smith, Editors, Land Evaluation for Rural Purposes, Publication 17 (Wageningen, The Netherlands: International Institute of Land Reclamation and Improvement, 1973), pp. 14-18, adapted by A.P.A. Vink, Land Use in Advancing Agriculture (New York: Springer Verlay, 1975), p. 2.

[3]Virk, pp. 2; Francis A. Walker, Political Economy 3rd Edition (London: MacMillan and Co. 1892), pp. 193-203, 211-218. Nassau W. Senior, An Outline of the Science of Political Economy, New York. August M. Kelly, 1951. pp. 128-129.

[4]Ciriacy Wantrup, Resource Conservation : Economica and Policy revised. (Berkely: University of California Press, 1963). pp. 38-40.

[5]note that political here is used in the general sense of referring to policy and the process of policy information and implementation.

[6]Earl O. Heady and Harold R. Jensen, The Economics of Crop Rotation and Land Use: A Fundamental Study in Efficiency with Emphasis on Economic Balance of Forage and Grain Crops, Res., Bull. 383 Agric. Exp. St. (Ames, Iowa State University, 1951), p. 427.

[7]A common procedure has been to apply capability or suitability to the relative capacity of land to support a given activity, i.e., production of rapeseed. In these instances, evaluation is applied to the relative capacity of land to attain a goal given the costs incurred in doing so. See Vink, Land Use pp. 254-280. However, economists frequently use the concept of land-use capacity to specify this special use of evaluation. (See Barlow, Land Resource Economics, pp. 13-17). In addition, some agronomists and economists will use the terms capability and/or suitability to refer to the relative capacity of land to support a use without reference to the costs involved. Frequently a threshold or msximum cost is specified, is the use entails a greater cost than the threshold, the land is no longer capable of supporting the use. In order to allay confusion among the agronomic and economic disciplines we should establish agreement of the use of these terms. We can see the internal logic of using capability to refer to the judgement that the land does or does not have the capacity to support a given activity. Once that is established we are in the realm of relative evaluation. This occurs regardless of the objective in mind or use being considered, e.g. crop production or ranching. The fundamental issue is the nature of the relative comparisons involved: comparisons based on either goal attainment or on the time frame involved, cost can include the effects of land capability coincides with this longer-run view of evaluation.

J. Dumanski, "Principles of land Evaluation:, Land Evaluation and Systematic Data Collection edited by R.L. Halstead and J. Dumanski (Ottawa: Researc Branch, Canada Agriculture, 1977), p. 8. Indeed, the concept of land as a form of biological capital raises questions of how to evaluate land over the long term, i.e., over generations. These considerations point to problems in establishing discount rates and evaluative criterion.

[8]note that land can be evaluated against multiple goals.

[9]See W.T. Williams, ed., Pattern Analysis in Agricultural Science (Amsterdam: Elsevier Scientific Co., 1976).

[10] D.F. Acton and J.G. Ellis. Soils of the Saskatoon Map Area. Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon, Saskatchewan. 1978.

[11]H.P.W. Rostad, S.L. Burton and H.B. Stonehouse. Soils of the Silverwood Rural Municipality (123) Saskatchewan. Saskatchewan Institute of Pedology, University of Saskatchewan. 1980. (In Press).

[12]D.F. Acton, J.S. Clayton, J.G. Ellis, E.A. Christiansen, and W.O. Kupsch, "Physiographic Divisions of Saskatchewan", Map (Saskatoon, Sask., University of Saskatchewan - Saskatchewan Research Council, Geology Department, and Saskatchewan Soil Survey, 1960.

13 J.S. Clayton, W.A. Ehrlich, D.B. Cann, J.H. Day, and I.B. Marshall. Soils of Canada. Research Branch, Canada Department of Agriculture. 1977.

[14]For the sake of convention, small scale refers to the map scale used in mapping. Hence, a small scale relative to a large scale covers a greater area for the given size of map.

Development of Basic Levels of Output from the Soil Performance and Management File of CanSIS

K.B. MacDonald

Introduction

Within the data management subsystem of CanSIS there are a number of separate files or sets of data each dealing with characteristics of the soil resource. Some of these such as the DETAIL file or the DAILY files contain descriptive and analytical information about the soil at a specific location; some such as the SOIL NAMES FILE describe some general characteristics to be associated with a named soil.

Within the data management subsystem the SOIL PERFORMANCE AND MANAGEMENT (P/M) FILE has been developed for the purpose of recording data on the actual performance of an area of land. Data are collected and entered into the P/M file to relate crop growth and development production and quality to know and recorded descriptions of site characteristics, geographic location, climate, imposed management both historical and present, and soil physical and chemical properties.

