Expert Committee
on Soil Survey

Proceedings of the Sixth Annual Meeting

Guelph, Ontario
26-30 November 1984



Canada

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Edited by J.A. SHIELDS and D.J. KROETSCH
Land Resource Research Institute
Ottawa, Ontario

The Expert Committee on Soil Survey is a subcommittee of the Canada Committee on Land Resource Services, which is part of the Canadian Agricultural Services Coordinating Committee systems.

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SUMMARY

These proceedings are a record of the current stages of development of selected technical subjects related to the methodology of conducting soil surveys in Canada. It includes contributions to the improvement of methods for classifying soils, for interpreting soil information, for handling and storing large amounts of soil data, and for evaluating the extent of degradation of soils.

RESUME

Ce procès-verbal est une photo de l'état d'avancement de certains sujets techniques reliés à la méthodologie d'exécution des prospections pédologiques au Canada. Il comprend certaines contributions à l'amélioration des méthodes de classification des sols, de traitement et de stockage d'un grand nombre de données pédologiques, d'interprétation de ces données et d'évaluation du degré de dégradation des sols.

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Soil Degradation

Working Group

Reports Presented at

Technical Working Group Sessions

Compiled and Edited

by

D.R. Coote

Chairman

Introduction

The proceedings of last year's workshop on Soil Degradation held at the 5th Annual ECSS meeting in Ottawa were published in the Proceedings of that meeting and provide a valuable reference on this subject. A review of the response that had occurred to the recommendations arising from last year's meeting indicated that progress was being made in salinity and acidification sensitivity mapping, and that the soil survey data base was being augmented for the evaluation of these problems. Contamination and organic matter loss were two areas in which mapping was still of questionable value, and for both these soil degradation factors a degree of additional data collection was underway. It was in the areas of erosion mapping and assessing soil structure loss and compaction that there appeared to be greatest disagreement. Little progress had taken place on soil compaction assessment. It was therefore decided to concentrate on Work Group meetings this year on these problems.

We were fortunate to be able to draw on the expertise of several researchers actively involved in soil erosion and soil structure. They provided "seed" information in their introductory statements which generated discussion, which in turn helped to reveal the extent of agreement as well as disagreement among workshop participants. They then helped focus attention on some of the issues and alternatives which still must be evaluated.

Erosion - (Monday Nov. 26)

i) Past Soil Erosion:

M. Miller (U. of Guelph) presented a summary of his estimation of past erosion in Waterloo Co., Ontario, and its effect on crop productivity.

He assessed the severity of erosion on a 300 km^2 area using aerial photos. Severely eroded areas were defined as having lost their A and B horizons, moderately eroded areas had lost the A horizon. In the area surveyed 18% of the area had suffered moderate to severe erosion.

Seven fields were monitored for yield loss over two years, and yields from non-eroded areas were compared to moderate/severely eroded areas. There was an average yield reduction of 34% in 1982 and 47% in 1983. The yield loss was extrapolated to the 300 km^2 area. An average yield reduction of 5.4% was calculated, which was equivalent to $44.00/acre. Extrapolated to Waterloo County the estimated cost of erosion was approximately $1 million/yr.

Reduction in yield was related to loss of available water holding capacity (A.W.H.C.), which was considered irreversible. However, erosion was not strongly related to soil types.

In another study the USLE was used to estimate water erosion in Huron County. Further estimates considered the effects on AWHC, texture, porosity etc. The derived data were then put through a corn yield model. After 25 years of simulated erosion the production loss in the county was 11,500 tons worth $1.3 million per year.

Both studies gave results similar to those estimated by Wall and Driven, in their 1982 report "Cropland Soil Erosion - Estimated Cost to Agriculture in Ontario" (Ontario Institute of Pedology).

D. Anderson (Sakatchewan Institute of Pedology) presented the preliminary results of an erosion study in Saskatchewan using 18 paired sites (undisturbed versus eroded) on 6-10% slopes 30-50 m long. Profile characteristics were described, samples were analyzed for bulk density, organic carbon and ^{137}Cs.

In the Brown soil % topsoil losses varied from - 50 to + 45% from crest to bottom of slope

organic C ..... - 62 to - 38%

and total soil mass ..... - 84 to + 145%

Accumulations of topsoil occurred in lower and depressional areas. Similar data were reported for Black and Grey Luvisolic soils.

There followed much discussion of the need for, and feasibility of mapping past erosion. In some areas, such as Manitoba, it was considered possible to estimate past erosion using existing soil survey recorded erosion, together with some field checking and airphoto analysis. The changes taking place in cropping practices in Ontario made such a map of questionalbe value. For Saskatchewan it was considered impossible to estimate the "degree" of past erosion, particularly on knolls. Newly available satellite imagery provides some new possibilities. Although many could not see the need for maps of past erosion, it was agreed that a generalized map based on soil survey data and "professional insight" could be prepared in most regions.

ii) Erodibility and Erosion Risk:

E. de Jong (Saskatchewan Institute of Pedology) summarized the results of recent analyses of climatic data. An attempt was made to predict the incidence of rain in early spring during highly erodible snowmelt conditions. On average at Saskatoon significant rain occurs 39 days after the frost is out of the ground, however once in 25 years a rain may occur during snowmelt. At Lethbridge there is little chance of a significant rain on frozen ground. Calculated "R" values were the same for both stations, using maximum 30 minute intensity and hourly data for different storms. On the use of the Universal Soil Loss Equation, he questioned the applicability of K values without adjusting for seasonal variation, and raised concerns about the use of current LS factors in Saskatchewan landscapes.

A new wind erosion factor was also derived using data from the Versatile Soil Moisture Budget and hourly windspeeds greater than 12 mph. The windspeeds were cubed and accumulated per month into the factor. The new factor correlated quite well with the number of days of blowing dust reported at Lethbridge and Saskatoon. He proposed this method as an alternative for predicting wind erosion events.

R. Coote (LRRI, Ottawa) briefly outlined the preparation of wind erosion risk maps for the Prairie Provinces, and the current effort to estimate crop yields and tillage effect estimates.

L. van Vliet (L.R.R.I., Vancouver) has mapped water erosion risk for the B.C. Peace River District at 1:100 000 using data from existing soil maps. Individual C, K and LS factors were derived for each polygon and six erosion risk categories were developed. Potential erosion risk has been mapped for the Lower Fraser Valley by the B.C. Ministry of the Environment at a scale of 1:25,000.

T. Dickinson (Univ. of Guelph) reported on his mapping of erosion risk and sediment production by extrapolating modelling data from small representative watersheds. Four categories were set up.

	Erosion problem	Sediment problem
I	✓	✓
II	✓	-
III	-	✓
IV	-	-

This identified the nature of the risk and the location of high risk areas.

He also reported on research to investigate the variability of spring soil erodibility using a rainfall simulator and simulated conditions of frozen subsoil and saturated soils following snowmelt. Soil erodibility was greatest when bulk density was low and moisture content was high.

I. Shelton (Ontario Institute of Pedology) presented a recently prepared map of erosion risk for southern Ontario. The factors used in the USLE were estimated for each polygon after dividing the entire area into regions with similar crop management practices.

iii) Erosion Monitoring:

A wide diversity of monitoring options were discussed. These included runoff/erosion plots with collectors and samplers (as being used by L. van Vliet in the B.C. Peace River region), rillmeters (as used by D. Chanasyk in the Alberta Peace River Region), use of mobile runoff collectors and rainfall simulators, and analysis of the latest generation of satellite imagery. It was generally agreed that more monitoring is needed, especially as related to climatic data and specific events. For plots, 10-12 years may be sufficient as additional information gained after this time does not justify the cost.

Soil Structure Deterioration (compaction) - (Tues. Nov. 27)

i) Characterization:

J. de Vries (Univ. of B.C.) presented an overview of the soil compaction problem in the Lower Fraser Valley. He emphasized the value of saturated hydraulic conductivity as an indicator of the problem, especially where surface ponding is a result of compaction. Tillage without adequate drainage initiates a "cycle of compaction" which gets progressively more serious.

B. Kay (Univ. of Guelph) discussed the dynamics of soil structure. The stability of pores is especially important during wetting and drying, when freeze-thaw cycles occur, and when a load is applied. The role of biopores

and their continuity could be seriously affected by agricultural practices.

G. Mehuys (Macdonald College) discussed the effect of machinery traffic on compaction. The moisture conditions at which compaction is most severe are not at the very wet end of the scale, but rather at just below field capacity when many field operations are carried out.

Discussion included the following points. Compaction needs to be described in terms of depth - surface layer compaction (0-30 cm) can generally be reversed (may not be easily achieved with some plow-pans within this depth); subsoil compaction is less readily corrected. The problem may affect the whole profile at some period of the year, yet may not be visible when the soil is moist. Much subsoil compaction is genetic in origin - e.g. in the Atlantic Provinces. Our concern is primarily with man-induced compaction.

Techniques of measurement include wet stability of aggregates, penetrometer resistance, bulk density, hydraulic conductivity, wet/dry cycles applied to aggregates, analysis of biopores, structural descriptions, root distributions, and combinations of these. Using texture and organic matter to predict bulk density and plastic limits was also proposed.

Another area of discussion was whether the present degree of compaction should be compared with some perceived earlier "satisfactory" condition, or with the "virgin" or undisturbed state.

There was a general concensus that a set of quidelines should be put together by someone in the Soil Classification Section (e.g. A. McKeague or C. Wang) so that soil surveyors can identify the presence of compaction in the field. These observations should be recorded on the "daily" and "detailed" field sheets so that the sites can be further investigated to check the criteria, attempt to explain why the problem was present, and estimate its significance to productivity.

ii) Risk Mapping Possibilities:

No one parameter or test adequately describes compaction. Critical bulk density is tabulated in the U.S., however it varies with the crop grown. Depth of rooting is recorded in Manitoba. Compaction cannot be mapped from existing survey data. A study would be required to test if bulk density can be adequately related to texture and organic matter content, so that estimates made from data in CanSIS files can be used with confidence.

It was suggested that a nomograph could be prepared for compaction risk considering the soil characteristics which contribute to compaction and the soil management imposed on the field.

iii) Monitoring:

Requirements for monitoring "benchmark" sites were discussed. Alternatives suggested included using existing long-term rotation sites where they still remain at Research Stations - often not representative of the landscape at large, or of local management practices. "Monitoring" involves accepting current practices, while controlled soil management is really research. It may be necessary to have some long-term rotation sites continued

so as to provide reference points for changes in soil structure. Sites should be combined so as to allow for monitoring a range of parameters under the same conditions - e.g. SWIG toposequence sites. Criteria for long-term monitoring sites have not yet been defined - it should be done as soon as possible.

Small scale mapping - review of status (D.R. Coote):

i) Small scale maps - water erosion

To date we have:
- 1:100,000 maps completed for 2 of 6 map sheets in B.C. Peace River Region, - unpublished, not included on extended legend of digitized map sheets. Information includes USLE factors K, LS, C, and predicted erosion.
- 1:500,000 map of Southern Ontario completed, unpublished, data on extended legend for soil landscape map of Ontario. Digitizing not yet complete. Information includes USLE factors and predicted erosion.
- 1:500,000 soil landscapes map of New Brunswick 70% complete. Will be completed and digitized by end of 1986. Will have soil and slope data in extended legend suitable for risk mapping (no land use data).
- 1:75,000 generalized soil map of P.E.I. and 1:500,000 generalized soil map of Nova Scotia are available for use in degradation risk assessment, but have no data analysis for this purpose.

ii) Small scale maps - wind erosion

To date we have:
- 1:1M soil landscapes maps showing wind erosion potential based on texture, April-May soil moisture (from Versatile Soil Moisutre budget) and April-May wind speeds, computed from a modified wind erosion equation based on Chepil's work. Manitoba and Saskatchewan completed, Alberta completed but subject to finalizing polygon boundaries. Manitoba and Sakatchewan digitized, data to be added to extended legend. Unpublished.
- 1:1M soil landscape maps showing wind erosion reduction due to crop residues in preparation, based on 1981 cropping practices by Census enumeration areas, current tillage by agricultural extension regions, and yields by municipalities. Data for winter-spring period, programming underway, completed maps by end of 1984 for Manitoba and Saskatchewan.
- 1:1M soil landscape maps showing "net" wind erosion by combining "potential" and "reduction" by crop

"residues". Early 1986, Manitoba and Sakatchewan.

iii) Small scale maps - data needs

- Generalized soil landscapes maps at scale of approximately 1:500,000 for Southern B.C., Quebec and Newfoundland (Ontario, N.B. and Alberta in final stages of preparation).

- For water erosion in all provinces, except Ontario and B.C. Peace River Region, estimated R, K, L, S, C and P for each polygon of available generalized soil map (i.e. Prairie Provinces, New Brunswick, P.E.I., Nova Scotia).

- For wind erosion, soil moisture and wind speeds for periods when wind erosion prevalent, for polygons of available Ontario and P.E.I. generalized soil maps.

- Water erosion equation factors for generalized soil maps of southern B.C., Quebec and Newfoundland, when (if) such maps become available.

- Wind erosion factors for generalized soil maps of Southern B.C. and Quebec, when (if) such maps become available.

iv) Small scale maps - research needs

- For use of water erosion risk equation (e.g. USLE) needs are for improved K estimation procedure to account for high K values during early spring. Research by Dickinson and Wall, and Coote, provide indication of ways to modify K estimation. Procedure still to be developed.

- For use of water erosion risk equation (e.g. USLE) in Prairie region, improved climatic data interpretations are needed as current estimation of R appears to be unsatisfactory. De Jong has made proposals based on analysis of data at Saskatoon and Lethbridge. Need to compute comparable values at other stations and assess suitability as erosion - potential indicators. Lack of data on actual erosion to make this assessment.

- For wind erosion risk prediction, de Jong has proposal for data analysis using meteorological observations of blowing dust to separate wind speed and soil moisture conditions. Allows for freeze drying in winter as factor in prairie wind erosion. Results for Saskatoon and Lethbridge encouraging. Need to complete for other stations and assess suitability as risk indicator.

v) Inventory - past erosion

- Project underway in Saskatchewan to identify eroded landscapes using airphotos and field measurements of ^{137}Cs, organic matter and profile depth.

- Project in Ontario (Miller, U. of G.) to estimate effect of past erosion on crop yields.

- Recent remote sensing project (CCRS) looked at past erosion in New Brunswick potato fields.

vi) Research/monitoring of erosion

- Historical data from Alberta (Toogood), Southern Ontario (Ketcheson), Eastern Ontario (Ripley), Quebec (Dubé), and P.E.I. (Stewart).

- Continuing research and monitoring in Southern B.C. (Woods), Peace River (van Vliet, Chanasyk), Saskatchewan (de Jong), Ontario (Wall), Quebec (Pesant), New Brunswick (Chow), and Nova Scotia (vander Leest).

- Special projects with direct or indirect data, e.g. Swift Current (Nicholaichuk), Manitoba (Shaykewich), Ontario (Dickinson), and others.

2. Compaction

i) Small scale maps

- none at present; no plans.

- mapping needs still not clear.

ii) Data needs

- need definition of useable data

- present data availability is limited: Some for Southern B.C. (de Vries); south-western Ontario (Harrow R.S.); Southern Ontario (U. of Guelph); Ottawa area (Coote); Southern Quebec (Macdonald College; Soil Survey); New Brunswick (Fredericton R.S.); P.E.I. (Charlottetown R.S.).

- What data to collect and where?

iii) Research needs

- How to identify "compaction" in field;

- How to extrapolate data to other soils and

cropping systems;

- How to prepare reliable maps of compaction (present) and future risk.

Update and activities of Work Group (Wednesday Nov. 28)

i) Salinity:

R. Eilers presented a summary of the Salinity Sub-Group's progress. This is presented elsewhere in these proceedings (see pages) and is not repeated here.

ii) Acidity:

The following reports were presented.

Acidification - Eastern Canada (H.W. Rees):

At the 1983 meeting of the ECSS Soil Degradation Working Group it was concluded that the original objectives of the working group had been fulfilled with regards to acidification in Eastern Canada.

> "There are two eastern Canada maps currently available - one of agricultural areas only at 1:5 million, and a more recent 1:1 million map of all eastern Canada prepared for the Canada - U.S. Acid Rain Impact Assessment. The criteria for these acidification risk maps were considered suitable for either acid rain or fertilizer induced acidification. These assessments could be done in routine soil surveys since data requirements (ie. organic matter, pH, texture, CEC) were usually met." (Soil Degradation Working Group report to the ECSS, 1983).

Recommendations for future soil acidification studies remain valid and should be reiterated briefly. Research is needed on the quantification and distinction of anthropogenic and natural acidification. Benchmark sites should be established to monitor impacts on various terrestrial ecosystems. Such sites should be interdisciplinary in design and scope. Long-term effects on forest soil and biota and productivity are especially warranted.

In light of this, activities have been directed towards the preparation of a set of criteria for evaluating potential "benchmark" sites for soil degradation monitoring in respect to acidification. No concrete guidelines have been established to date but the following points are worthy of mention:

1. Soil degradation through acidification is a long-term process that is not easily measureable, due to normally occuring temporal and spatial variation in soil properties. Inputs of acid (by precipitation or fertilizers) must be studied and monitored in the context of large fluxes of acid which are common in soils. The detection of additional hydrogen ion input will be difficult.

2. Complexities of the acidification phenomenon necessitate a very broad multi-disciplinary approach. Studies of one system in isolation need to be

put into the broad context.

3. The effect of acidifying substances in precipitaion depends relatively little on the amount of hydrogen ion inputs as compared to the susceptibility of the soils to acidification. Stratification of benchmark sites should be made accordingly, based on existing risk maps and soil susceptibility to acidification classifications.

4. Input to soil covered by vegetation is not simply the sum of the atmospheric inputs, but it is also affected by the type of vegetation. Vegetation intercepts and modifies acidic precipitaion input to soils. The removal of bases due to tree cropping has a significant soil acidifying affect which must be considered for managed forests. Many plant species can also alter the acidity of the soil.

5. Other soil and site criteria of particular importance include:
   a) climate - especially excess of precipitation over evapotranspiration.
   b) topography and physical soil structure - which influence the amount of runoff relative to soil percolation and thus the time of contact between acid percolating solutions and cation exchange sites in the soil.

6. Indicators of soil degradation resulting from acidification could include aluminum leaching, weathering of secondary minerals, reduction of base saturation and other chemical changes since they are easier to measure, and as well, biological changes are mainly a response to chemical changes, but they should be related in some way to loss of plant productivity.

Surface horizons and shallow-rooted plants and organisms that inhabit the surface horizons are likely to be better indicators of acidification than deeper horizons or plants that utilize a greater portion of the soil. Upper soil layers should be examined.

Auxiliary note:

Soil acidification as a result of acid precipitation and fertilizer use was recognized by the Standing Senate Committee on Agriculture, Fisheries and Forestry as causing serious soil chemical deterioration leading to degradation of the Canadian soil resource.

Update On "Soil Sensitivity to Acidification Mapping in Western Canada" (H.P.W. Rostad):

A. Background (Prepared by G.A. Padbury)

In 1980, a study was commissioned by the Departments of the Environment of Saskatchewan, Alberta and the Federal Government [Long Range Transport of Atmospheric Pollutants (LRTAP) Committee] to investigate the transport of acid forming emissions and potential effects of deposition in Northeastern Alberta and Northern Saskatchewan. The study, conducted under the direction of the Saskatchewan Research Council, entailed a receiver of all relevant available studies either underway or that were completed after April 1, 1970, the preparation of an inventory of industrial atmospheric emissions in the study

area, the preparation of an inventory of areas where aquatic environments, soils and geology, and vegetation may be susceptible to gaseous or particulate emissions or changes in pH of precipitaion, and recommendations as to what additional studies would be required to further define the nature and magnitude of the problem. One of the recommendations was that the study area be expanded to all of Western Canada including the Territories, and since soils and geology were considered basic to other aspects of the envrionment such as vegetation and aquatics, the decision of the LRTAP committee was to proceed with the soils and geology aspects first.