Of these information types, an accurate description of location is considered of prime importance because it allows the information to be related to a soils map (or other coverage) and the site can be revisited if necessary to collect additional data on the site or soil physical and chemical properties.

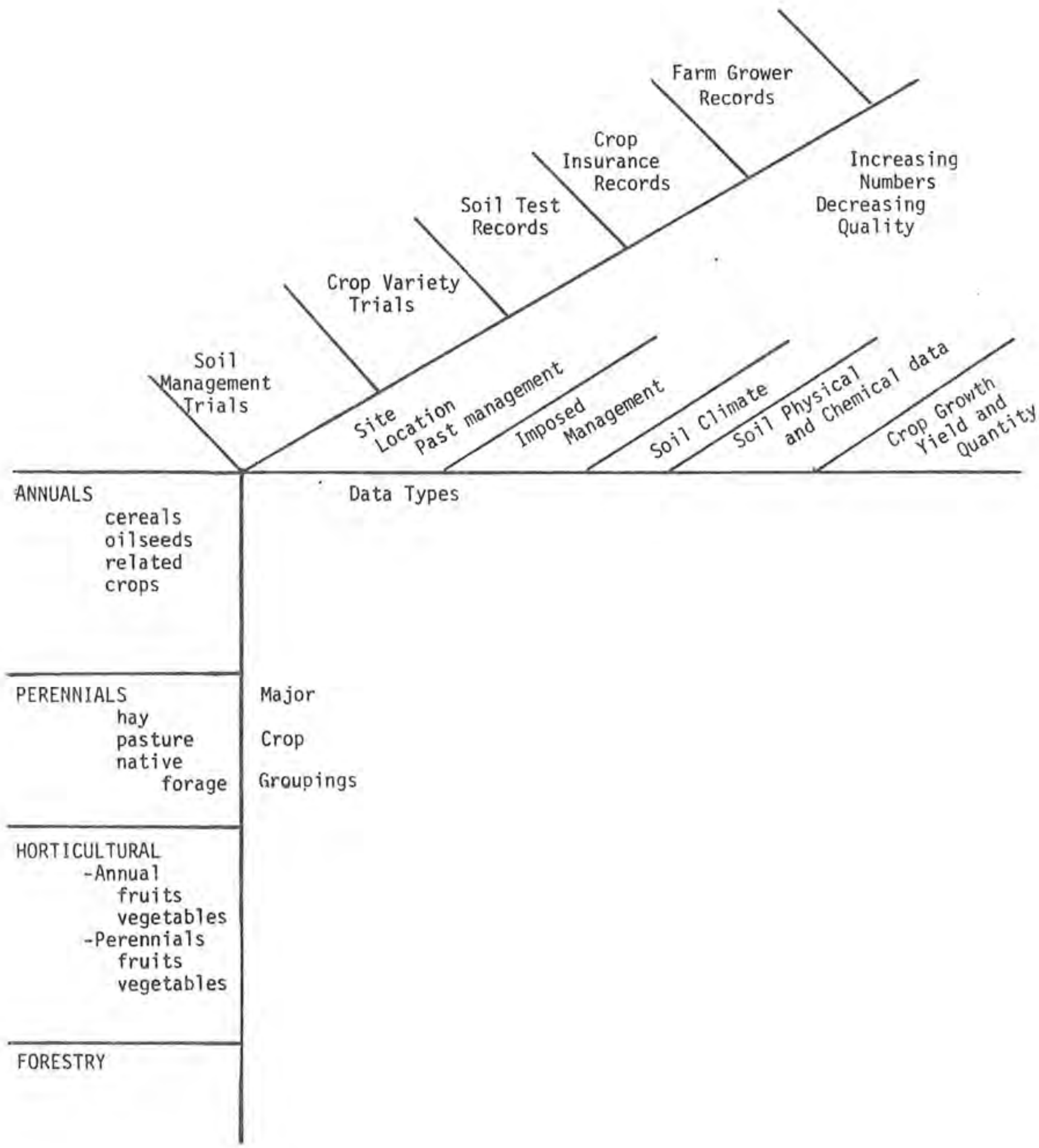
Some of the major uses of the P/M file are to archive information on soil and crop performance from a variety of regions and sources in a comprehensive, compatible format. It provides reports to contributing researchers on their individual experiments and it will provide to soil management committes and soil surveyors the facilities to select and manipulate data from groups of experiments to assist them in preparing summaries for the purpose of revising soil management recommendations or interpreting soil sruvey maps.