In 1982, a working group, consisting of representatives of the Departments of the Environments of each of the Western Provinces as well as the Federal Government, was established and assigned the task of developing guidelines and preparing a map or maps of Western Canada showing the sensitivity of soils and geology to acidification.

At present, the maps are in various stages of completion in each of the Provinces and Territories and are scheduled for publication in 1985.

B. Research Needs

More research is needed on the effects of fertilizer and other inputs on soil acidification. We need to look at long-term research plots on experimental farms where various cropping practices have been used.

More research is needed regarding the lime requirement of prairie soils and the response of cereal crops to additions of lime.

iii) Contamination (J. MacMillan):

More samples have been analyzed from New Brunswick since the heavy metal contamination problem was discussed last year. Two samples were very high in Cadmium, and this incidence is still to be investigated. Alberta has developed a data file on Heavy Metals in soils (M. Dudas). Manitoba is compiling some data on pesticide levels in soils submitted to labs (B. Wood). Similar data are available in Ontario (R. Frank). The city of Vancouver is also apparently monitoring atmospheric heavy metal levels.

iv) Organic Matter (D. Anderson):

Organic matter loss in the Prairies is historically important, especially in relation to the "50% reduction" in organic matter widely discussed in the literature. Where "good agronomy" is practiced, further declines do not seem to be a problem. This involves increasing crop residues through increased yields and indirectly from the increased use of fertilizer and better moisture conditions from snow trapping techniques. These factors also decrease erosion, which in turn reduces loss of O.M. Present effort is directed to obtaining information on slope position, erosion and mineralization with a view to developing a landscape model so as to predict changes in organic matter.

There was some discussion on the use of soil test lab data for O.M. trends. Analysis done by Hedlin in 1980 is to be reviewed.

ALBERTA PROVINCIAL CONCERNS AND INITIATIVES IN SOIL MAPPING

This report was prepared by R. MacMillan and presented by R. Howitt to the Mapping Systems Working Group.

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INTRODUCTION

The principal concern in Alberta with respect to soil mapping is how best to evaluate, adapt, and integrate a wide variety of currently available improvements into our existing overall mapping strategy. We recognize the need to keep current but wish to adopt new methodologies as extensions and enhancements to our existing expertise rather than as replacements. We expect to plan initiatives that will permit us to experiment with a wide range of potential improvements within an overall integrated mapping strategy. Our concern can best be summarized as: How can we maximize the reliability and utility of our maps while at the same time keeping them cost effective?

BACKGROUND

Recent developments in Alberta have resulted in substantial changes in the role expected of the provincial component of the soil survey unit (i.e., Alberta Research Council - Terrain Sciences Dept.).

The developments have been partially driven by the financial constraints associated with the recent economic slowdown. Internally, these constraints have caused the provincial component to become increasingly entrepreneural and to devise proposals for both survey and non-survey work which are able to attract funding from external agencies. In order to provide the services and products desired by funding agencies, the Research Council soil surveyors have been integrated into a Terrain Sciences Department comprised of soil surveyors, soil scientists, surficial geologists, and hydrogeologists. Already, most site research requires cooperative involvement of individuals from all of the above disciplines. It is expected that future mapping efforts will increasingly adopt this cooperative approach with a view to providing integrated soils, geology and hydrogeology map products. Externally, there has been a realization, at the highest levels, that limitations on funding necessitate cooperation among government departments to minimize redundancies in information gathering. This has led to a very strong push to standardize the presently diverse data collection methodologies and land inventory products. The desired goal is to organize data collection and display such that inventory work collected by or for any given agency will satisfy the requirements of all other relevant agencies. Steps have been taken through a high level interdepartmental coordinating committee Alberta Soil/Land Inventory Coordinating Committee (ASLICC) to begin the process of standardization and rationalization of inventory methodologies and products.

An additional external, mutlidepartmental development has been the recognition that field data collection will be achieved largely through the use of contracted private consultants. This policy change has strongly influenced the percieved role of the Research Council survey unit. No longer is this unit seen as primarily a field mapping group with a mandate to define and realize a province wide inventory program. The focus has shifted very rapidly. The current perception is that the trained soil survey personnel constitute a pool of expertise which is best used for research into soil inventory procedures or management and quality control of contracted consultant surveys. There is considerable pressure from the

major government departments to have the Research Council survey group act in this research and management capacity. Consequently, we anticipate an increased need and an increased opportunity to address the issues of new mapping methodologies, quality control, project management and product design outlined below.

Finally, there are considerable forces, both internal and external, related not so much to fiscal concerns as to technology push. In Alberta, there are several major technological developments which are driving changes in soil mapping methodology. Firstly, there is a long range, ongoing program to produce digital base maps of the province at compilation scales of 1:20,000 and 1:250,000. It is already underway and will be completed by 1990.

Associated with this base mapping program is an inititive to develop a provincial Land Related Information system (LRIS) tied to the digital base maps. One element of this LRIS would be a Natural Resources Information System (NRIS). The agencies promoting these systems are trying to encourage data gathering organizations to structure their data sets (and maps) to be compatible with the digital data bases. As envisioned, the data collection agencies would not only contribute to data base input but would benefit in being able to obtain output of preexisting soils information or digital elevation data for DTM's to give just 2 examples.

Associated with this digital approach has been the decision by the Energy and Natural Resources Department to input, store and retrieve digital, geospatial data using an Integraph image processing system. It appears that this specific hardware/software configuration is rapidly becoming the standard for image (map type) data in Alberta. If a proliferation of non-compatable data sets is to be avoided then a standard format for data storage and exchange will be necessary. The pressure exists to adopt digital mapping systems and to maximize their ability to interface with the existing Intergraph installations.

In summary, the provincial component of the soil survey unit has been placed in a position where its mandate is no longer to carry out large scale, ongoing soil inventory projects. It is now expected to function primarily as an agency capable of setting standards, evaluating alternative field mapping approaches, and defining data collection requirements for contracted consultants. The defined data sets must satisfy not only traditional soil survey notions of what information is needed and how to define it. They must also meet the requirements defined for numerous other institutional users (Alberta Energy and Natural Resources , Alberta Environment, Alberta Agriculture). Consequently, the Alberta provincial unit has a strong interest in all of the topics outlined below. We feel we must have some exposure to and familarity with all of these topics. We will be asked, increasingly, to give informed opinions on how best to carry out field mapping, map and report production and reproduction, information display and dissemination, quality control definition and evaluation and soil mapping project management.

We have recognized the need to bring together existing knowledge on these topics and to initiate research projects designed to utilize and expand upon this existing knowledge. We also believe that it is essential to

carry out such investigations within the framework of an overall inventory methodology design. There is little benefit to be realized through improvements to one phase of an overall inventory methodology if it is not accompanied by corresponding improvements in all other phases. Otherwise we simply relocate the bottleneck from, for example, field data collection to map drafting and publication. To this end we envision all individual research concerns to be part of a larger program to define the most efficient and effective overall inventory methodology designs. We would like to emphasize the need to relate discussions of individual avenues for improvements in mapping to the larger concern of producing one or more recommended overall inventory methodologies.

Our outline for individual avenues of research within an overall mapping strategy is presently as follows:

1) Investigate use of remote data aquisition and analysis to aid in prestratification of landscapes (Landsat, Airborne IR, Radar, DTM's).

2) Investigate use of geostatistical methods to

   a) minimize and optimize data (variables) collected in the field
   b) define minimum variance, maximum difference soil unit groupings
   c) determine most correct boundary locations (i.e., at locations of maximum rates of change of combined or single index soil properties

3) Investigate alternative field data collection strategies to determine relative accuracies and cost effectiveness (traditional, transect, grid point, remotely interpreted).

4) Investigate applications of computers for data storage, manipulation and presentation for

   a) digital cartography
   b) digital databases and land information systems
   c) report production, standardization and access

5) Define standards of reliability and quality.

6) Develop and test quantitative correlation procedures.

7) Develop project management guidelines.

We do not anticipate being able to address all of these concerns ourselves particularly as part of a single integrated project. We recognize that most of the concerns are already being investigated at one or more of the provincial units within Canada. We therefore are in the process of developing an implementation strategy as discussed later. The individual research areas making up this strategy are discussed below.

1) REMOTE SENSING APPLICATIONS

a) What Have We Done To Date?

We are presently involved in a limited way in using remote sensing materials other than black and white air photos. Turchenek is part of a research effort centered at the U. of A. which is attempting to use multispectral Landsat data to classify wetland (peat) areas. The image analysis and classification is being done by university personnel. Turchenek is involved in field checking and in classifying the vegetation and the organic soils found at the field check sites. Preliminary results favor the use of supervised classification using training areas which have been mapped and described by field inspection. This suggests that, for peatlands, Landsat imagery is not yet suitable as a data source for primary definition of minimum variance repeating landscape units (map units). It has been found more useful to first define what is mappable and useful for interpretation by means of traditional field inspection strategies. Mappable bodies so identified become 'training areas' whose signatures are recorded and used to identify other similar areas in the remaining portions of the image area.

Wells has completed a short study where the effectiveness of various dates and scales of color IR aerial photography was evaluated with respect to discrimination of solonetzic soils. This study found that timing was critical and that images were most useful if taken at periods of maximum crop growth and accompanying moisture stress. Wells has also obtained a Landsat MSS tape of his Paintearth map area and proposes to investigate the relationships between classifications of this image data and his completed soils map.

b) Why Do We Want To Maintain And Perhaps Increase Our Level Of Investigation Of Remote Sensing Applications?

We recognize that there are limitations to the effectiveness of remotely sensed data in defining valid mappable soil/landscape units. The procedures have not been proven capable of doing it all for you. They have not yet proven superior to traditional methods for both defining and locating reasonable and useful soil/landscape units. However, the methodology exists and has been shown to be useful for some tasks. The role of the provincial unit has changed insofar as we are expected to act as experts on how best to map. We will be asked to establish guidelines and standards to be adhered to by contracted private consultants. It is therefore incumbent upon us to be aware of the potential advantages offered by these techniques and to provide judgements to both consultant mappers and contracting agencies on the usefulness and reliability of existing methods.

c) What Remote Sensing Applications Do We See As Having Potential For Soil Mapping?

i) Definition And/Or Location Of Mappable Soil/Landscape Units

Our limited experience to date, and investigation of the relevant literature suggest that we should proceed cautiously with attempts to

stratify areas into map units using remote sensing data only. It does not appear that discrete, non overlapping soil/landscape units can be uniquely defined solely by analysis and classification of spectral values. Some opportunity apparently exists for using Landsat data to locate areas similar to previously mapped and described training areas. This supervised classification approach may prove to be useful for initial stratification of areas to be mapped providing that the stratification is based on valid, field verified map unit concepts. The Landsat methodology does not then fulfill the task of defining and establishing the concepts of minimum variance maximum difference soil/land units. It simply locates areas with signatures similar to training areas which have been conceptualized and defined by traditional human soil/landscape interpretation. We see some potential then for location of mappable bodies based on signatures similar to training areas mapped and defined according to traditional concepts. Specifically we expect such methods to be useful in the forested portions of the province where characteristic vegetation patterns can be related to soil/landscape units. Also, in these areas, the proposed scale of mapping is 1:100,000 which is appropriate to the present scale of resolution of Landsat data. The proposed 1:20,000 scale of mapping and the confounding influence of land use patterns decrease the likely utility of Landsat data for landform mapping the agricultural area.

We see a second potential use of Landsat imagery in terms of pattern analysis rather that spectral signature analysis. We would like to investigate whether Landsat data can be used to determine likely extent of variability within soil/landscape units defined by other means. Theoretically we should be able to correlate uniform reflectance patterns with relatively uniform soil/landscape units. Conversely highly variable reflectance patterns should be associated with more variable soil/landscape units. It would be beneficial if such relationships could be demonstrated then used to help plan field sampling strategies. Presumeably, field inspection intensities could be lowered in areas of uniform image and therefore soil pattern. Field inspection efforts could then be concentrated in areas of observed high image variability and assumed associated soil variability. This type of application is best suited to high field inspection intensity mapping such as associated with 1:20,000 mapping of the agricultural portions of the province.

Besides Landsat multispectral data we might like to investigate the utility of airborne MSS or color IR data to assist either traditional human interpretation or computer assisted digital interpretation. We have not as yet identified specific ways in which to apply and evaluate these methodologies.

One last remote data aquisition methodology which appears promising is airborne elevation measurement using radar. Aquisition of digital elevation data by this method could permit construction of digital elevation models with a vertical resolution of less than 1 meter. These could be used to assist in prestratification into slope/landform units of areas to be mapped. Thus a large portion of the prestratification task normally done by airphoto interpretation could be accomplished automatically. The interpretation of slope would be quantitative and unambiguous. Computer routines already exist which permit calculation of slope gradient, upslope and downslope lengths, catchment areas, drainage

courses, divides and ponding locations based on such digital elevation information. Remote aquisition of elevation information with an effective contour interval of 1 meter would permit the construction of very detailed landscape models. These could form the basis not only for soil/landform map units but also for stand alone slope maps, drainage maps and others. They would also be highly useful for predicting likely behaviour such as erosion which is related to land and slope parameters.

2) STATISTICAL METHODS

a) What Have We Done To Date?

We have made several initial efforts to use statistics to assist in soil class definition or to test and evaluate traditionally defined soil/landscape units.

MacMillan used transect data obtained from traditionally mapped soil/landscape units to try and establish the variability of soil properties and soil classifications within those units. The computed values were compared with the values inferred from general map unit descriptions. This comparison was used to evaluate the accuracy of the original traditional soil map. Means and confidence intervals were also calculated for major observed and laboratory determined properties for most major soil landscape units on the Calgary map. These were used to establish reliable descriptions for those map units. Transect data has subsequently been collected for similar types of analysis for the Beaver and Paintearth surveys (Howitt, Wells). We have not yet tried using random transects as an ongoing field mapping tool. Neither have we used them to establish soil unit descriptions and limits at the initial stages of legend development.

Turchenek has used descriptive statistics for collections of peatland sample sites manually assigned to various classes. He has also used ordination and clustering techniques to help define statistically significant groupings of vegetation data in order to define reliable vegetation classes. He is currently using the same techniques to define peat material classes. He is also using other methods such as discriminant analysis to determine what properties best differentiate peat materials.

Finally MacMillan used his transect data and principal component analyses techniques to try and identify which few variables from the complete list of field and laboratory data elements collected were most useful in explaining the observed variation among soil series and soil map units. Turchenek is now using similar methods to try and isolate the few variables most useful in separating and defining valid peat material groupings. We have not progressed too far on this score and have much to learn from BC and Ontario.

b) Why Do We Want To Investigate Statistical Techniques?

We have accepted that statistical techniques can improve our ability to accurately describe soil/land units mapped by traditional methods. We have also found that they give us a better idea of the variability of these units with respect to taxonamy or to soil property values. These capabilities enhance the value of traditional soil survey maps and reports

by enabling accurate descriptions of soil unit characteristics and alerting users to limitations associated with unresolved variability.

We see also that statistics can be used to minimize the number and optimize the usefulness of costly field observations and samples. We feel that it is necessary to investigate the utility of all currently recorded information in defining and differentiating soil series and map units. Similarly we feel that statistical techniques can predict the number of sample sites needed to achieve minimum levels of descriptive accuracy for any given map unit. Reduction in both the number of observations made at a given site, and the number of sites visited in a given unit or area to a minimum acceptable level is desirable from a cost effectiveness standpoint. It also assures that data collected and digitized will be used in a beneficial manner, not just for display purposes. Besides cost considerations, we feel that the potential exists to use geostatistics to define minimum variance soil/land units and to determine their distribution in a more accurate manner that currently obtainable by traditional mapping methods. We have no data to support this contention but feel we must at least test the potential in view of our role as assessors of mapping methodologies. It is quite likely that the utility of such methods will be scale dependant. Burrough and others (1971) indicated that below about 1:50,000, scale grid survey and interpolation techniques were more cost effective and produced better maps than free survey techniques. With a developing trend toward 1:20,000 scale mapping in Alberta we anticipate a need to address the question of free survey vs grid survey utility. Several consulting companies are already using statistical interpolation techniques to produce single factor 'soil' maps for Alberta clients. We expect to be asked to comment on the credibility of such products so had best have some experience in their use.

c) What Do We Feel Is Needed In Terms Of Statistical Applications?

We see three major, interrelated applications for statistics in soil mapping. They are:

1) Minimization and optimization of field data collection observations and sites.

2) Definition and description of 'best possible' minimum variance, maximum difference mappable soil bodies (soil units).

3) Definition and location of 'best possible' soil unit boundaries based on analysis of spatial variance of multiple or single index soil property values.

In the first instance we have to take a hard look at all the data elements we currently collect during field mapping and some we presently do not collect. We have to determine which parameters and what types of classifications, measurements or laboratory determined values are truly useful in making valid soil individual and soil area groupings. Information is costly to collect, record and analyse and we have to demonstrate that everything we collect is useful for making valid separations and is in fact used to make the separations. We see stepwise

regression, discriminant, principal component or factor analyses techniques as being useful to accomplish these objectives. We have not yet addressed this problem in Alberta and welcome the experience of those people who have tried to define the elusive 'minimum data sets'. The set arrived at for mineral soils in Alberta may differ from that in BC or Ontario but hopefully we can utilize your methodologies to define these sets.

The second point involves defining the most statistically valid groupings of soil individuals which can still remain mappable. It is not discrete from point 3 below but has been kept separate for discussion purposes. One way of defining minimum variance groupings is to use discriminant, cluster or principal component analyses techniques to group individuals into minimum variance or maximum within group similarity groupings. This approach assigns sites to minimum variance classes. The classes of site data can be plotted and contoured according to their geographical distribution. However this type of approach is difficult to utilize to outline heterogeneous areas which would normally be mapped as catinas or complexes. Consequently it has limitations for producing areal displays of complex repeating landscape units.

Finally, we would like to investigate use of statistical techniques for interpolation of gridded data and location of boundaries at locations of maximum rates of change of single factors (slope) or multiple factors (slope, texture, soil morphologic features). There has been considerable development recently in the application of kriging, time series analysis and other spatial analysis techniques to the definition and mapping of soil and material groupings. These estimation and interpolation techniques have proven useful where the scale of mapping permits data collection at distances less than the maximum distance over which soil properties show spatial dependance. Reviews of the literature suggest that spatial dependance is operative over distances of about 100 meters for many soil properties. At scales of 1:20,000 it becomes feasible to consider collecting data at such intervals, at least for highly variable areas. Thus, the utility of statistical interpolation techniques is worth investigating for production of maps of 1:20,000 scale or larger.

3) FIELD DATA COLLECTION TECHNIQUES

a) What Are We Doing Presently?

At present all soil mapping in Alberta done by government agencies and most mapping done by private consultants utilizes traditional techniques. Air photo interpretation is used to define mappable repeating landscape units and field checking is carried out at representative sites within delineated areas to confirm the air photo interpretation. As previously mentioned, transect sampling of randomly selected delineations is not currently used as an operational mapping technique. This free mapping approach is used at all survey intensity levels (SIL).

b) Why Do We See a Need To Investigate Alternative Field Data Collection Methodologies?

Again the driving force for investigating alternative strategies is the possibility of achieving increased accuracy and reliability at potentially

lower cost. Steers and Hajek (1979) reported substantially lower costs and higher reliability using transect sampling of air photo interpreted delineations of forested areas at SIL 4. Burrough and others (1971) and Beckett (1981) indicated that grid survey and interpolation techniques produced better maps at lower relative costs than free survey at SIL's less than 3 (scales less than 1:25,000). We expect to be asked to set standards and define appropriate mapping methodologies for future surveys especially at 1:100,000 and 1:20,000 scale. It is therefore necessary that we have proven results which demonstrate the superiority or cost effectiveness of one method over the other.

c) What Do We Propose To Do In the Area Of Evaluating Different Field Data Collection Strategies?

We hope to set up pilot studies in two areas, one agricultural and one forested, to document the relative abilities and costs of various data collection strategies for various scales of survey. (Specifically 1:20,000 and 1:100,000.)