Design of the Performance and Management file for Data Input

The objectives in designing the P/M file were to provide a data structure which was sufficiently comprehensive to encompass within one organizational framwork all types of data relevant to soil performance; and sufficiently flexible to allow data on a broad range of crop types and management conditions to be stored in one consistent format.

To achieve these objectives, the data are grouped into five major data types which have been summarized along one axis of figure 1.

Figure 1. Conceptual Structure of the Soil Performance and Management File of CanSIS



These are:

Location, site characteristics, past management, climate
-all of these properties relate to the entire study area.

Soil climate- this property can represent the entire area or may be observations specific to particular treatments.

Imposed management-can be constant over the study area or may constitute a series of treatments leading to differing crop performance.

Soil Physical and Chemical Properties
-frequently constant over the area prior to an experiment, but may differ depending on imposed management after the experiment. Provision is made to record data on the basis of the entire plot, groups of treatments, or individual treatments.

Crop Growth and Development, Production and Quality
-these properties can be measured over an entire area or for individual treatments and replicates. The data structure is sufficiently flexible to accomodate both of these or some intermediate combination.

Kinds and Sources of Input

Information in the P/M file can come from a variety of sources (figure 1). The best data should come from detailed soil management studies which will have the most complete information on the soil. Crop variety trials have good information on yield and crop development but probably little variation in the level of soil management imposed. Data from soil testing laboratory files contains soil analytical information but have only an estimate of last years yield at a single level of management. Crop insurance information contains yield estimates only at one level of management, but has been standardized to some extent by on-site inspection. Farm surveys generally consist entirely of estimated yields and management. White the quality and completeness of data tends to decrease through this range the number of sites goes from relatively few for the soil management studies to large numbers for the soil testing, crop insurance, and farm survey information.

By storing all this information in one compatible format the reliable data can be used to develop hypothesis and recommendations and the less reliable but more numerous data can provide information for verification, generalization, or lidentification of areas where the suggested trends or recommendations apparently do not apply.

In assessing soil performance at various locations across Canada it is essential that the crops used are adapted to the particular regions and economically important. For this reason a wide range of crop species are relevant when considering data on soil performance and management. An attempt has been made to summarize these crops into major crop groupings (figure 1). This affects the P/M file in two of the data areas - specifically in the range of management imposed and in the types of crop properties measured to indicate crop performance (i.e. from boxes of blueberries harvested in Nova Scotia to tonnes of wheat harvested in Saskatchewan to board-feet of lumber in B.C.). In designing the data structure for the P/M file every effort was made to maintain flexibility as to the types of information acceptable. White it has not been exhaustively tested, the section of the file in which imposed management information is recorded has been adequate for recording all types and combinations of management practice encountered. This includes studies on tile drain spacings, depth of cultivation, fertilizer rates and times etc. The capability of the format to handle information on crop performance has been tested for annual field crops, forage crops, and some horticultural crops. These capabilities appear generally adequate although, as interest increases in describing crop growth and development, these sections may require expansion. It appears desirable to retain common data structures for this information where possible so that where comparisons are meaningsul they can be made easily.

Adaptability of the P/M File Structure

One of the results of designing a data structure which is comprehensive and flexible is that the computer files tend to be large and relatively complex. In most cases, an experiment or set of data to be input will use only selected portions of the complete file. The forms required to record the information for input do not have to be large and comprehensive so long as they are adequate to record the types of information to be input. For the P/M file, a comprehensive set of input forms have been prepared comprising 33 separate pages, to facilitate the input of data. But for any experiment or series of experiments only a limited selection of the possible pages will be used. Each page is self-contained and independent of the others; each can serve as a computer input document. For most experiments, the relevant data can be reported for input on approximately seven different pages. This is still a large number than are really required as many areas on the pages will remain blank. In cases where a standardized set of data is being collected for a number of experiments it is a simple matter to adapt the forms to reflect only the information pertinent to a study. In several regions this has been done and the input form has been reduced to 3-4 pages. As long as care is form, there is no problem inputting these data. This task of adapting the forms for specific data types is one which will receive further development as the other capabilities become implemented.

Design of the P/M File for Data Output

The objectives which had to be met with the design of the data structure had to allow for (i) complete reports of individual experiments or studies (ii) summaries and tabulations of results from a selection of data, (iii) easy interface of the data into canned statistical software packages for further manipulation, (iv) interface to a spatial display package to allow any of the results to be presented in a form suitable for overlaying onto a soils map or other coverage, (v) formatting the data into a machine readable form so that it could be transferred easily onto other computer systems for additional manipulation, (vi) general user access to the data in a form in which it could be sorted, selected and manipulated in an interactive fashion. Of these objectives, one of the major considerations which determined the structure of the data in the P/M file was the need to facilitate INTERACTIVE MANIPULATION AND SELECTION OF THE DATA BY THE GENERAL USER:

The easiest way to ensure that this final objective was achieved was to organize the data into a series of relationships. In this context, a relationship consists of a table of data with two major axes; one a key or identification axis and the other a characteristic axis containing all the properties which are associated at the level of detail specified by the key. For the example relationship AB

Key / Characteristics

	yield	moisture	nitrogen%	protein%	grade	etc
ab12	12.3	15.5	2.35	43.6	3y	---
ab13	15.9	15.5	1.89	38.7	2y	---

In the simplest case, the key is the experiment and the characteristics include information at the experiment level such as; site characteristics; location, climate, past management, etc. A more restrictive key might include experiment, treatment number, replicate number and data and in this case the characteristics might include descriptions and dates for crop growth stages and development rates within an experiment.

In developing the output data structure for the P/M file, a total of 12 independent relations which describe all possible data types associated with an experiment have been defined. The distinguishing feature between the relations is the degree of specificity of the key. In table 1 these relationships are listed along with the keys or identifiers used to specify each level of data.

Types of Output from the P/M File

Development is proceeding to complete the types of output required to make this file useful. At this stage 5 of the 12 relations have been defined and can be used to manipulate data. Output capability by means of standard reports which are prepared in batch mode is limited to a standard summary report giving the title, purpose soil texture, taxonomy and location for each data set and a related report describing the management factors which have been varied in the experiment.

The relations which have been defined are #4 the Factor relation, #5 the Factor-level relation, #6 the Nesting order relation, #10 the Crop yield and analysis relation and #12 the Notebook relation. These relations are being used in an interactive fashion to select and manipulate data from approximately 200 records from a wide variety of experiments. Simply by using these relations it is a straight forward procedure to obtain a complete description of the management practices which have been imposed on the study as treatments. From the crop yield and analysis relation, the effects of each treatment on yield and quality of the crop can be summarized, and from the notebook relation any special notes or interpretative comments can be read to assist in interpreting the results.

The remaining relations in the P/M file are now being implemented and will be tested using the sample 200 data sets already in place. After all 12 relations are operational, the remaining data in the file will be transferred into the relational set-up and work will begin to familiarize the users with the capabilities for interactive+ manipulation of their data. At the same time, a series of standard reports will be developed which describe individual experiments so that the system will be capable of provinding preliminary treatment and data reduction of experiments to individual researchers right from the field results.

Table 1: DATA RELATIONS FOR THE SOIL PERFORMANCE AND MANAGEMENT FILE OF CanSIS

Name of RElation	CanSIS ID	Key	Attributes
1. Experiment		expt	identification, location site description soil classification, soil test recommendations
2. Horizon		expt, horizon	soil morpholoty
3. Global Management Practice		expt, year sequence/ association	historical management first year past mgmt current year global mgmt
4. Factor	pme1	expt, factor #	management factors
5. Factor-level	pmf1	expt, factor # level #, assoc.	level definition and description
6. Nesting order	pmg1	expt, treatment #	treatment description
7. Weather		expt, date	above ground climatic observations
8. Soil Information		expt, treatment # rep # date, depth	soil temperature soil moisture, physical and chemical data
9. Crop Development		expt, treatment # rep #, date	growth stages and damage
10. Crop Yield and Analysis	pmi1	expt, treatment # rep # date, sample type property	yield, elemental analysis quality characteristics
11. Crop enzyme	pmi3	expt, treatment # rep #, date, sample type	enzyme type, activity assay method
12. notebook	pmi4	expt, note type treatment # rep # date, sample type	special notes interpretive comments free format comments.

Soil Degradation in Canada: Assessment of Location and Extent

D.R. Coote

At last year's meeting I presented a list of soil degradation processes and commented on the research, or lack of it, underway in Canada to assess the nature and severity of these processes. In this brief report I will present a summary of activities being carried out by LRRI to improve our knowledge of the location and extent of soil degradation problems in Canada.

As a review, Table 1 summarizes the ten principal soil degradation processes which seem to be active in Canada. The LRRI is involved either directly or indirectly in the following projects:

1. Preparation of a Departmental Monograph on "Degradation of Agricultural Lands in Canada" by D.R. Coote and J. Dumanski. The first draft of this document was widely circulated within the Soil Science and Agricultural Research fraternities during 1979. Comments are being incorporated into a second draft to be completed in April 1980. Publication is planned for later in 1980. Part of this effort will consist of generalized maps showing locations and extent of major soil degradation problems in Canada. These are discussed in more detail later in this report.