We envision collecting field data in a dense grid and then selectively utilizing or deleting sample ponts to simulate mapping via the various alternatives (grid, transect, random point). The study sites will be within areas undergoing current mapping by traditional methods. We propose to compare the accuracies and costs of maps produced by the various methods in order to establish the relative efficacies and costs of the alternative approaches. This should permit us to recommend the most suitable and cost effective alternative at each of the intended SIL's.

We would hope, in combination with this exercise, to define a minimum data set which would be both effective at identifying diferent soil/land units and would satisfy the basic data requirements of the various major users of soil/land information in Alberta. Thus, this data set might contain information such as pebble lithology or systematic electrical conductivity determinations to satisfy geologic mapping or irrigability mapping requirements to name just two examples. We see here that the minimum data set defined for Alberta may be considerably different than that defined for other provinces. This relates more to our newly accepted requirement to attempt to service multiple agency needs than to any basic differences in properties of concern for soil mapping.

4) DIGITAL DATA CAPTURE AND MANIPULATION

a) What Have We Done To Date?

Our use of computers to capture, manipulate and analyse data and text has increased steadiy over the last 5 years. A detailed report on usage to date has been prepared by R. Howitt for presentation elsewhere at these meetings ECSS-computer committee). Consequently only a short summary is given here.

Our first use of computers was as word processors to insert, edit and output text information for soil survey and associated project reports. All reports are now assembled in electronic form. We have not developed a systematic, uniform format for soil survey reports which is followed by all

authors. Thus we do not have one or two basic documents designed as standard formats for specific types of survey reports. A few of the early reports to have been output in digital form have been used extensively by subsequent authors who chose at their own discretion to cut and paste large sections of these early reports into their later reports. Such sections as glossaries, interpretations tables and their description, and appendices of soil profile descriptions and analytical data have regularly been extracted and modified for other reports. In this way we have tended to build up master files particularly for glossaries, interpretations and appendices. However these developments have been more spontaneous than planned and channeled. This is demonstrated by the considerable variety found in soil series and map unit writeups which form the bulk of most reports. We have not developed to the point where we have set report formats and prewritten materials for all sections of a report where the author more or less fills in the blanks. With the very low level of mapping activity we are currently sustaining we have little justification for designing modular reports. If we are asked to manage and standardize an extensive provincial inventory initiative the justification for creating one or two modular report formats might develop.

After word processing we began to use computers to capture, manipulate and output field and laboratory data. For this we needed data management software. We use Micro on the university computer and Datatrieve on the Council VAX. Our initial data structure consisted of three basic files one for site information (SITEDAT) one for horizon descriptions (HORDAT) and one for laboratory data (LABDAT). All data was related back to the site at which it was taken and through the SITEDAT file to the series, map unit, parent material etc. which were recognized at that site. We found that much of this data was difficult to use for any meaningful computer assisted analysis. Most of the coded catagorical data (drainage class, color, parent material class) could only be used for frequency counts to determine modal characteristics of sampled sites. Such data was inappropriate for most parametric analysis statistical techniques. Also the bias used in site selection gave very skewed descriptions of map unit attributes since not all sites within map units were given the same degree of attention.

Our reaction to this limitation was to collect and store more continuous variable data and to collect the data in a systematic fashion along random transects through map unit delineations. We found that this approach allowed us to do more with the data. We were able to establish mean values and confidence limits for series and map unit attributes especially attributes used for critical interpretations. Also we had some confidence that the descriptions of the mapped areas (map units) were unbiased and reliable.

Having electronic data sets of information collected at fixed intervals along random transects led to the recognition of other potential uses. It became possible to study spatial dependance relationships through trend surface analysis, semi variograms and the like. This led to our current interest in use of geostatistical estimation and interpolation techniques. It also became obvious that much of the data collected was redundant or unuseable. Codified classes of attributes were very difficult to use to advantage for statistical analysis. Also many currently recorded soil properties were found to be so strongly autocorrelated that little

advantage was gained in utilizing more than a few of a long list of autocorrelated properties. This realization lead us to conclude that systematic evaluation of recorded variables is necessary in order to identify a minimum set of useful observations and sample data.

Next, we found ourselves defining data sets for each project area. The data sets used the same software and basic conceptual design but the specific formats and coding specifications varied from project to project. They rapidly became incompatable. This is our experience within one small organization with a single hardware/software configuration. This highlighted for us the need to define a logical design for digital storage of field and laboratory data that would be universal among all of our projects and across a wider community of Alberta users. We have not done this as yet. However the machinery is in place and initial efforts have been undertaken towards defining a standard data set and data format.

The most recent item we have had to confront is that of digital cartography. The federal survey group has used quarter section raster digitization of all existing soil maps to build a province wide digital database (SIDMAP). We have not yet tried to do inhouse polygon digitizing. We are looking at the recent experiences of other units for guidance in this area.

b) Why Do We Want To Investigate Computer Applications?

As with the previously discussed applications we feel a need to have a familiarity with recent advances which will allow us to comment on and recommend useful procedures. We have also been named to participate in a multidepartmental effort to identify the components of existing soil/land databases. The objective is ultimately to define a standard minimum data set and an interchange format. Having had a few small project related electronic databases, we have experienced the major improvements in data analysis and descriptive accuracy which become possible in such an environment. We have also had an awareness forced on us of the limitations and lack of utility of some forms of data presently collected for soil survey. The result has been an increasing awareness of the need to readdress the question of what data to collect and how to record it. We must unambiguously define the reasons why we collect each piece of data and show how it is used to good effect. We must then assure that the data is collected, stored and coded in formats addressable by a wide variety of other soil/land data collection agencies. These questions must be addressed in a systematic, coordinated fashion, not in the piecemeal, unplanned, fashion which has developed more or less on its own up till now.

c) What Do We Feel Is Needed In Terms Of Research Into Computer Applications?

We believe that the major focus at the present time should be on the identification, evaluation and installation of linked digital cartography and digital database capabilities. Again, a great hazard exists if developments in this area, which are sure to come, are allowed to proceed in piecemeal, uncontrolled fashion. The digital cartography capability requires not so much standardization of hardware/software configurations (through that would make things easier) as it does a standard interchange

format for line and symbol data. My understanding is that considerable effort has been expended by the Ontario group to address the need for standard interchange formats to CANSIS and to Intergraph (ASCII). We don't propose to redo that here. This polygon information must however be linked to our extended legend lookup table which, in effect, is an digital database. The structure of such a legend (i.e., its fields, field definition, catagorical coding, etc.) must be made as standard as possible in order to facilitate information exchange. Otherwise we will be balkanizing our individual data bases and limiting rather than increasing information exchange. In Alberta we have a requirement to standardize not only to CANSIS specifications but also to as great an extent as possible to specifications acceptable to ENR, Alta Ag and other major soil/land data collectors/users.

To address this problem adequately we need expert systems analyst help as well as cooperative input from all concerned database users. As mentioned previously, each data element that goes into any eventual database must be critically examined to determine its usefulness and to document how it will be used. A data base, once built, is difficult to alter and even harder to abandon. Therefore we must make some effort to assure that it will contain the right information and do the right tasks before we allow any particular format to become institutionalized.

We would like to have the opportunity to have hands on experience with several of the alternative, relatively inexpensive, map digitization systems in a training project environment. We see the need to test several systems in actual operation in order to evaluate how well they do the job. We see ourselves as an intermediary between the large, sophisticated digital cartography systems used to service line department databases (i.e., ENR's intergraph) and the field data collectors (mainly consultants). We would like to be able to advise the consulting community on what systems will satisfy their need to be able to deliver digital map products to contracting agencies at an acceptably low cost. We see a need for a project which will allow us to to do this.

We would also like to participate in an effort to identify which of the data elements currently collected for soil survey, land classification, PLC and other major soil/land methodologies in Alberta are most useful for mapping valid separations. We would like to see a common or at least an umbrella data set definition established to serve these major mapping agencies. To as great an extent as possible, we would like to see the data set minimized. A formalized, standard data set would greatly facilitate digital field data entry through electronic notebooks, hand held computers etc.

Finally we see the possibility of a need for one or two standard report formats to be used by the wide variety of consultants likely to be involved in the anticipated large scale Alberta inventory program. If such a major initiative is launched, it will be beneficial in terms of consistency and uniformity to have all participating consultants using the same basic source document to produce their reports. This will result in a uniform data set which will be of greatest use to the largest community of users.

5) STANDARDS OF RELIABILITY AND QUALITY

a) What Have We Done To Date?

To date we have not had explicitly defined standards of reliabilty and quality. Reliability has been equated to ground truth inspection density and survey intensity level. Several foreign publications (Beckett and Webster 1971, Webster 1983) have shown a close relationship between survey intensity level and reliability. However few attempts have been made to explicitly measure reliability and to convey information on that reliability to users.

In Alberta, MacMillan used his transect sampling to help determine the correspondence between original descriptive estimates of soil/map unit properties and the quantitative values obtained from transect data. The results confirmed that the major Calgary map units had reliabilities about normal for 1:50,000 free survey methods using air photo interpretation. This study confirmed Websters (1983) reported class purities of 25 to 65 percent for accurate recognition of series, textures and other narrowly defined classes within soil map units. It also supported his observation that interpretation accuracy tended to be much higher as it was based on broader and fewer parameters. Still about 50% series classification accuracy can be accepted as good for survey intensity level 4 (1:50,000) free survey maps. That is about all the quantitative data we have to go on at present.

b) Why Do We Want To Investigate Quality And Reliability Standards?

The principal reason for wanting to determine and set such standards arises from a need to evaluate map products produced by diverse private consultants for a single major inventory project. If this project goes ahead then some standards will need to be set to determine the quality of the products received.

Also, the increasingly sophisticated and demanding users of soil/land data have indicated a preference for quantifiable statements of reliability to accompany the information they are using. As the scale of mapping gets larger the uses to which the information is put became more critical and the requirement for reliability figures increases. Consequently we perceive a need to address this question.

c) What Do We Feel Is Needed In Terms Of Research Into Quality And Reliability.

We suggest that companion studies be initiated in conjunction with the field data collection methodology investigations described in section 3 above. These projects should attempt to define the levels of accuracy and reliability which can reasonably be expected of each of the proposed mapping methodologies (free, grid, random transect) at each of two scales (1:20,000 and 1:100,000). If we can document the likely achievable standards then we can specify desireable levels of quality expected from mapping projects commissioned at a given scale and utilizing a given mapping approach.

6) QUANTITATIVE CORRELATION PROCEDURES

a) What Have We Done To Date?

Research Council soils personnel have not exercised a correlation role in Alberta for over ten years. Correlation has been handled by the federally employed provincial correlator. He has used traditional means including frequent field trips and close supervision of naming conventions and mapping approaches utilized by federal or provincial field parties. Correlation has been more of an art than a science but it has proven effective in maintaining consistency and quality. We believe that, the levels of reliability and accuracy attained by our maps are acceptable and comparable to levels achieved elsewhere by similar mapping means. The transect evaluation of the Calgary map is the only quantitative documentation we have of this reliability. However, we believe that it is reasonable to conclude that similar levels of quality have been achieved by all other recent map products, partly as a result of the correlation procedures used.

b) Why Do We Want To Investigate Quantitative Correlation Procedures?

The problems with correlation procedure as it now stands are that it is a qualitative process; it requires the dedicated participation of a highly trained and knowledgable soil mapper (a disappearing breed); and it is lacking in quantitative supporting documentation. If the Research Council is to be asked to operate as a provincial correlator for numerous surveys contracted out to a variety of private consultants a more formalized correlation procedure will be needed. We will be in a position of having less experienced manpower called upon to correlate a large number of diverse survey groups over which operational control is not as strong as in the present soil survey unit setup. Also, in order to be fair to the private consultants, they must know in advance, the correlation procedures they will be expected to conduct by themselves and those they can expect to have imposed upon them by outside management. It is necessary that the procedures be fair, equitable and explicitly stated in advance.

c) What Do We Propose To Do In The Way Of Correlation Research?

We see a need to test various quantitative correlation procedures in the two study areas previously mentioned. Random point and random transect checking techniques could be formalized so that major map units and overall map products could be tested and compared to the expected levels of reliability as discussed in section 5 above. Units or maps found to be seriously below standards would require upgrading to meet the standards.

In terms of naming conventions for series and map units, we feel that clear guidelines on the distribution of named series should be formulated based on Wayne Pettapiece's physiographic regions map of the province and an updated agroclimate/soil climate map. We have seen recent maps of temperature/precipitation which utilized all available climate stations and then computed temperature/rainfall parameters for all of a US State (Penn) based on lat, long, elevation data relationships. We would encourage development of such a map for Alberta to help define geographic limits for

spread of series names. We are, however, unlikely to attempt this ourselves.

7) PROJECT MANAGEMENT CONCERNS

No review of project management concerns will be attempted here. It is sufficient to note that the Research Council survey component expects to be asked to accept a project management function in relation to surveys contracted to private consultants by other government agencies. We have not done this before and hope to pick up some ideas from the experience of others at this meeting.

We are concerned with aspects of budgetting, time management, product delivery schedules and product design. We are also concerned with assessing accuracy, reliability and cost effectivenss of contracted surveys as previously discussed. We have no formalized procedures for project planning, management, review and evaluation. We would appreciate receiving suggestions for guidelines from others who have experience in this area.

IMPLEMENTATION STRATEGIES

The above list of necessary research efforts is extensive and cannot likely be undertaken by a single research group. What is needed by an individual group, like the Alberta unit, is an overall program design that recognizes each of the required research elements and permits each to be addressed as funding or personnel become available internally, or as solutions are proposed by external researchers.

We propose to address the various concerns discussed above within the context of the overall implementation strategy previously mentioned. This strategy will definitely be designed to reflect the new Terrain Sciences committment to producing integrated soils, surficial geology and groundwater products. We will be putting considerable effort into defining ways of integrating surficial geology, overburden material, surface and subsurface water mapping into an overall mapping methodology. This report concentrates on issues of concern to soil mapping, but many are equally applicable to geology and hydrogeology mapping.

The Research Council recognizes that it must maintain at least a skeleton program of active ongoing mapping. This is necessary because it is mainly through production scale mapping that new problems and likely solutions are regularly recognized. Also involvement in ongoing mapping produces the practical experience which gives a unit its credibility. It also provides an opportunity to test proposed methods under actual operating conditions prior to introducing them into general use. To this end, the Research Council survey unit has identified a need to be actively involved in at least two mapping projects, one in an agricultural area and one in a forested area.

A proposal has been submitted to Alberta Agriculture for funding to continue mapping in east central Alberta in Flagstaff county. Mapping scale would be 1:50,000. Preliminary discussions have been held with Alberta Energy and Natural Resources regarding selecting an appropriate location in the forested area in which to undertake a pilot inventory

project. It is envisioned that these will be stand alone projects with the traditional objectives of providing base line soil and land information. However, they would also provide ideal test locations for evaluation of related map production, correlation and display methodologies. It is anticipated that individual research projects will be formulated for each of the listed concerns and undertaken in the selected pilot areas as funding and personnel become available. Many discrete individual projects are possible but all will be integrated into an overall design to help improve the mapping process. To as great an extent as possible, we wish to take existing methods and solutions and adapt them for application to the Alberta environment. We look forward to receiving advice and instruction from individuals and groups with existing expertise in these areas so as to benefit from their efforts.

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FUTURE WORK

New survey procedures and principles are at different stages of development. This makes it difficult to attempt a complete revision of the 1981 Soil Mapping System publication. Therefore the Working Group proposes to write a progress report on selected topics instead of a completely revised manual. The main topics and authors will be as follows.

Survey Objectives, special and general purpose	K. Valentine
SIL Specifications	K. Valentine
Properties, Minimum Data Sets	J. Shields
Survey Design	K. Valentine, C. Wang, M. Langman
Data handling and Storage	B. MacDonald
Information Packaging	C. Tarnocai
User Involvement	J.M. Cossette
Survey Procedure Examples - SIL 2 Agronomic	D. Holmstron
- SIL 3 General	G. Padbury

The first draft of these sections must be ready for distribution by December 1985. The Working Group will then meet to discuss them in January 1986 and prepare final sections by spring 86.

The Working Group should no longer have priority status, and could change its role from one of advocation to one of communication; acting as a national clearing house for various ideas and procedures. The chairman, K. Valentine, said he wished to resign in the near future and would be looking for a replacement.

MANITOBA CANSIS NODE UPDATE

A Report for the Guelph Meeting of the
CanSIS Working Group of ECSS, November, 1984

W.R. Fraser

INTRODUCTION

This report consists of two parts, the first of which is a progress report on the direction of file development within the Manitoba CanSIS "Node" since 1982. This may be considered as an update to an earlier report to the CanSIS working group (W. Fraser, 1982. Soil Survey Data Management/Future CanSIS Node Development Needs) which basically outlined the structure and status of the Manitoba CanSIS Node at that time. Both this update and the original report reflect a heavy reliance on data processing using local mainframe facilities. Particular emphasis has been placed on recent Manitoba Daily File developments.

The final section of the report deals with adopting procedures to use a hand-held micro-computer for field data collection, specifically for the new Manitoba Daily File.

THE MANITOBA CANSIS NODE

An overview of the current status of Manitoba's Soil Data Base (or CanSIS "Node") is provided in Figure 1. The various computer files can be considered as four main types: Cartographic Files, National CanSIS Files, Manitoba Soil Survey Data Files, and Other Files (mainly Provincial or University of Manitoba Files).

Cartographic Files

Cartographic, or digital map files, have been considered in 3 groups: inventory maps at a full range of scales; generalized maps, usually at 1:500,000 or 1:1,000,000 scale; and derived and interpretive maps.

The Manitoba Soil Survey Unit has had a stand-alone digitizer system in place since 1977, which has permitted us to digitize all subsequent inventory projects as well as many older reconnaissance maps. An array of generalized maps are also approaching completion and will, in turn, be digitized. A new IBM-PC based stand-alone digitizer system provided by LRRI is expected to become operational in 1985. This new in-house facility, which will include an optional flat bed plotter, should provide a significant improvement in reliability and digitizing capabilities.

National CanSIS Files

National CanSIS files were initially developed to meet the objectives of soil characterization and quantification for purposes of national soil correlation, soil resource interpretation and land evaluation. As with most other soil survey units, Manitoba has routinely input data into the

SOIL DATA BASE FOR MANITOBA

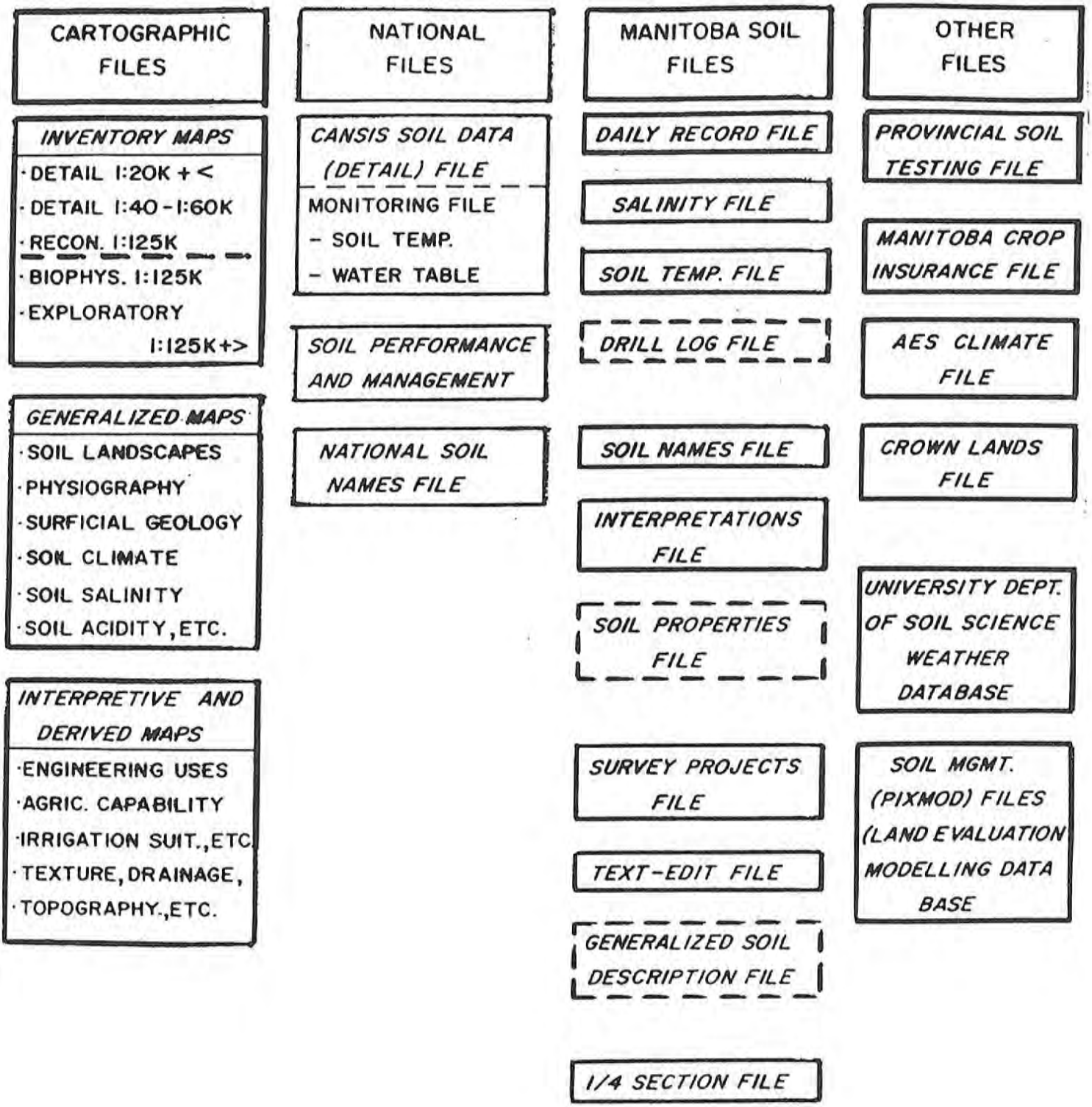


Figure 1

Soil Performance and Management, National Soil Names, and the Detail (CanSIS "Soil Data") files.

Manitoba has actively promoted, through the SWIG and Soil Climate working groups, the need for a national Monitoring File. This has been developed as an addition to the Detail file by Bruce MacDonald and the national CanSIS staff. Several output formats for monitoring data are also now in place in the national file, modelled largely after Manitoba examples. The large volume of provincial soil monitoring data collected since 1971 and stored in local files will be reformatted and input to the new Monitoring File as time permits.

The Manitoba Soil Survey Unit relies heavily on the Detail File for soil characterization purposes and profile descriptions. To date, approximately 1,600 Manitoba soil profiles have been input. Since this file is vital to determine sampling and correlation needs for all inventory projects, a local file has been created to enhance the utility of national Detail File data. This local file contains series code, location, project code, and several other key parameters (oneline of data per record) and is updated whenever new Detail records are added to the national file. Various EASYTRIEVE summary programs are run using this local file to assist survey project leaders in determining if future sampling of a soil series is needed in their area, and to identify existing samples which may be suitable for reference or correlation purposes. Examples of these local detail record output formats are a summary by project (Figure 2), and a sort by series code, name, and location (Figure 3).

It is anticipated in the near future that a copy of the RAPID defined Detail File for all Manitoba records will be installed on the local University of Manitoba mainframe system. This will allow for in-house manipulation of our Detail records for various purposes, such as proposed Soil Properties File development, Land Evaluation Modelling exercises, soil correlation, research into SWIG and soil temperature regimes, future sampling strategies, etc. It should also provide a link to our text editing files, so that better soil profile descriptions can be generated and merged directly with our soil reports.

Manitoba Soil Data Files

It has long been an established policy of CanSIS that national files be created to serve national needs, and that local files (hopefully compatible) be created within the units to serve particular provincial needs. The Manitoba Soil Survey Unit has endeavored to do this utilizing local university and provincial mainframe computer facilities, with budget support and some programming expertise provided by both federal and provincial governments. This has provided us with a set of Manitoba Soil Data Files listed in Figure 1. Existing files are indicated by solid lines, while proposed files are indicated by dashed lines.

A review of many of these files (the Manitoba Soil Names and Interpretations files, Monitoring files, Drill Records file, Survey Reports file, and text editing files) and their role in the inventory process

PROJECT SUMMARY OF SOILS CHARACTERIZED IN THE DETAIL FILE Page 1

Proj Code	Project Area		Series Code	Year	Prov. Id.No	Location			Data Fld	Data Lab
AWS	Almasippi Wet Sand	(1)	SKL	81	18	NE10	09	8W1	1	1
		(2)	LOP	81	19	NE10	09	8W1	1	1
		(3)	LOP	81	20	NE10	09	8W1	1	1
		(4)	LOP	81	21	NE10	09	8W1	1	1
		(5)	WWC	81	22	NE10	09	8W1	1	1
		(6)	WWC	81	23	NE10	09	8W1	1	1
		(7)	LLT	81	24	NE10	09	8W1	1	1
		(8)	LOP	81	25	NW10	09	8W1	1	1
		(9)	ASS	81	26	NW10	09	8W1	1	1
		(10)	ASS	81	27	NE10	09	8W1	1	1
		(11)	WWC	81	28	NE10	09	8W1	1	1
		(12)	LLT	81	29	NE10	09	8W1	1	1
		(13)	LLT	81	30	NW10	09	8W1	1	1
BIF	Bifrost Project	(1)	THG	80	28	NW17	23	4E1	1	1
		(2)	FYLP	80	29	SW17	23	4E1	1	1
		(3)	ABG	80	30	NW16	23	4E1	1	1
		(4)	TRO	80	31	SW19	22	3E1	1	1
		(5)	FMS	80	32	NE22	22	2E1	1	1
BJR	Beausajour Area	(1)	AND	78	5	NW10	12	7E1	1	1
		(2)	PLN	78	6	SE 7	12	7E1	1	1
		(3)	PRG	78	7	NW13	14	6E1	1	1
		(4)	PGU	78	8	SE23	13	6E1	1	1
		(5)	RIV	78	9	SW32	10	5E1	1	1
		(6)	GRH	78	10	NE 6	11	7E1	1	1
		(7)	GHP	78	11	NE19	12	8E1	1	1
		(8)	MCR	78	12	SE 7	12	7E1	1	1
		(9)	MRQ	78	13	SW 8	13	7E1	1	1
		(10)	BLO	78	14	SE 2	12	8E1	1	1
		(11)	DCS	78	15	SE17	13	8E1	1	1
		(12)	CAY	78	16	SE13	12	7E1	1	1
		(13)	GNL	78	17	NW26	13	6E1	1	1
		(14)	LUR	78	18	NE 8	12	7E1	1	1
		(15)	LKD	78	19	SW15	13	8E1	1	1
BRA	Brandon Region	(1)	SWR	75	10	SE24	8	19W1	1	1
		(2)	SXB	75	11	SE11	8	19W1	1	1
		(3)	CYN	75	12	SW 2	10	19W1	1	1
		(4)	MRH	75	13	SE33	8	18W1	1	1
		(5)	CLN	75	14	NW29	8	18W1	1	1
		(6)	FND	75	15	SW27	8	19W1	1	1
		(7)	WWD	75	16	NW 1	11	18W1	1	1
		(8)	SGO	75	17	SE19	11	18W1	1	1
		(9)	BSF	75	18	SW18	11	18W1	1	1
		(10)	WHL	75	19	SW26	10	18W1	1	1
		(11)	BWO	75	20	SW33	7	18W1	1	1
		(12)	CXT	75	21	SW34	10	18W1	1	1
		(13)	SHX	75	22	NE12	10	17W1	1	1

Figure 2. Sort by Project Example from the Manitoba Detail Summary File.

SUMMARY OF SOILS IN THE DETAIL FILE Page 19

Series Code	Series Name	Year	Prov. ID.No.	Location	Data Fld	Data Lab	Proj Area		
		(2) 81	5	NW11-10-18W1	1	1	BRA		700
		(3) 81	72	NW12- 8-14W1	1	1	SPW		701
LEV	Lee River	(1) 62	20	SC20-14-11E1	1	1	LDB		702
		(2) 63	82	SW13-13-11E1	1	1	LDB		703
		(3) 71	26	8-24-14E1	1	1	PDB		704
		(4) 78	30	SE 3-17-13E1	1	1	LDB	NS-BIRD ISUTF92918745	705
LIG	Liege	(1) 77	30	NW30- 3-16W1	1	1	PEL		706
LIS	Lone Island	(1) 80	104	- -	1	1	WHS	15UUF 2750 4500	707
LKD	Lakeland	(1) 63	58	20-32- 8W1	1	1	GRL		708
		(2) 63	72	NW35-24-15W1	1	1	STR		709
		(3) 63	138	NW 3-15- 6W1	1	1	LDB		710
		(4) 65	117	SE 2-26- 1W1	1	1	RRW		711
		(5) 65	141	SW11-26- 1W1	1	1	RRW		712
		(6) 65	181	32-31- 9W1	1	1	GRL		713
		(7) 65	184	SE17-32- 9W1	1	1	GRL		714
		(8) 74	168	NE33-14- 2E1	1	1	WPG		715
		(9) 77	1	SW29-19- 4E1	1	1	MGR		716
		(10) 78	19	SW15-13- 8E1	1	1	BJR		717
		(11) 80	78	SW 6-14- 8E1	1	1	GDA		718
		(12) 82	5	NE 7-15-11W1	1	1	WBN		719
		(13) 83	40	11- 1- 2E1	1	1	EMR	TOWNS AREA RL 32	720
LLTP	Lelant	(1) 77	52	SE29-10- 8W1	1	1	PGW		721
		(2) 78	46	NE 7-10- 7W1	1	1	PGW		722
		(3) 78	53	NE22-10-10W1	1	1	PGW		723
		(4) 80	65	SW10-11-10W1	1	1	PGW		724
		(5) 81	24	NE10-09- 8W1	1	1	AWS		725
		(6) 81	29	NE10-09- 8W1	1	1	AWS		726
		(7) 81	30	NW10-09- 8W1	1	1	AWS		727
		(8) 81	31	NW 7-10- 6W1	1	1	PGW		728
		(9) 81	35	NE20-10- 6W1	1	1	PGW		729
		(10) 83	5	SW24-13-11W1	1	1	WBN		730
		(11) 83	6	NE 7-13-10W1	1	1	WBN		731
LMP	Limestone Point	(1) 70	56	5-53-13W1	1	1	GRR		732
		(2) 71	82	SW32-52-13W1	1	1	STS		733
		(3) 75	41	NE10-49-13W1	1	1	GRR		734
		(4) 75	46	SW34-56-13W1	1	1	GRR		735
LOP	Long Plain	(1) 78	51	NE 7-10- 7W1	1	1	PGW		736
		(2) 79	19	NW12-12-10W1	1	1	PGW		737
		(3) 81	19	NE10-09- 8W1	1	1	AWS		738
		(4) 81	20	NE10-09- 8W1	1	1	AWS		739
		(5) 81	21	NE10-09- 8W1	1	1	AWS		740
		(6) 81	25	NW10-09- 8W1	1	1	AWS		741
		(7) 81	33	NE10-10- 6W1	1	1	PGW		742
		(8) 81	34	NE 7-10- 6W1	1	1	PGW		743

Figure 3. Sort by Series Code Example from the Manitoba Detail Summary File.

was prepared for the CanSIS Working Group in 1982 and will not be repeated here. Many of these files are now an integral part of the inventory program, and an updated listing of summaries from these various files is provided to all Manitoba Soil Survey staff on an annual basis. Additional information on these files may be obtained from the "applications compendium" forms or from the author.

Several Manitoba soil data files have been proposed or modified since 1982, and these will be briefly described here.

The Soil Properties File is intended, as the name suggests, to act as a central repository of information on Manitoba soils. It is proposed that it be established on a soil series basis, with a large number of specific columns used to record generalized data on various soil properties, such as texture, pH, SWIG parameters, etc. In a sense, it will function as a very large extended legend of soil properties which will be used for interpretive ratings and map production, as input into land evaluation modelling programs, as well as for soil correlation and documentation purposes. Many decisions on the nature and content of the data base have yet to be determined, such as whether to use estimated class ranges or averaged statistical values for various parameters, and what constitutes acceptable data sources and update procedures.

A generalized soil description file is also proposed as a type of word processor file for report writing. It is part of an effort to standardize and streamline the production of informal soil survey reports. The series description format (Figure 4) is modelled after standardized USDA soil description examples. The first two paragraphs will be completely standardized, while the third and fourth paragraphs will be altered slightly to suit individual reports. Eventually, soil descriptions will be added for all one thousand established Manitoba soil series. The report writer will then be able to selectively copy ("cut and paste") these descriptions into a new soil survey report as required, along with blocks of text from other text-edit files.

The Manitoba Daily File is another local file that has undergone substantial changes since 1982. This file consists of soil site description records which are completed during the course of all inventory projects. Over 33,000 daily records in 63 projects have been completed between 1977 and 1983, with an average of about 5,000 completed in 10 individual projects per year.

The original Manitoba Daily File was derived from the national Detail I File, with its own CanSIS FMS (file management system) programming. This file has been maintained on the Manitoba Data Services mainframe computer system, with support from the Manitoba Department of Agriculture. Several types of summary output programming, mainly summaries of various soil parameters for each soil series in each project, were developed for our unit by provincial programmers. This was done in COBOL which accessed a flatfile version of the Daily FMS data. The need for continuous improvements in field data collection (such as the provision for recording transect data, SWIG data, and lab analysis data) all required alteration of the original FMS file definition. Accommodating these changes, as

W_____ Series (WWW)

The W_____ series consists of 1 _____ drained 2(a) _____ 2(b) _____ soil developed on 3 _____, 4 _____, 5 _____, 6 _____, 7 _____, 8 _____. These soils occur on 9 _____ of 10 _____, 11 _____ deposits and have 12 _____ permeability, 13 _____ surface runoff and a 14 _____ water table during the growing season. W _____ soils are 15 _____ eroded, 16 _____ stony and 17 _____ saline. The native vegetation often comprises 18 _____. The majority of these soils are currently used for 19 _____.

In a representative profile of A(n) W _____ soil, the solum is generally 20 _____ cm thick. The profile is characterized by A(n) 21 _____ horizon overlying A(n) 21* _____ _____ horizon, and a 21* _____ _____ horizon. The parent material is typically 22 _____ _____ _____ _____.

W _____ soils occur in close association with (u) (v) & (x) _____ soils. They are similar to (v and/or x) _____ soils by having 23 _____ _____, but differ from (u)_____ soils because of 23 _____. W _____ soils have 24 _____ available water holding capacity, 25 _____ organic matter levels, and 26 _____ natural fertility. W _____ soils correlate with R and/or S _____ soils previously published in ?? _____ soil report.

In this study W _____ soils vary slightly from the norm by having 23 _____ _____ and have been mapped as a 27 _____ _____ variant. An example profile of this variant is presented in Appendix.

Figure 4. Manitoba Standardized Soil Series Description Format

well as providing an array of profile generator and other output formats, proved too difficult a task from the CanSIS FMS. A new format for the Daily File was needed that could handle not only current, but also future changes to the file definition.

Attempts were also being made concurrently to revise the national CanSIS Detail File, which despite the virtues of the custom FMS system for data entry, was very difficult to subsequently modify definitions and output formats. While maintaining the CanSIS FMS "front end" for data entry, the Detail File is now reformatted to a new relational data base management system called RAPID, a development of Statistics Canada. Amendments to the file definition, such as the addition of monitoring data fields, are made to the RAPID file definition. The RAPID data base also offers a much greater potential for output programming, utilizing the on-line DREAM (Direct Relational Access Method) utility or commercial software packages such as SAS or EASYTRIEVE.

In order to overcome similar problems with the Daily File, as well as to take advantage of CanSIS expertise in RAPID programming, the decision was made in 1983 to convert the Manitoba Daily File to a RAPID format. This decision required an agreement with the University of Manitoba computer system to install and maintain the RAPID DBMS. This ensured that the Daily File could be run locally in a timely and cost efficient manner, and that keypunching and data processing costs would continue to be supported by the Manitoba Department of Agriculture.

The development of a suitable new Daily data base format required a great deal of cooperative effort. The file format was developed in consultation with Bruce MacDonald of the Ottawa CanSIS Group. The decision was made to scrap the old FMS format and replace it with a pure RAPID file definition. The content and organization of the data forms were then established in consultation with the Manitoba Soil Survey staff. The file definition was then prepared by Barb Lacelle of the Ottawa CanSIS group. Keypunch programming, editing, and data transfer procedures were developed in consultation with Rex Tucker of the MDA Computer Services Unit. Data loading procedures on the University of Manitoba system are also being developed by the author in consultation with various people, notably Gary Mills and John Gabel of the Univ. of Man., Chris Aglugub of Manitoba Soil Survey, and the Ottawa CanSIS staff.

The layout of the field data form (2 sides of one page) is shown in Figures 5 and 6, while the accompanying lab data form (one page) is shown in Figure 7. A number of diverse constraints were all carefully evaluated and had an influence on the final form layout. These requirements were as follows:

1. Compatibility with RAPID. This requires fixed format data entry with selection of a set of recognized coded values for many data fields. Data must also be coded on 80 column card types, 10 of which were required for this file. A format similar to that developed for the RAPID defined Wetlands Registry was followed.

2. Compatibility with Detail 2 codes and Detail 2 RAPID file definitions wherever possible. This will eliminate confusion for pedologists and programmers who must extract and manipulate data from both of these RAPID files in the future.