2. The LRRI Vancouver Unit, in cooperation with the Beaverlodge Research Station, is assessing soil erosion parameters in the Peace River District. Laurens van Vliet has established and instrumented standard runoff/erosion plots on a 9% slope at Beaverlodge and data collection is underway.

3. The Ontario Soil Survey is developing soil erodibility mapping techniques for soil surveys. Greg Wall has described his work elsewhere in these minutes.

4. The LRRI in Ottawa is preparing details of alternative approaches to meeting Great Lakes Water Quality soil erosion objectives. Karen Switzer-Howse and John Culley are analysing data and preparing information materials for use by the Province.

5. The Atlantic Soil Survey Unit in Truro is cooperating with the Nova Scotia Department of Agriculture in the establishment of runoff/erosion plots near Truro. Ken Webb and Jan van der Leest are trying to iron-out some technical problems.

6. The LRRI in Ottawa is studying the effect of 25-30 years of continuous tillage on four major eastern Ontario soil types at the Central Experimental Farm. The author is attempting to isolate the most significant variables as a first step towards extending such work to other sites.

7. The LRRI in Ottawa is working with the Ontario Soil Survey in the continued assessment of the effect of pipeline construction on agricultural productivity. John Culley, Bruce Dow and Ted Presant have continued data collection for the third year.

8. The Department of Soil Science at the University of Manitoba was funded by LRRI in 1978-80 to carry out soil organic matter analyses on 3000 soil samples to compare data with those gathered in a similar survey in 1963-65.

The following projects are planned for the 1980-81 period:

1. Cooperative assessment of soil erosion in New Brunswick, with LRRI and the Canada Center for Remote Sensing in Ottawa, and the N.B. Dept. of Agriculture, styding eroded and forested sites in similar soils in the potato growing area. Chang Wang, Joe Cilhar, Randy Trenholm and John MacMillan will be carrying out this work in the summer of 1980.

2. The University of Guelph, School of Engineering, will be conducting contract research in 1980 and 1981 on soil erosion during the spring months and ways to control it. The LRRI has been provided funds by a committee of the Canada-U.S. Great Lakes Water Quality Agreement for this work. The author will be working with Greg Wall and Trev Dickinson on this project.

Land Degradation Maps

As part of the Land Degradation monograph, it is planned that maps of Canada at a scale of 1:5,000,000 will be prepared showing the location and severity of major problems. To date, provisional maps have been prepared of soil erosion by water and wind, the effects of repeated tillage, soil salinization and soil acidification. The principle involved has been to identify the chief factors determining the probability of the problems arising, divide these into high, medium and low, and then map combinations of high probabilities and low probabilities, with the remainder falling in the moderate category. Thus far, the following factors have been mapped:

1. For soil erosion by water:
   - mean annual water movement to streams;
   - 10 yr return frequency, 1 hour storm intensity;
   - soil parent material texture;
   - % of land area tilled;
   - % of land area in wide-spread row-crops;
   - % of land area in summerfallow;
2. For soil erosion by wind:
   - Mean 10 yr return frequency 1 hour wind speed;
   - soil parent material texture;
   - % of land area tilled;
   - % of land area in summerfallow

3. For effect of repeated tillage:
   - Mean growing season soil moisture deficit;
   - soil parent material texture;
   - % of land tilled;
   - % of land in wide-spread row-crops
4. For soil salinization:
   - Land on ridges and hill tops;
   - steep topography;
   - irrigated land;
   - existing salinity;
   - solonetzic soils;
5. For soil acidification:
   - soil parent material calcareousness;
   - soil parent material texture;
   - fertilizer nitrogen useage;
   - atmospheric acidity as H^+ and NH_4^+

On each of the maps will be plotted any available known soil data in terms of soil erosion, salinity, compaction, loss of organic matter, pH etc. The maps can then be verified and calibrated. Advice will then be sought from provincial soil scientists as to the accuracy of the maps and adjustments needed before they can be reduced in scale and used in the Soil Degradation monograph.

TABLE 1: Land Degradation Types

1. Water Erosion
2. Wind Erosion
3. Repeated Tillage:
   - compaction, structure loss
   - loss of organic matter & fertility
4. Salinization & Alkalinization:
   - dryland
   - irrigation
5. Acidification
6. Contamination
7. Mixing & Disturbance
8. Earthflows & Landslides
9. Organic Soils Subsidence
10. Drainage Deterioration

APPENDIX 6 LIST OF PARTICIPANTS

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