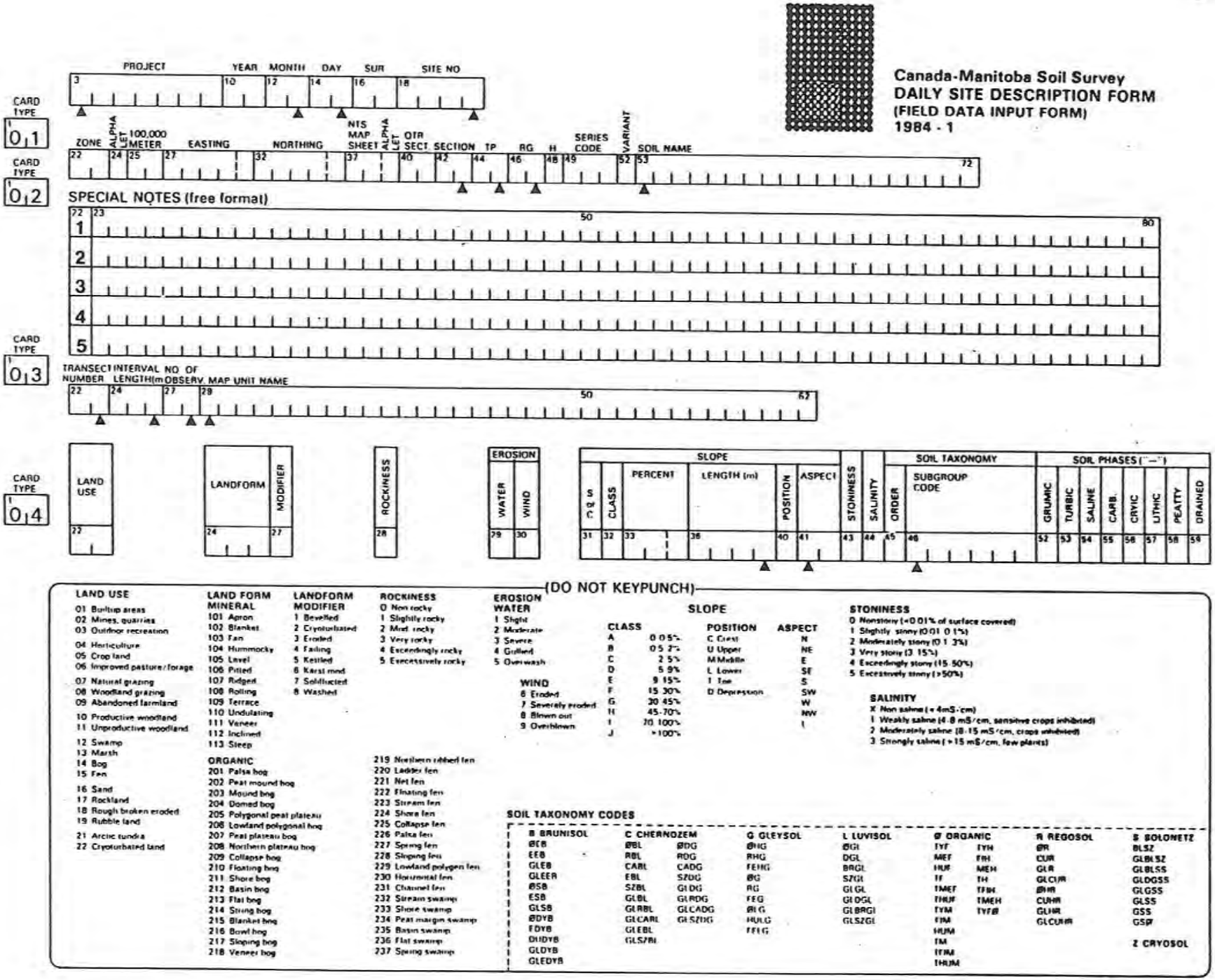

Canada-Manitoba Soil Survey
DAILY SITE DESCRIPTION FORM
(FIELD DATA INPUT FORM)
1984 - 1
CARD TYPE 0,1
PROJECT
YEAR
MONTH
DAY
SUR
SITE NO
CARD TYPE 0,2
ZONE
ALPHA LET
100,000 METER
EASTING
NORTHING
NTS MAP SHEET
ALPHA LET
QTR SECT
SECTION
TP
RG
H
SERIES CODE
VARIANT
SOIL NAME
SPECIAL NOTES (free format)
CARD TYPE 0,3
TRANSECT NUMBER
INTERVAL LENGTH(m
NO OF OBSERV.
MAP UNIT NAME
CARD TYPE 0,4
LAND USE
LANDFORM
MODIFIER
ROCKINESS
EROSION
WATER
WIND
SLOPE
PERCENT
LENGTH (m)
POSITION
ASPECT
STONINESS
SALINITY
SOIL TAXONOMY
ORDER
SUBGROUP CODE
SOIL PHASES
GRUMIC
TURBIC
SALINE
CARB.
CRYIC
LITHIC
PEATTY
DRAINED
(DO NOT KEYPUNCH)
LAND USE
01 Built-up areas
02 Mines, quarries
03 Outdoor recreation
04 Horticulture
05 Crop land
06 Improved pasture/forage
07 Natural grazing
08 Woodland grazing
09 Abandoned farmland
10 Productive woodland
11 Unproductive woodland
12 Swamp
13 Marsh
14 Bog
15 Fen
16 Sand
17 Rockland
18 Rough broken eroded
19 Rubble land
21 Arctic tundra
22 Cryoturbated land
LAND FORM MINERAL
101 Apron
102 Blanket
103 Fan
104 Hummocky
105 Level
106 Pitted
107 Ridged
108 Rolling
109 Terrace
110 Undulating
111 Veneer
112 Inclined
113 Steep
ORGANIC
201 Palsa bog
202 Peat mound bog
203 Mound bog
204 Domed bog
205 Polygonal peat plateau
206 Lowland polygonal bog
207 Peat plateau bog
208 Northern plateau bog
209 Collapse bog
210 Floating bog
211 Shore bog
212 Basin bog
213 Flat bog
214 String bog
215 Blanket bog
216 Bowl bog
217 Sloping bog
218 Veneer bog
LANDFORM MODIFIER
1 Bevelled
2 Cryoturbated
3 Eroded
4 Failing
5 Kettled
6 Karst mod
7 Soliflucted
8 Washed
ROCKINESS
0 Non rocky
1 Slightly rocky
2 Mod. rocky
3 Very rocky
4 Exceedingly rocky
5 Excessively rocky
219 Northern ribbed fen
220 Ladder fen
221 Net fen
222 Floating fen
223 Stream fen
224 Shore fen
225 Collapse fen
226 Palsa fen
227 Spring fen
228 Sloping fen
229 Lowland polygon fen
230 Horizontal fen
231 Channel fen
232 Stream swamp
233 Shore swamp
234 Peat margin swamp
235 Basin swamp
236 Flat swamp
237 Spring swamp
EROSION
WATER
1 Slight
2 Moderate
3 Severe
4 Gullied
5 Overwash
WIND
6 Eroded
7 Severely eroded
8 Blown out
9 Overblown
SLOPE
CLASS
A 0-0.5%
B 0.5-2%
C 2-5%
D 5-9%
E 9-15%
F 15-30%
G 30-45%
H 45-70%
I 70-100%
J >100%
POSITION
C Crest
U Upper
M Middle
L Lower
T Toe
D Depression
ASPECT
N
NE
E
SE
S
SW
W
NW
I
STONINESS
0 Nonstony (<0.01% of surface covered)
1 Slightly stony (0.01-0.1%)
2 Moderately stony (0.1-3%)
3 Very stony (3-15%)
4 Exceedingly stony (15-50%)
5 Excessively stony (>50%)
SALINITY
X Non saline (<4mS/cm)
1 Weakly saline (4-8 mS/cm, sensitive crops inhibited)
2 Moderately saline (8-15 mS/cm, crops inhibited)
3 Strongly saline (>15 mS/cm, few plants)
SOIL TAXONOMY CODES
B BRUNISOL
ØEB
EEB
GLEB
GLEER
ØSB
ESB
GLSB
ØDYB
FDYB
DUDYB
GLDYB
GLEDYB
C CHERNOZEM
ØBL
RBL
CARL
EBL
SZBL
GLBL
GLRBL
GLCARL
GLEBL
GLS/BL
ØDG
RDG
CADG
SZDG
GLDG
GLRDG
GLCADG
GLSZDG
G GLEYSOL
ØHG
RHG
FEHG
ØG
RG
FEG
ØLG
HULG
FFLG
L LUVISOL
ØGL
DGL
BRGL
SZGL
GLGL
GLDGL
GLBRGL
GLSZGL
Ø ORGANIC
TYF
MEF
HUF
TF
TMEF
THUF
TYM
FIM
HUM
TM
TFM
THUM
TYH
FIH
MEH
TH
TFH
TMEH
TYFØ
R REGOSOL
ØR
CUR
GLR
GLCUR
ØHR
CUHR
GLHR
GLCUHR
S SOLONETZ
BLSZ
GLBLSZ
GLBLSS
GLDGSS
GLGSS
GLSS
GSS
GSP
Z CRYOSOL

Figure 5

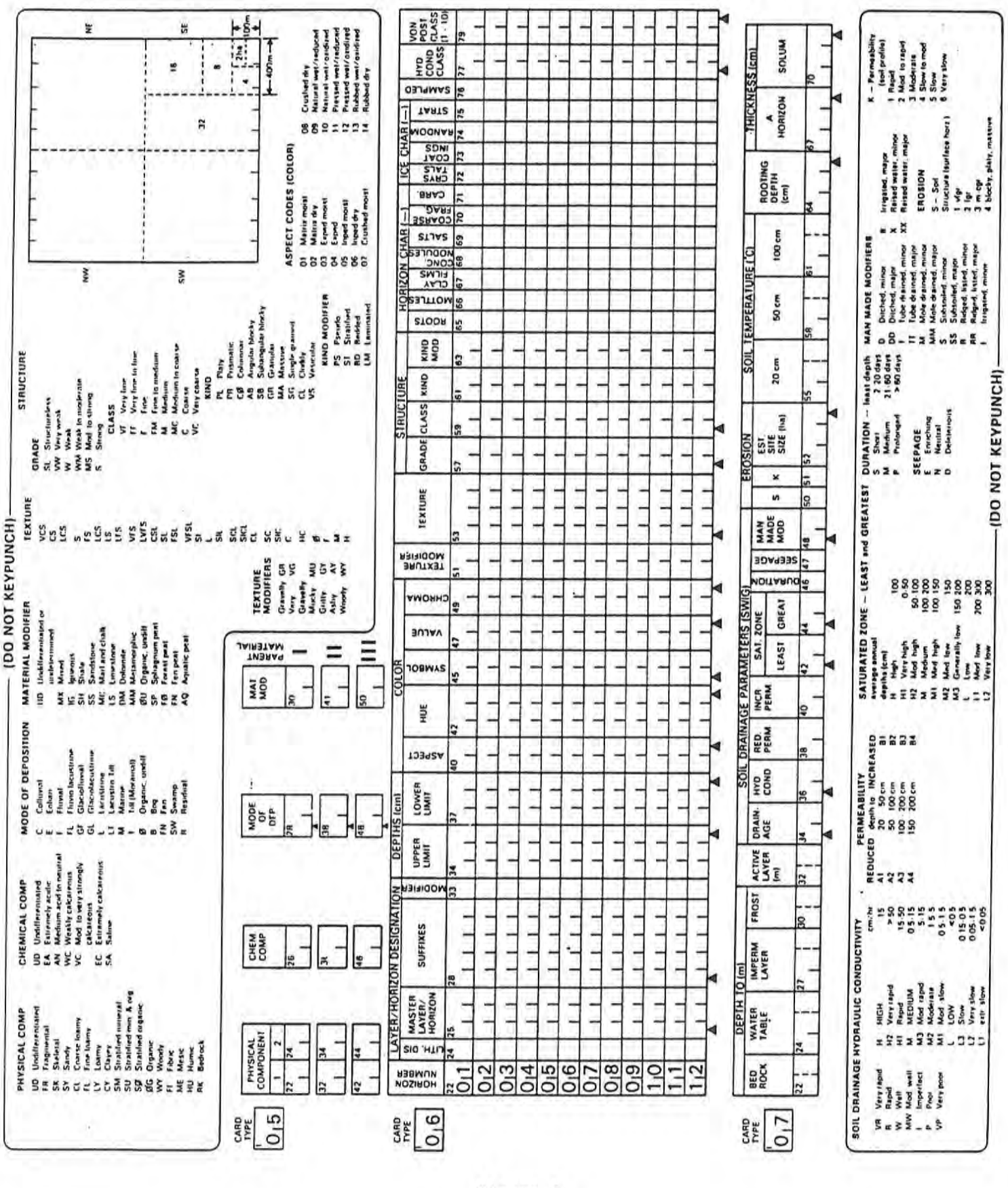

(DO NOT KEYPUNCH)
PHYSICAL COMP
CHEMICAL COMP
MODE OF DEPOSITION
MATERIAL MODIFIER
TEXTURE
STRUCTURE
GRADE
TEXTURE MODIFIERS
ASPECT CODES (COLOR)
CARD TYPE 0,5
PHYSICAL COMPONENT
CHEM COMP
MODE OF DEP
MAT MOD
PARENT MATERIAL
CARD TYPE 0,6
HORIZON NUMBER
LITH. DIS
LAYER/HORIZON DESIGNATION
MASTER LAYER/ HORIZON
SUFFIXES
MODIFIER
DEPTHS (cm)
UPPER LIMIT
LOWER LIMIT
COLOR
ASPECT
HUE
SYMBOL
VALUE
CHROMA
TEXTURE MODIFIER
TEXTURE
STRUCTURE
GRADE
CLASS
KIND
KIND MOD
HORIZON CHAR (—)
ROOTS
MOTTLES
CLAY FILMS
CONC
MODULES
SALTS
COARSE FRAG
CARB
ICE CHAR (—)
CRYSTALS
COATINGS
RANDOM
STRAT
SAMPLED
HYD COND CLASS
VON POST CLASS (1 - 10)
CARD TYPE 0,7
BED ROCK
DEPTH TO (m)
WATER TABLE
IMPERM LAYER
FROST
ACTIVE LAYER (m)
SOIL DRAINAGE PARAMETERS (SWIG)
DRAIN. AGE
HYD COND
RED. PERM
INCR PERM
SAT. ZONE
LEAST
GREAT
DURATION
SEEPAGE
MAN MADE MOD
EROSION
S
X
EST. SITE SIZE (ha)
SOIL TEMPERATURE (°C)
20 cm
50 cm
100 cm
ROOTING DEPTH (cm)
THICKNESS (cm)
A HORIZON
SOLUM
(DO NOT KEYPUNCH)
SOIL DRAINAGE HYDRAULIC CONDUCTIVITY
PERMEABILITY
SATURATED ZONE — LEAST and GREATEST
DURATION — least depth
MAN MADE MODIFIERS
K — Permeability (soil profile)

Figure 6

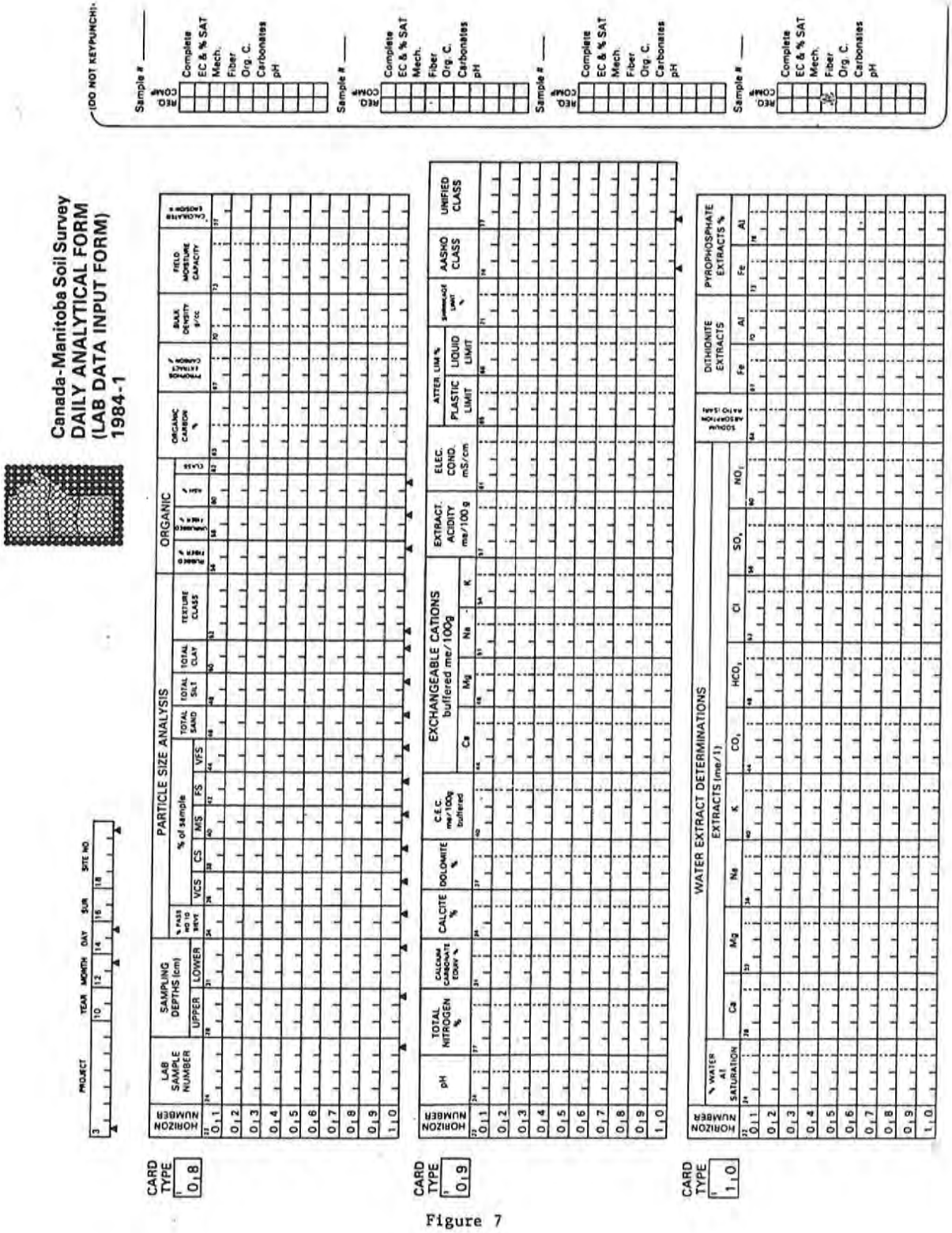

Canada-Manitoba Soil Survey
DAILY ANALYTICAL FORM
(LAB DATA INPUT FORM)
1984-1
PROJECT
YEAR
MONTH
DAY
SUB
SITE NO
CARD TYPE
0 8
0 9
1 0
HORIZON NUMBER
LAB SAMPLE NUMBER
SAMPLING DEPTHS (cm)
UPPER
LOWER
PARTICLE SIZE ANALYSIS
% of sample
VCS
CS
MS
FS
VFS
TOTAL SAND
TOTAL SILT
TOTAL CLAY
TEXTURE CLASS
ORGANIC
ORGANIC CARBON %
BULK DENSITY g/cc
FIELD MOISTURE CAPACITY
AASHO CLASS
UNIFIED CLASS
TOTAL NITROGEN %
CALCIUM CARBONATE EQUIV %
CALCITE %
DOLOMITE %
C.E.C. me/100g buffered
EXCHANGEABLE CATIONS buffered me/100g
Ca
Mg
Na
K
EXTRACT. ACIDITY me/100 g
ELEC. COND. mS/cm
ATTER LIM %
PLASTIC LIMIT
LIQUID LIMIT
pH
% WATER AT SATURATION
WATER EXTRACT DETERMINATIONS
EXTRACTS (me/l)
Ca
Mg
Na
K
CO3
HCO3
Cl
SO4
NO3
DITHIONITE EXTRACTS
PYROPHOSPHATE EXTRACTS %
Fe
Al
(DO NOT KEYPUNCH)
Sample # ____
REC. COMP
Complete
EC & % SAT
Mech.
Fiber
Org. C.
Carbonates
pH

Figure 7

3. Compatibility with earlier Manitoba Daily forms. This will facilitate conversion of pre-1984 data to the new format and ensure continuity of the data base definitions.

4. The form must be easy to use for surveyors in the field. This proved to be the most challenging aspect to the entire project and is the area which has most often been neglected when completed by programmers with inadequate user input. A well designed form encourages more complete and efficient data entry, with fewer errors. Among the specific attributes of this form are:

   a) The field data form is limited to one double-sided sheet of 8½" x 11" paper so that it can be completed and stored in ring binders.

   b) The form is universal for all inventory projects in Manitoba, from agricultural to organic and northern surveys. A large number of optional data fields had to be accommodated.

   c) Data entry areas are highlighted in white, while all other areas are in a low contrast light yellow. The new CanSIS Wetlands Registry input document has a similar colour scheme.

   d) Where data fields are of variable length, small triangles located below them indicate whether they are left or right justified.

   e) Connotative symbols, many already familiar to soil surveyors, are used as codes wherever feasible. These include texture, structure, parent material, and soil taxonomic codes. For example, texture classes are common USDA abbreviations (FSL, CL, etc.) and soil taxonomic classes are standard subgroup codes with the period omitted (i.e. OGL for Orthic Gray Luvisol).

   f) Code lists are all provided on the form in "do not keypunch" areas, located as close to the appropriate data entry fields as is practical (either directly above or below is preferred).

   g) Other ergonomic considerations have also been made. For example, the layout of phase information (erosion, slope, stoniness, and salinity) follow the same order and coding as they appear in the denominator of the map symbol. Coding areas don't extend to the bottom of the form as it is difficult to write in these areas under field conditions, particularly on the first page. Stacking up parent material codes vertically and providing all horizon coding on the same line also aids in coding and reading the data forms.

5. The forms must be easy and relatively inexpensive to keypunch. Many of the same factors which make the form easy to use by surveyors also permit faster keypunching with fewer errors. A keypunching program is used which provides automatic tabs for the data fields and also accepts only the RAPID defined codes for each. If an incorrect symbol is coded the keypuncher is informed, and either the correct code can be determined or a blank code will be substituted.

A flowchart illustrating the Manitoba Daily data management system is shown in Figure 8. With the exception of the data transfer step from the MDS system (where keypunching facilities are located) to the University

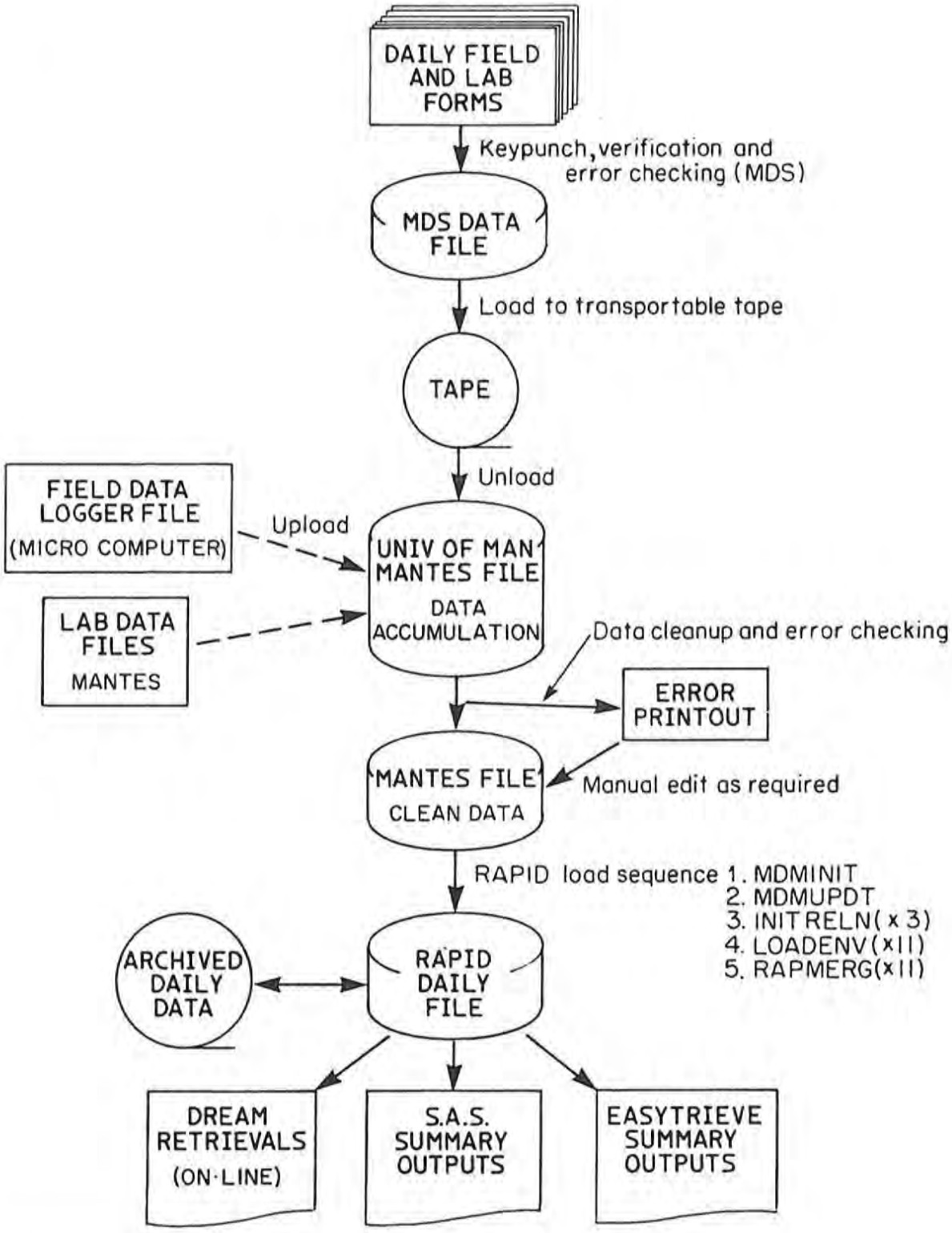


Figure 8. Manitoba Daily File Data Flow Chart.

of Manitoba system, the data handling procedures are essentially similar to those used for national RAPID defined CanSIS files. Currently the tasks of preparing the RAPID loading sequence jobs for the Daily file, and adapting and testing the necessary JCL, error checking and sort programs are being conducted. This is expected to be completed by Spring, 1985, and loading of all 1984 Daily data and work on suitable archiving and operational procedures, summary programming, and proper documentation of these procedures will follow.

Two other alternate means of inputting Daily record data are proposed as indicated by dashed lines in Figure 8. The first of these involves use of a field data recorder (Micro-computer) to capture daily site data and later upload it to the mainframe. The second involves transferring lab data from other mainframe files, currently under development, directly to the Daily file. Both of these procedures will eliminate the manual encoding and keypunching of data forms by transferring data directly to a mainframe data accumulation file for later loading to RAPID. This will eliminate keypunching costs (currently about $5,000 per year) as well as reducing errors and speeding up turn around time for obtaining data summaries.

Progress on these two proposed methods of processing daily field and lab data will be considered separately.

Lab Data Management System

Concurrent with development of the Daily file has been the development of a set of mainframe computer files designed to streamline and centralize the recording, calculating, sorting, and data output procedures for the Manitoba Soil Survey Lab. This lab data management system has been devised by Chris Aglugub of the Manitoba Soil Survey in consultation with Peter Haluschak, the survey lab supervisor. A flowchart illustrating the components of this network is shown in Figure 9. After samples are initially received, the assigned lab number, sample location and analytical requests are all keyed into a file. This is updated, checked, and used to generate worksheets for each type of lab analysis required. These worksheets are given to lab technicians who obtain the samples requested, conduct the lab analysis, and key in the raw data. After checking this input, the lab calculations are made, an error report generated, and the calculated values are all accumulated in an on-line disk file. Various lab reports can be generated from this file illustrating work completed or remaining to be done. When all analysis from a batch of samples is completed, the results can be printed in tabular format for the lab supervisor and pedologist, and the data may be transferred to the Daily Data Accumulation File for loading to RAPID.

Many of the steps of this lab data management system are either operational or under active development, and the major links in the network are expected to be in place by the summer of 1985.

Field Data Logger Developments

The recent advent of reasonably priced office and field portable micro-computers has resulted in a major advance in data processing

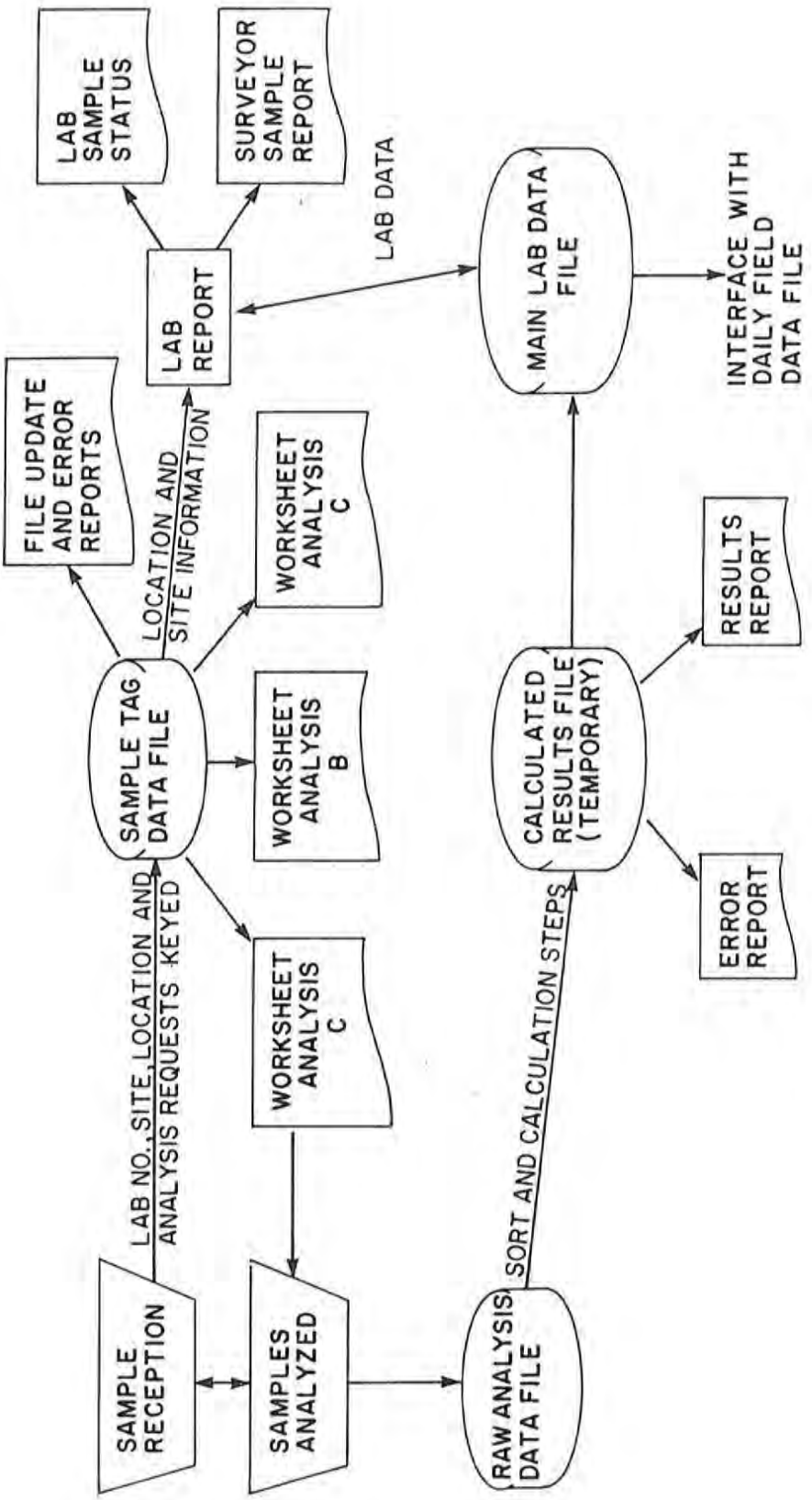


Figure 9. Manitoba Lab Data File Flow Chart.

capabilities for many business and professional occupations. Dave Moon of LRRI has been conducting an extended evaluation of field and office micro-computer applications for soil survey operations. As part of this study, two Radio Shack Model 100 micro-computers were acquired by LRRI for evaluation as field data recorders. One was provided to Dave Moon to prepare, document, and evaluate field data entry programming, and the other was provided to the Manitoba Soil Survey Unit for testing this field data entry programming in our Manitoba environment. Specifically, we wanted to explore the feasibility of its use for inputting Manitoba Daily Field Records. The Manitoba Unit currently spends about $5,000 a year for keypunching this data; use of suitable dataloggers would eliminate this cost and enforce cleaner data recording. These fixed format data records are quite large (up to 1 K, with several hundred data fields) compared with some other daily field forms and therefore, present a greater programming challenge. Due to other inventory and CanSIS work commitments in the 1984 field season, programming for Manitoba Daily Record inputting was not completed to the field testing stage. Nonetheless, the experience gained to date has proven invaluable, to the extent that a preliminary assessment of the current hardware and software limitations can be made.

Hardware Limitations

The Radio Shack Model 100 is a very light weight, small sized micro-computer, and is already designed for portable use in an indoor environment; for field use a membrane keyboard and a moisture and dust resistant body would be required. The Model 100 also has provision for an optional bar code recorder, and as originally suggested by Bruce MacDonald, this method of quickly inputting field data from a menu should also be investigated.

The Model 100 was equipped with the optional maximum 32 K RAM, yet this memory capacity is inadequate for Manitoba Daily Records. Data input programming will require approximately half of this memory, leaving only enough space for 15 to 20 records. This is commonly less than one day's work. An adequate datalogger for our purposes will need at least 64 K RAM, with even larger memory capacity a very desirable option.

The screen size of 8 lines x 40 characters is also a limitation. By reducing the character and/or pixel element dimensions, a screen of comparable physical size could contain a larger set of characters. A 16 line x 80 character screen would be desirable. As it stands, an optional printer is just about essential for program development or editing of large data files.

Software Limitations

Dave Moon of LRRI has produced a document entitled A Guide to Preparing a Data Entry Program on the Radio Shack TRS-80 Model 100. This document describes the generalized BASIC program modules he has created, and how to use them as templates to construct custom data entry programs for this micro-computer. This programming and documentation

are very well done and should work well for simple field form applications.

Problems arise from using this programming approach for very large data forms such as the Manitoba Daily.

The programming follows a linear sequence for inputting data fields; the order in which they are to be done is critical and may differ radically from the standard field form. For example, soil classification and series codes should be input only after horizon and parent materials are recorded.

Three or more screen displays are needed to show all the data for editing purposes (only one required for the B.C. Gulf Islands Form). There must be a provision for going back to previous screens for additional editing if required. A larger screen size, or at least the ability to "scroll" the display (as is possible with the "PREV" function key in TELECOM mode) is a better solution.

The main problem in the use of this field-by-field prompted input programming is that is is very awkward to use for recording soil horizon nomenclature and other horizon features, particularly in following a CanSIS type fixed format which requires separate fields for (i) lithologic discontinuity, (ii) master horizon, (iii) horizon suffixes, and (iv) modifier. When inputting horizon data, it is important that all other horizon information be displayed at the same time, as on a manual form. This greatly aids the pedologist, as soil horizon nomenclature, depths, texture, color criteria and also adjacent horizons are all interdependent criteria. A column by column approach to horizon data entry has been devised for the Manitoba Daily program, but this is strictly an interim measure. I believe an adequate software solution will require the use of a spreadsheet program or full screen edit capability. This will mimic the data entry process on manual forms in that it will allow the pedologist to move the cursor to edit and input data in any sequence on a standard screen display.

Besides the actual data entry process, the overall operation of a field data recorder versus traditional methodology should be considered. In current Manitoba operations, a stack of field forms (one per site) are filled out and stored in a ring binder. These are frequently consulted during map editing in the airphoto interpretation stage, either in the field, motel, or survey office. Exact UTM site coordinates are often calculated and input on these forms at a later date. Some soil series concepts change during the course of the project and also require manual edits of some data forms. Once the soil map is ready for transfer to the base, the forms are sent for keypunching so that data summaries will be available for correlation and report descriptions. The utility of a datalogger vis a vis these current procedures must be further evaluated. Does the limited micro-computer memory capacity require many inconvenient cassette uploading and downloading data transfers to accomplish the required data displays and edits, or will all the data first be uploaded to a mainframe file for these purposes? Are there constant insecurities (justified or unjustified) about data integrity? Do the extra data transfer

and backup procedures, field durability and battery considerations, as well as the major computer hardware investments, really justify the cleaner and cheaper data input benefits?

The answer to these questions at the present time is debatable, although many of the problems arise from the limitations of the Model 100 micro itself. Current progress in micro-computer hardware and software technology is phenomenol, with the trends clearly towards less expensive micros with larger memory capacity and well integrated software packages. Certainly in the near future, a suitable datalogger will be available in the market, and the experience now being gained will be put to good use in significantly reducing data entry time and costs and providing better data for many soil survey applications.

CURRENT STATUS (JANUARY, 1985) OF THE ONTARIO INSTITUTE OF PEDOLOGY STAND ALONE DIGITIZING SYSTEM

The following information describes the current capabilities of the Ontario Institute of Pedology's Collins & Moon stand alone digitizing system. It must be stressed that this information relates only to the current OIP system and does not describe, necessarily, the nature of installations planned for other provincial soil survey units. The terms "polygon" and "map unit" have been used interchangeably.

A. CURRENT HARDWARE CONFIGURATION:
- 1 IBM PC WITH BLACK & WHITE MONITOR
- 20 mB HARDDISK
- CALCOMP DIGITIZING TABLE
- TEKTRONICS GRAPHICS DISPLAY TERMINAL
- CALCOMP PLOTTER

B. CURRENT SOFTWARE:
1. ENTERING OF POLYGON DATA (LINES AND NODES)
2. EDITING AND PROCESSING OF MAP DATA
3. INFORMATION RETRIEVAL

1. ENTERING OF POLYGON DATA

The input of map unit boundaries (polygons) in a digital format using the IBM-PC, Calcomp Digitizing Table and Graphics Display Terminal.

SADINIT: Initializes the map by opening all necessary files, establishing the corner points, setting map scale, accepting map title and other necessary "header" information.

LINCAPT: Enters map unit boundaries (lines) by "drawing" them with the cursor and marks line end points (nodes) on the digitizing table. Digital coordinates are picked up by the magnetic grid beneath the table surface. Lines are displayed on the Graphics Display Terminal as they are "drawn". The digital files produced at this stage represent the beginning point of all digitizing and are necessary for all further processing. The number of polygons is only limited by the space available on the hard disk (20 mB Tallgrass).

SYMCAPT: Enters map unit symbols ("edits"), if so desired. This symbol entry is not essential for the digitizing system, however it does provide the opportunity to have map unit labels plotted onto the polygons. Symbol entry format is quite flexible and does permit the use of "leaders" for very small units.

PROBLEMS

SADINIT: Occasionally will lock-up and hardware must be re-booted from a "cold start" in order to resume processing.

LINCAPT: Frequently will "corrupt" a map by placing garbage information into the coordinate file, particularily if line deletion is used frequently during input.

SYMCAPT: Has not been thoroughly tested as yet.

Generally speaking, the OIP has found these programs to be functional, but they will require further testing to be sure of their reliability.

2. EDITING AND PROCESSING OF MAP DATA

TRANSFORM: Following the entry of several control points, this program will tranform digital coordinates read from the table into whatever coordinates you desire (e.g. U.T.M.). This standardizes coordinate data to a common base thus facilitating the joining or overlaying of map sheets. It is not an interactive program.

POLYFORM: Using the coordinate files, it calculates and forms map units or polygons and places these data in a map unit file suitable for subsequent map unit retrieval. This is not an interactive program.

ENTCODE: This program graphically displays each map unit on the Graphics Display Terminal and then allows the user to assign a numerical code to it for the purpose of subsequent map interrogation. This procedure only allows for the coding of a single attribute for each map unit for each "pass" of the entire map. The attribute that is coded however could be a simple code for soil drainage, a code representing the dominant soil (series) component of the map unit or simply a code for each map unit (i.e. map unit number).

PROBLEMS

Any changes to boundaries at this point cannot be corrected unless you go through all of the processing again starting at TRANSFORM. There has been some discussion about this with Collins and Moon and it may be improved in the future.

TRANSFORM: At the moment this performs a mechanical function to update the file formation. This function should be a part of the map initialization process -- SADINIT.

POLYFORM: A very complex program which still requires futher operational testing. Several data edit checks still require improvement (e.g. better diagnostics).

ENTCODE: There are no problems with this program but there are several major adjustments that could be made to improve the processing. Ideally, the entcode processing of the cartographic polygon files should be linked with some form of soil data base files whereby various fields within the data base can be called-up, linked to the cartographic data base and then be plotted out.

3. INFORMATION RETRIEVAL

ARCPLOT: A "dump plot" of the map boundaries (i.e. a coordinate data dump, not polygon dump) to the Calcomp plotter.

FILLPLOT: Assesses information about the map units according to the encoding and allows the assignment of colour or black and white "fill patterns" for the various codes. It then plots this information on the Calcomp plotter.

GFILL: Allows the assignment of fill patterns to map units and stores this information in a file so that it can be dumped to the plotter later using GLOAD.

PROBLEMS

SADPLOT: Has not been thoroughly tested but seems to be functioning as intended.

FILLPLOT & GFILL: Essentially perform the same function. Both use the IBM's random access memory (RAM) for calculations and do not clear the memory properly. The programs can run out of RAM, lock-up the system and require a cold start re-boot to resume processing. This software still requires that "island" map units have a rather displeasing "connecting line" to a neighbouring map unit in order to function properly.

C. EXAMPLE TIMES FOR DATA PROCESSING

Example: a map of approximately 900 arcs - 300 polygons.

Task: to digitize the map and to produce one plot of the map units with no symbols (see E6 below) and one interpretive map plot.

SADINIT: 5 min.
LINCAPT: 8 - 16 hrs. depending on map complexity.
SYMCAPT: 8 - 12 hrs. depending on map and symbol complexity.
Plotting: 20 min. initial plot of map unit boundaries for error checking.
TRANSFORM: 30 min.
POLYFORM: 45 min.
ENTCODE: 3 - 4 hrs. if surveyor provides well prepared information.
ARCPLOT: 20 min.

FILLPLOT &
GFILL: 2 - 8 hrs. depending on complexity of map and fill patterns chosen.
GLOAD: if used, 45 min to dump the interpretive cartographic data file to plotter.

TOTAL MINIMUM TIME*: 23 hrs. 45 min. with symbols, 15 hrs. 45 min. with no symbols.

* Assumptions: 1) maps are well prepared by surveyor.
2) error-free data entry.
3) problem-free hardware and software operations.

D. GENERAL COMMENTS ON SOFTWARE

There are many "little" problems with the digitizing system as it is operating currently at the OIP. While these problems do not interupt processing they do cause concern and confusion. The hardware and software described above can produce but their overall efficency and reliability needs substantial improvement. For example the encoding procedure could be greatly simplified with an appropriate interface between the cartographic polygon files and the soil survey (interpretive) data base. Most of the software needs improvement and some software needs to be developed, implemented and tested.

With respect to software documentation, three programs have documentation dating June, 1984. All other documentation dates to 1982 and 1983. Only a small part of the system is adequately documented. Due to the frequent software changes implemented by Collins and Moon, the existing documentation is out-dated.

E. NECESSARY SOFTWARE IMPROVEMENTS

1. The calculation of areas for map units.

2. The capability to link the soil survey (interpretive) data base with the cartographic files.

3. The need to address the plotting of hydrological features (e.g. rivers, lakes, streams, etc.) and various planimetric information (e.g. roads, townships, latitude and longitude, etc.). Current capability is via a mechanical, on-the-plotter overlay of separate coordinate files.

4. The capability to overlay various resource maps and plot "integrated" interpretations (e.g. soils and land use).

5. The capability to join adjacent map sheets.

6. The capability to print symbols from SYMCAPT using the Calcomp plotter.

7. The capability to print legends on the Calcomp plotter.

8. The streamlining of programs that form and label polygons.

9. Minor revisions to the whole system in terms of screen displays, menus and other operator aids.

10. The capability to change scale simply and consistently.

11. The capability to dissolve lines and print interpretive symbols (i.e. similar to current CanSIS derivative plots).

Recent discussions with Collins and Moon suggest that some of the major revisions will be completed by March, 1985. As for the completion of the "total package", no estimate was given. As with the development of any system of this magnitude, adequate testing requires a considerable amount of operational application time. Minor updates and revisions can be expected for some time.

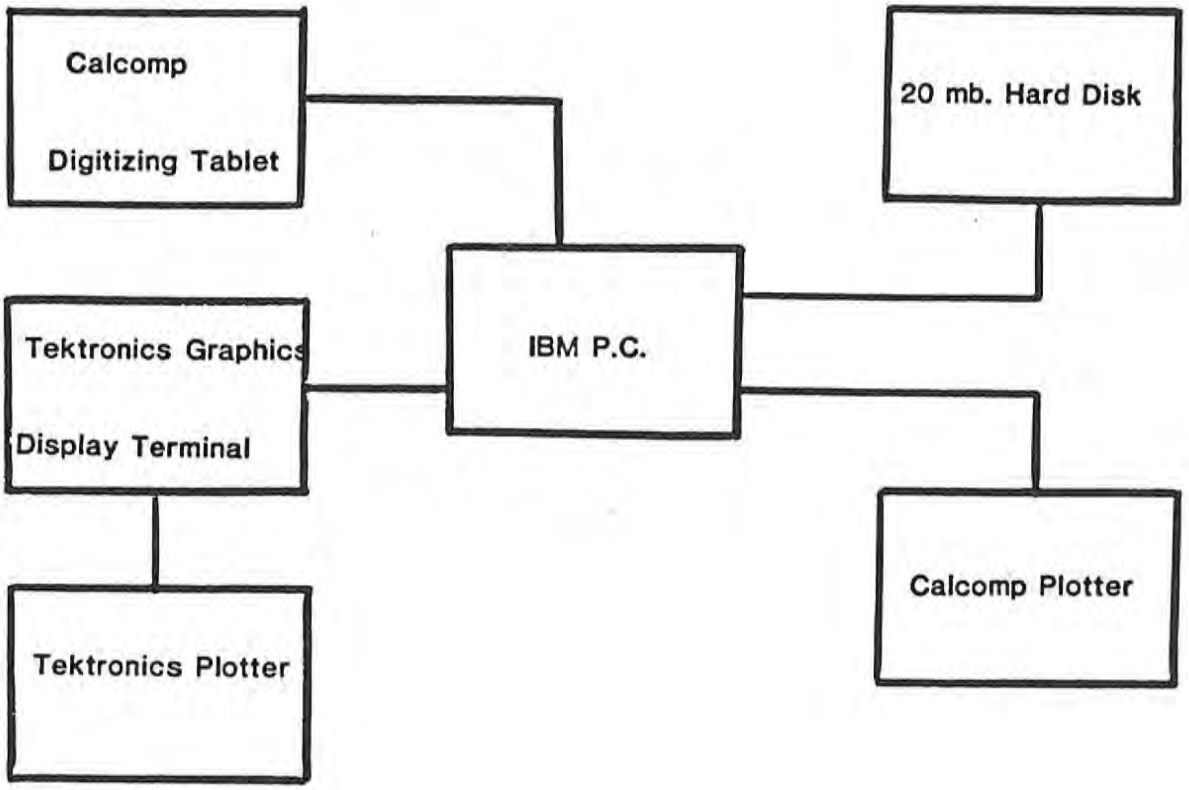
F. CanSIS -- CML (Stand Alone Digitizing System) UPLOADING/DOWNLOADING

CML to CanSIS file interchange: Apparently this has been handled in part by CML and in part by LRRI staff. LRRI staff has indicated that the file exchange software is now functioning. The OIP has not submitted any maps to CanSIS for interchange to date.

CanSIS to CML file interchange: This need has certainly been considered but no action has been taken so far.

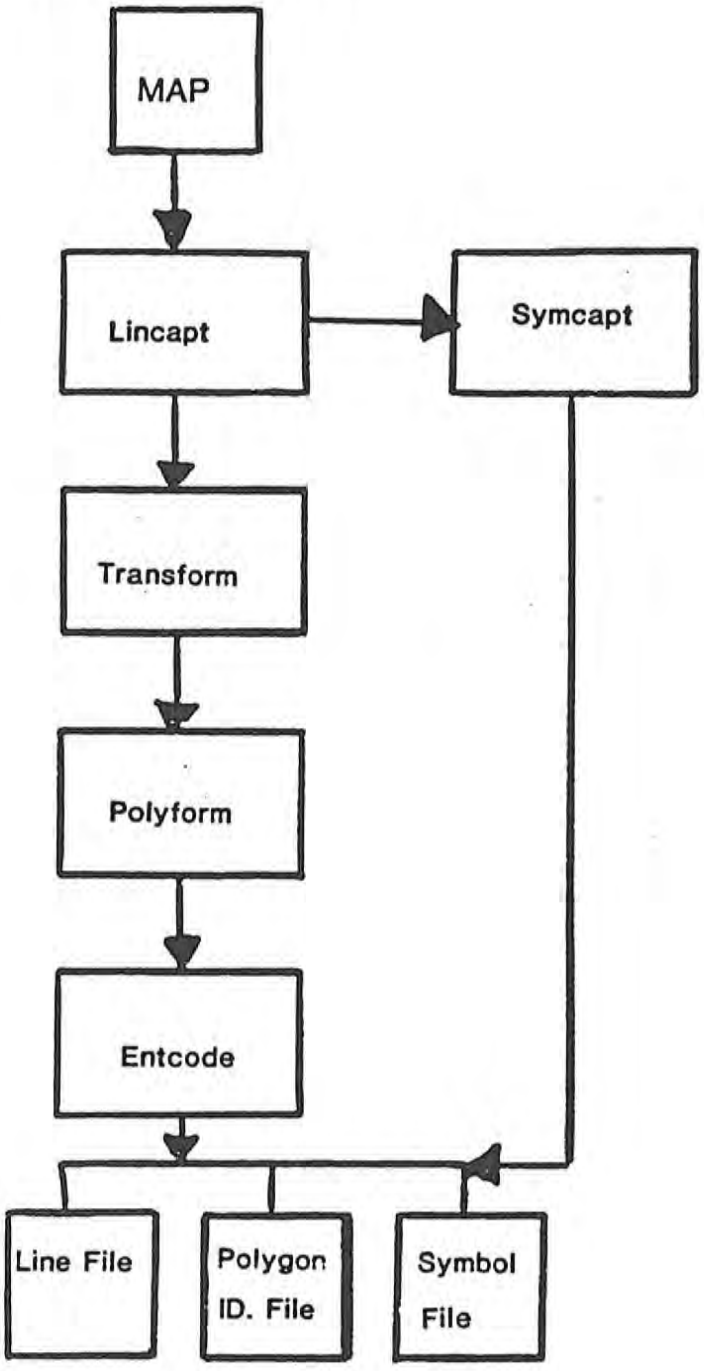
HARDWARE USED FOR THE STAND-ALONE

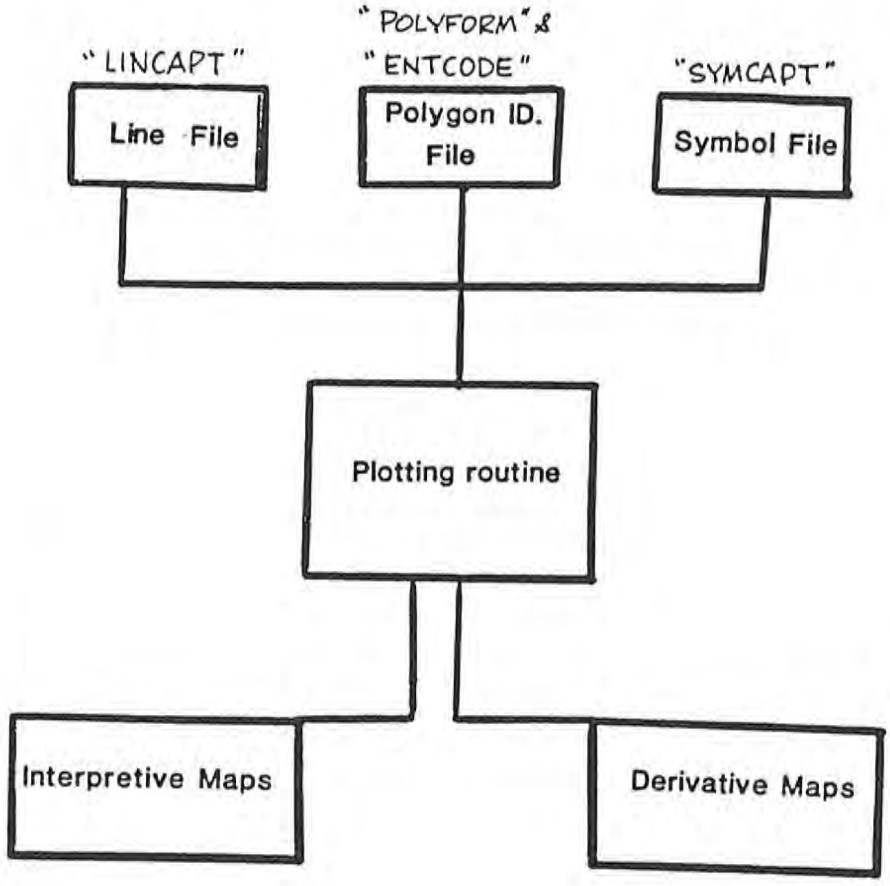
DIGITIZING SYSTEM



SOFTWARE USED FOR THE STAND-ALONE

DIGITIZING SYSTEM




"LINCAPT"
Line File
"POLYFORM" &
"ENTCODE"
Polygon ID. File
"SYMCAPT"
Symbol File
Plotting routine
Interpretive Maps
Derivative Maps

CASPIR - A program to calculate family particle size class from horizon data
by M. Schweiger

Summary prepared by B. MacDonald

The Canadian System of Soil Classification (1978) provides a family category in the taxonomic system between the more general subgroup and the more specific soil series. Despite the constrictions that standardized classifications can impose on use interpretations, the criteria for soil family classes attempt to emphasize the more important physi al and chemical soil properties rather than soil horizonation and genesis. The criteria and guidelines for family classes are provided in chapter 13 (CSSS, 1978).

Due to the complexity of soil family guidelines and criteria, soil surveyors are either inconsistent with the application of soil family classification criteria or do not attempt it. The Ontario Institute of Pedology (OIP) has developed a software package called (CASPIR) (Computer Assisted Soil Pedon Information Reported). This package consists of three programs all controlled by one main menu.

The first option allows the interactive entry of data with limited editing facilities.

The second choice is the family option which calculates the correct assignment of Family Particle Size Class, reaction class and calcareous class. At the request of OIP surveyors, surface (0-40 cm) soil particle size class and reaction class are also reported using similar weighted averaging procedures.

The third option is the zone option whereby the surveyor can define the top and bottom boundaries of a zone and the program will take a depth weighted average and asign a zone texture. This last option allows the surveyor to specify contrasting and transitional horizon thicknesses.

The program is written in Microsoft basic and is designed to run on an IBM personal computer.

Documentation Organization

The package is available on request from the OIP and the associated documentation has the following elements

Introduction
Overview
  Operating environment
  General assumptions
  File specification
  Error recovery

Input option
  Field description
  Variable assumptions
  Editing

Family Option
  Surface property assumptions
  Family input specifications
  Output
        Screen
        Printer
        Disk

Zone Option
  Assumptions
  Input Specifications
  Output

Tutorial
  Input option
  Family option
  Zone option

ORGANIZING, MANAGING AND STORING DATA FROM CONTRACT SOIL SURVEYS - THE NOVA SCOTIA EXAMPLE

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prepared for the CanSIS-Computer working group workshop Guelph, Nov. 25-27, 1984

Over the past few years all soil survey units across Canada have used edp facilities both local and in Ottawa to store and manipulate soil survey data. Their general experience has been that
(i) at least some of the computer resources must be local;
(ii) as some computer applications are implemented others become apparent; and
(iii) the data from soil surveys are required for analyses over longer periods of time and for types of analyses other than the objectives of the original survey.

With these sorts of considerations in mind, the LRRI edp committee, the CanSIS group and the surveyors and correlators have been working to establish some minimal standards for edp applications and for appropriate hardware and software installations regionally and nationally.

Briefly, these include the need in each unit for general purpose edp equipment to manage site observations, handle some word processing and office management functions, and to communicate through the agrinet system to LRRI, Ottawa.

The hardware and software configuration which has been assessed as appropriate for these tasks is summarized in Table 1. This configuration has been established after consideration of regional and national requirements, availability of support and experience within Systems and Consulting Directorate (SCD).

Contract soil surveys as a means of collecting data for our federal inventory program are a relatively new development. They represent the first time that the data will be collected compiled and presented by a group outside of the federal and provincial survey units, and a group which has no commitment to the project after its completion. For this reason the Nova Scotia contract has led to the consideration of such aspects as precise specification of exactly what data are to be collected, the type and frequency of sampling and analysis, and the ways in which the data are to be delivered and summarized.

Table 1: - Approximate General Purpose Microcomputer Configuration for Regional Implementation

IBM PC 384 to 512 K RAM

Single disk drive and preferable dual drives

Monitor adaptor/printer interface

Amdek 310A 12 inch monitor

Epson FX-100 parallel printer

Printer cable

Intel 8087 co-processor

Tallgrass hard disk (replaced by Santa Clara on newer installations)

Hayes Smart Modem - external

IBM PC DOS Version 2.00 or current

dBASE III/BASIC

Wordstar or current recommended word processing package

Statpak

It is within this background that the current project was initiated:
- to test the suitability of the general purpose microcomputer to organize, store and manipulate the data collected in the course of a contract soil survey. (With particular reference to the site data)
- to develop the capabilities specified by the scientific authorities on the contracts to manage and retrieve the data using commercially available software.

Nature of the problem

Three contracts have been established with two contractors in Nova Scotia to carry out Soil Evaluation and Mapping for Agricultural Production at a scale of 1:20000 for 75 map sheets as defined within the LRIS framework. The data collected consists of both tabular data from site inspections and cartographic data from air photo interpretation and field confirmation.

The sampling data for each map sheet is specified in the contracts to consist of:
- transect data, a total of 250 sites per full map sheet
- a minimum of 1 site will be sampled for every 20 observed, major horizons will be sampled (minimum of 3 per site).
- an additional minimum of 100 sites (bench mark) will be sampled by major horizon.
- analyses on the transect data will consist of particle size (hydrometer method) and pH (CaCl2 method).
- analyses for the bench mark samples (100 sites minimum of 300 samples) will consist of pH in CaCl2 and water, organic content of A and B horizons, CEC; Ca, Mg, K, Al, particle size, bulk density, hydraulic conductivity, and water retention at 4 tension levels.

The requirements for data management include the initial storing, editing and manipulation for the purposes of the soil evaluation and mapping (i.e. inventory and correlation) and in a longer time frame they must be available to provincial crops and soils specialists for access on demand for projects dealing with planning and development in specific areas.

Development of the Problem Definition and Specification

On June 4, 1984 a meeting was held in Truro between the contractors, the scientific authorities and Bruce MacDonald and Brian Edwards representing CanSIS. At this meeting the nature of the map symbol was resolved and also the formats of the site data and the types of analyses required from the contractors.

The maps are to be digitized by one of the contractor using the Collins and Moon software on an IBM PC based stand-alone digitizing work station. The polygons will be assigned a number. Once the data are apparently clean in the micro system they will be transferred to Ottawa for input to the National Cartographic File of CanSIS. Appropriate procedures have been worked out for the error correction cycle. In addition a correspondence file will be prepared which contains the polygon number and the map symbol (delineation definition) in a fixed format form. In other words this correspondence file constitute a basic computer legend for the maps.

For the site inspections and transect data each contractor has developed a data collection form which makes provision for collection of basic information on the site, on the horizon and special notes. It also contains a designation of the map unit being sampled as well as the delineation definition. In this way there is a direct link between the site data and the map symbols.

The contractor is required to deliver to the scientific authority all the field transect data in machine readable form as well as analyses by map sheet and by contract for each delineation definition of all the soil site characteristics recorded.

Specification of the Problem to the Programmer/Analyst (Louise Boardman)

The problem as specified to Louise was designed to test the general purpose hardware configuration, to assess the suitability of commercially available software, and to provide advice and specific examples to the scientific authorities on the Nova Scotia contracts as to what should be required from the contractors in terms of formats.

Specifically the tasks were:

- develop techniques to input data in (i) card image form (ii) screen forms (2)
- develop techniques to edit the data (i) in card image form (ii) in interactive form
- establish procedures to load the data to a data base manager
- define in a database manager three files (i) site (ii) horizon (iii) notes
- investigate and implement procedures to calculate frequency distributions for all site soil characteristic variables including coded or classed varibles e.g. parent material, continuous variables e.g. map unit with or without variant, and numeric variables e.g. slope.
- assess capabilities to prepare reports of complete records subsets of records, and joins of records.
- investigate and test procedures to export data to other packages such as word processors or graphics and spreadsheet such as Lotus 1-2-3.

Project as Carried Out by Programmer/Analyst

For the site inspections and transect data each contractor has developed a data collection form which makes provision for collection of basic information on the site, on the horizon and special notes. It also contains a delineation of the map unit being sampled as well as the delineation definition.

The computer analysis required from the contractor is described as follows and refers only to the Delineation Transect data and delineation definitions. The following analyses are required for all delineation definitions sampled within each contract.

The analyses are required by
- map sheet, and by
- contract (aggregating all map sheets within a contract)

Where frequency distributions are specified these will be normalized to an area of 100 under the curve and the number of samples analysed will be reported.

Analysis Requirements

PM1	frequency distribution
PM2	frequency distribution
Rockiness	frequency distribution
Stoniness	frequency distribution
Bedrock type	frequency distribution
Constriction layer type	frequency distribution
Drainage	frequency distribution
Soil transmissibility	frequency distribution
Transmissibility Loose Layer	frequency distribution
Map unit and variant	frequency distribution
Slope %	frequency distribution, range, mean
Depth to constricting layer	frequency distribution, range, and mean

The project was carried out using dBASE III as the commercial package available to input, store and manipulate the data. So far as possible dBASE III procedures were used to meet the requirements. Where this was not possible the requirement was analysed and specific programs were written to perform the required data manipulation. A manual was prepared to document all procedures developed including the command procedures within dBASE III and the additional custom programs.

Specifically the manual describes
(i) IBM PC equipment and software used to develop the system
(ii) inputs
(iii) outputs
(iv) processes

It includes copies of all the programs developed and used and outlines the impact various changes to the system (e.g. changes to the input form) will have on the various programs and the things which must be considered when changes of this nature are necessary.

All procedures are menu driven. The main menu provides the access.

Main menu

Access to the main menu provides the following options

********** MAIN MENU **********

0 - exit
1 - add new data - data already keyed
2 - add new data - data to be entered online
3 - update data
4 - delete records
5 - frequency distribution

enter desired action

Depending on the selection, the appropriate programs will be executed and additional menus called as required. If an incorrect selection is made the user will be asked to reenter. Selecting "0" to exit brings the user back to the "." prompt of dBASE.

Input

The two contractors involved in the project had each designed their own form. Provision was made to capture data from either form and also from the form developed by the Truro soil survey unit including three fields added after the initial design. (A sample input form is found in Appendix A)

Data can be captured in any of the following methods:
(i) keypunched and then copied onto a diskette or tallgrass cartridge
(ii) using the append command of dBASE to add the data directly to the database
(iii) entered interactively using a screen designed to look like the input form with capabilities for updating the data as they are being entered.

The manual documents the first and third methods and the second is described in the dBASE manual.

Output

The captured data are stored by cardtype and routed to one of three data bases depending on the cardtype
(i) site (cardtype 1)
(ii) horizon (cardtypes 2 to 7)
(iii) notes (cardtypes 8, 9 and 0)

The structure of these three data bases is documented in Appendix B.

Once the data has been captured, they can be used to produce reports either through use of dBASE commands such as DISPLAY and LIST or through the system programs designed to calculate frequency distributions.

Examples of reports using dBASE commands can be found in Appendix C whereas examples of frequency distribution reports are shown in Appendix D.

Note - in the examples, areas not enclosed in blocks are printed by the system whereas those enclosed in blocks are the user,s response to the prompts.

Summary

A complete menu driven package was prepared and will be tested by one of the contractors. All aspects of the requirements were handled except the export of data, files and interim calculations to other packages such as Lotus 1-2-3. Insufficient time was allocated to the project to allow this latter aspect to be explored.

The package was developed on version 1 of dBASE III. One contractor implemented it on version 1.1. Some of the instructions in the manual required modification to reflect the differences. Also the directory on the hard disk must have a minimum on 70 entries for the above work.

Site #	Card Type	Day	Mo.	Yr.	Surveyor	Field Sheet #	Zone	Alpha Let.	100,000 Metre	Easting	Northing
0190	2	19	07	84	DH	ANVALNS	20	T	LE	382	8563

Column 35 P.M. 1	P.M. 2	Rock	Stone	Bedrock Type	Slope	Constricting Layer: Depth to (cm)	Constricting Layer: Type	Drainage	Soil Transmiss. Sublayer	Soil Transmiss. Loose Layer
07		X	X		05	30	2	4	02	H
1-15	1-15	X-5	X-5	1-14	Percent		1-8	1-6	Sublayer	Loose Layer

Soil Unit Code	Variant
KGP	03

Map Unit Delineation Code

Soil Unit Code	Variant	%ile	Soil Unit Code	Variant
KGP	01			
*				

P.M. 1 & P.M. 2
1. Fluvial: Flooded
2. Colluvial
3. Eolian
4. Fluvial: Not Flooded
5. Fluviolacustrine
6. Fluviomarine
7. Glaciofluvial
8. Glaciolacustrine
9. Glaciomarine
10. Lacustrine
11. Lacustro-till
12. Marine
13. Morainal (till)
14. Organic
15. Residual

Rockiness
x. Nonrocky
1. Slightly rocky
2. Moderately rocky
3. Very rocky
4. Exceedingly rocky
5. Excessively rocky

Surface Coverage
< 2
2-10
10-25
25-50
50-90
> 90

% Stones
x. Nonstony
1. Slightly stony
2. Moderately stony
3. Very stony
4. Exceedingly stony
5. Excessively stony

Surface Coverage %
< 0.01
0.01-0.1
0.1-3
3-15
15-50
> 50

Type of Constricting Layer
1. Fragipan
2. Ortstein
3. Placic
4. Duric
5. Plowpan
6. Compacted Basal Till
7. Other or Unidentified
8. Bedrock

Soil Site Drainage Classes
1. Rapidly drained
2. Well drained
3. Moderately well drained
4. Imperfectly drained
5. Poorly drained
6. Very poorly drained

Soil Transmissibility (CM/HR)

1.	HIGH	> 15
2.	Very rapid	> 50
3.	Rapid	15-50
4.	MEDIUM	0.5-15
5.	Mod-rapid	5-15
6.	Moderate	1.5-5
7.	Mod-slow	0.5-1.5
8.	LOW	< 0.5
9.	Slow	0.15-0.5
10.	Very slow	0.05-.15
11.	Ext. Slow	< 0.05

Soil Transmissibility of Looser Layer (CM/HR)
H-High: More than 15
M-Medium: .5-15
L-Low: Less than 0.5

Cementation
DEGREE
W-Weakly cemented
S-Strongly cemented
I-Indurated

EXTENT
C-Continuous
D-Discontinuous

Consistence (moist)
1. Very firm
2. Firm
3. Friable
4. Very Friable
5. Loose

Text Modifier
G Gravelly
VG Very Gravelly
M Mucky

Bedrock Type
1. Ingeous
2. Granite
3. Basalt
4. Metamorphic
5. Slate
6. Quartzite
7. Shist
8. Sedimentary
9. Shale
10. Siltstone
11. Sandstone
12. Conglomerate
13. Limestone
14. Gypsum

	Card Type Column 6	Lith Dis.	Master Layer Horizon	Suffixes	Modifier	Modal Depths Upper Limit	Modal Depths Lower Limit	Consistence (moist)	Texture Modifier	Texture Class	Coarse Fragments (% by vol.)	Cement Degree	Cement Extent	Sampled
2			L	F		6	0							
3			A	EG		0	15	4		S	0			
4			B	H		15	30	4		S	0			
5			B	HC		30	70	1		S	0			
6			C	G		70	100	5		S	0			
7														

* added after this form was made to be used to represent rock, slope and stone for map unit delineations

Special Notes: Free Format

8	
9	
0	

APPENDIX A

Appendix B

Format of the Data Bases Site

Structure for database :

Field	Field name	Type	Width	Dec
1	SITENO	Character	5	
2	DATE	Character	6	
3	SURVEYOR	Character	2	
4	FLDSHEET	Character	7	
5	ZONE	Character	2	
6	ALPHA	Character	1	
7	KM100	Character	2	
8	EASTING	Character	4	
9	NORTHING	Character	4	
10	PM1MDEPCD	Character	2	
11	PM1MDEP	Character	16	
12	PM2MDEPCD	Character	2	
13	PM2MDEP	Character	16	
14	ROCKCD	Character	1	
15	ROCK	Character	16	
16	STONECD	Character	1	
17	STONE	Character	16	
18	BEDRKCD	Character	2	
19	BEDRK	Character	16	
20	SLPPRCNT	Numeric	4	1
21	CONSDPTH	Numeric	3	
22	CONSTYPECD	Character	1	
23	CONSTYPE	Character	16	
24	DRNGCD	Character	1	
25	DRNG	Character	16	
26	SLTRANSLCD	Character	2	
27	SLTRANSL	Character	16	
28	SLTRANLLCD	Character	1	
29	SLTRANLL	Character	16	
30	SUGB	Character	5	
31	SUCODE	Character	3	
32	SUVAR	Character	2	
33	MUDELN	Character	11	
34	MUCD1	Character	3	
35	MUVAR1	Character	2	
36	MUPCT	Character	1	
37	MUCD2	Character	3	
38	MUVAR2	Character	2	
39	MUROCKCD	Character	1	
40	MUROCK	Character	16	
41	MUSTONECD	Character	1	
42	MUSTONE	Character	16	
43	MUSLOPECD	Character	1	
44	MUSLOPE	Character	16	
Total			281	

Appendix B.2

Structure for database : Horizon

Field	Field name	Type	Width	Dec
1	SITENO	Character	5	
2	CARDTYPE	Character	1	
3	LITHDIS	Character	1	
4	MSTRHZN	Character	2	
5	SUFFIXES	Character	4	
6	MODIFIER	Character	1	
7	MSTRHZNGB	Character	8	
8	UPDEPTH	Numeric	3	
9	LOWDEPTH	Numeric	3	
10	CONSISTCD	Character	1	
11	CONSIST	Character	16	
12	TXTGB	Character	7	
13	TXTMODCD	Character	2	
14	TXTMOD	Character	16	
15	TXTCLASS	Character	5	
16	COARSEFRAG	Numeric	2	
17	CEMDEGCD	Character	1	
18	CEMDEG	Character	16	
19	CEMEXTCD	Character	1	
20	CEMEXT	Character	16	
21	SAMPLED	Character	1	
Total			113	

Appendix B.3

Structure for database : Notes

Field	Field name	Type	Width	Dec
1	SITENO	Character	5	
2	CARDBI	Character	1	
3	NOTES	Character	27	
4	CARDTYPE	Character	2	
Total			36	

Appendix C

Using dBASE III commands to access the data

Example 1

```
. average slpprcnt for    easting >= "3000" ;
                  .and.   easting <= "3999" ;
                  .and.  northing >= "8000" ;
                  .and.  northing <= "8999"

     20 records averaged
  slpprcnt
       2.4
.
```

Appendix C2

```
. use site
. browse
```

Record No. 1 site

SITEND	DATE--	SURVEYOR	FLDSHEET	ZONE	ALPHA	KM100	EASTING	NORTHING	PM1MDEPCD
01901	190784	DH	ANVALNS	20	T	LE	3820	8565	15
01902	190784	DH	ANVLANS	20	T	LE	3822	8563	07
01903	190784	DH	ANVALNS	20	T	LE	3825	8562	07
01904	190784	DH	ANVALNS	20	T	LE	3827	8560	14
01905	190784	DH	ANVLANS	20	T	LE	3830	8558	07
01906	190784	DH	ANVALNS	20	T	LE	3832	8555	07
01907	190784	DH	ANVALNS	20	T	LE	3835	8553	07
01908	190784	DH	ANVLANS	20	T	LE	3837	8550	07
01909	190784	DH	ANVALNS	20	T		3839	8549	07
01910	190784	DH	ANVALNS	20	T	LE	3842	8547	07
01501	050784	DH	ANVLANS	20	T	LE	3435	8763	13
01502	050784	DH	ANVALNS	20	T	LE	3432	8754	13
01503	050784	DH	ANVALNS	20	T	LE	3429	8744	13
01504	050784	DH	ANVLANS	20	T	LE	3427	8737	13
01505	050784	DH	ANVALNS	20	T	LE	3423	8729	13
01506	050784	DH	ANVALNS	20	T	LE	3420	8720	13
01507	050784	DH	ANVLANS	20	T	LE	3418	8711	13

. to view the other fields press the <CTRL> key and the number 6 (->) ; on the keypad ;

Example 2 (cont.)

```
. browse
```

Record No. 1 site

NORTHING	PM1MDEPCD	PM1MDEP----------	PM2MDEPCD	PM2MDEP----------	ROCKCD
8565	15	GLACIOFLUVIAL			X
8563	07	GLACIOFLUVIAL			X
8562	07	GLACIOFLUVIAL			X
8560	14	ORGANIC	07	GLACIOFLUVIAL	X
8558	07	GLACIOFLUVIAL			X
8555	07	GLACIOFLUVIAL			X
8553	07	GLACIOFLUVIAL			X
8550	07	GLACIOFLUVIAL			X
8549	07	GLACIOFLUVIAL			X
8547	07	GLACIOFLUVIAL	08	GLACIOLACUSTRINE	X
8763	13	MORAINAL (TILL)			X
8754	13	MORAINAL (TILL)			X
8744	13	MORAINAL (TILL)			1
8737	13	MORAINAL (TILL)			X
8729	13	MORAINAL (TILL)			X
8720	13	MORAINAL (TILL)			X
8711	13	MORAINAL (TILL)			X

Appendix D Custom Data Manipulation Prodcedures

A series of command procedures have been written to produce frequency distributions.

frequency distribution can be done on either map sheet(s) or contract

if map sheet is specified you are prompted for the number of map sheets you wish to examine and their numbers

if contract is specified you are prompted for the contract

after you are prompted as to whether or not you want the output directed to the printer or the screen, a list of the available fields for which you can do a frequency distribution is presented

these represent fields on the site data base only as no provision for doing frequency
distributions on the horizon and notes data bases has been made

1 to d are discontinuous fields whereas e and f are continuous fields. For these two continuous fields you will be prompted for the number of ranges you wish to examine and the upper limits of the ranges. (See Appendix B.4)
The lower limits will be automatically generated by incrementing the upper limit by one. The last range will have an upper limit of 999

once you have specified the field for which you wish to produce a frequency distribution, you will be prompted for the basis you specify, you will be further prompted

Appendix D.2

Example 1.

Frequency Distribution for map sheet 01, 02, 03 and 04
for transect 601 to 910
for field stone

SLIGHTLY STONY	4
MODERATELY STONY	12
VERY STONY	1
NONSTONY	13
TOTAL	30

this is it for field stone - return to select another field

Example 2.

```
Frequency Distribution for contracct ANVALNS
                       for easting 3000 to 3999 and
                       for northing 8000 to 8999
                       for field slpprcnt

                              000 - 004          16
                              005 - 008           2
                                                 ---

                       TOTAL                     18

                       this is it for field slpprcnt - return to select another field
```

ADAPTING A MAINFRAME APL BASED SOIL SURVEY DATA MANAGEMENT FILE TO A MICROCOMPUTER

M.C. Nolin

INTRODUCTION

A soil data bank has been established in Quebec by the Canada Soil Survey Unit in order to make statistical treatment of soil survey data collected daily by transect or grid mapping. Seven (7) modules form the framework of this data bank (figure 1). This interactive system has been developed to retrieve soil data according to four distinct files: 1) the soil survey project file, 2) the map unit file which allows surveyor to get variation of all the delineations composing a given map unit and is usefull in the description and interpretation of map units, 3) the polygon file which allows users to get local variation of a given delineation of a soil map and, 4) the soil series and variant file which allows surveyor to get the variation of all sites belonging to a given soil series and is usefull in the description and correlation of soil series. Statistical treatment can be done according to three sampling designs: 1) simple random sampling, 2) cluster sampling and 3) stratified random sampling.

This system called FIDDUCS (Fichier Interactif de Description des Délimitations et Unités Cartographiques de Sol) has been implanted on APL System of Laval University on a personal library using four working blocks of 100K with an access to BSS file of 2 Meg. Soil survey data are first stocked on magnetic tapes until the project file is completed and afterwards sorted and loaded on BSS file. A tabular edition of results is obtained.

As it has been implanted on a mainframe, on which working sessions are very expensive, the FIDDUCS system cannot be used at its full capacity now. In order to overpass this restriction, a project has been conducted during Summer 1984 to adapt the FIDDUCS system on a microcomputer. The objective of this project was to try a commercial data base to retrieve soil data according to different files described previously and to use afterwards a statistical package to treat these.

MATERIALS AND METHODS

Soil data of 790 soil profiles were extracted from soil survey project of Richelieu county. These data belonged to three major soil map units and were distributed among 67 delineations. Stocked on magnetic tapes, these data were extracted according to the project number and to the map unit symbol using a "COBOL" program and stocked on a disk. Next, data were loaded on the MUSIC system (McGill University System for Interactive Computing) using MUSIC utilities. Afterwards, data were transferred from MUSIC to microcomputer using a communication program "PC Talk". For a transmission speed of 300 bauds, 10 sites per minute were transferred. Finally, a BASIC program was executed to segment data according to 106 distinct fields.

The microcomputer used was an Eagle PC Plus with 256 KB of RAM. It used the MS-DOS 2.0 operating system and two floppy disk drives with storage capacity of 360 Kbytes per diskette. Microsoft BASIC and Knowledge Manager vers. 1 were computer software used. KnowledgeMan is an interactive data base copyrighted by Micro Data Base Systems, (Lafayette, Indiana). This program was chosen because it includes statistical procedures (min., max., sum., count, mean, standard deviation and variance) as capabilities.

RESULTS

In order to make the SIGUC System (Système Interactif de Gestion des Unités Cartographiques) user friendly, KMAN's program files have been used extensively to produce a series of menus. Most operations are stored, listed and executed afterwards (batch processing). Some statistical procedures not included in the KMAN data base (standard error of mean, confidence interval, frequency table) have been programmed. A simple random sampling design was considered for statistical treatment.

As for "FIDDUCS" System, previously described, "modules" constitute the skeleton on which SIGUC is structured. Six modules are available to users: 1) to enter new soil survey data, 2) to modify existing data, 3) to get statistical treatment, 4) to sort and index data, 5) to list delineation numbers and related map unit symbols and 6) to terminate a computer session.

Module 1 allows user to enter new soil survey data to the data base. These data may have been stored on diskettes or entered directly on the keyboard. Module 2 is used to modify existing data concerning map unit designation of a given delineation, soil series designation of a given site or any other fields record of a given site. Module 3 is the statistical treatment module. It can compute any descriptive statistics according to a given map unit code, delineation number or soil series code. These are statistics about taxonomic composition, site characteristics, diagnostic depths and parent material description. Programs for statistical treatment of soil morphological data were not developed on account of the limited time of the project. Module 4 will be used to sort and index soil data before using module 3 when module 1 or 2 have been used previously. Module 5 gives an updated list of all delineations and soil sites composing each map unit. To terminate a computer working session, module 6 can be used.

Reliability of SIGUC system was tested by comparing results obtained by statistical treatment of data extracted from soil survey project of Richelieu county with those obtained by the FIDDUCS system using same data. As example, Table 1 present the taxonomic composition of the TH1 map unit (St-Thomas, fine sand) and Table 2, the depth to gley of the delineation number 1170 of the MS1 map unit. (Massueville, fine sandy loam).

DISCUSSION AND CONCLUSION

Adapting a mainframe soil survey data management file to a microcomputer using a commercial data base (KMAN) is feasible. Indeed, it takes more time for a microcomputer to execute a job than a mainframe but as SIGUC system can store jobs and execute them afterwards (during night) it is not a serious problem. SIGUC is cheaper to use than FIDDUCS and as reliable. Project did not include cluster sampling and stratified sampling design. Statistical treatment of data for these design is quite possible with more programming.

The sample size of the experiment was relatively small in comparison with a complete soil survey project file (5,000-10,000 sites). Utilization of an hard disk with storage capacity of 20 Meg will hasten the execution of SIGUC procedures.

Codes used on record were not documented in a dictionnary in the SIGUC system like the one used in the FIDDUCS system. This dictionnary could be stored on the hard disk to hasten code translation and a new module should be developed to edit its components.

An additional file compatible with the soil survey file should be created for routine laboratory data collected by transect in order to get statistical summary and to produce predictive models for soils using laboratory analysis.

Despite the fact that utilization of a commercial data base is relatively simple, a great deal of programming is implied in the development of a soil data management file on a microcomputer and this task is usually beyond pedologists programming capabilities. Soil survey teams will need the assistance of an experimented programmer-analyst in the implementation of an efficient system.

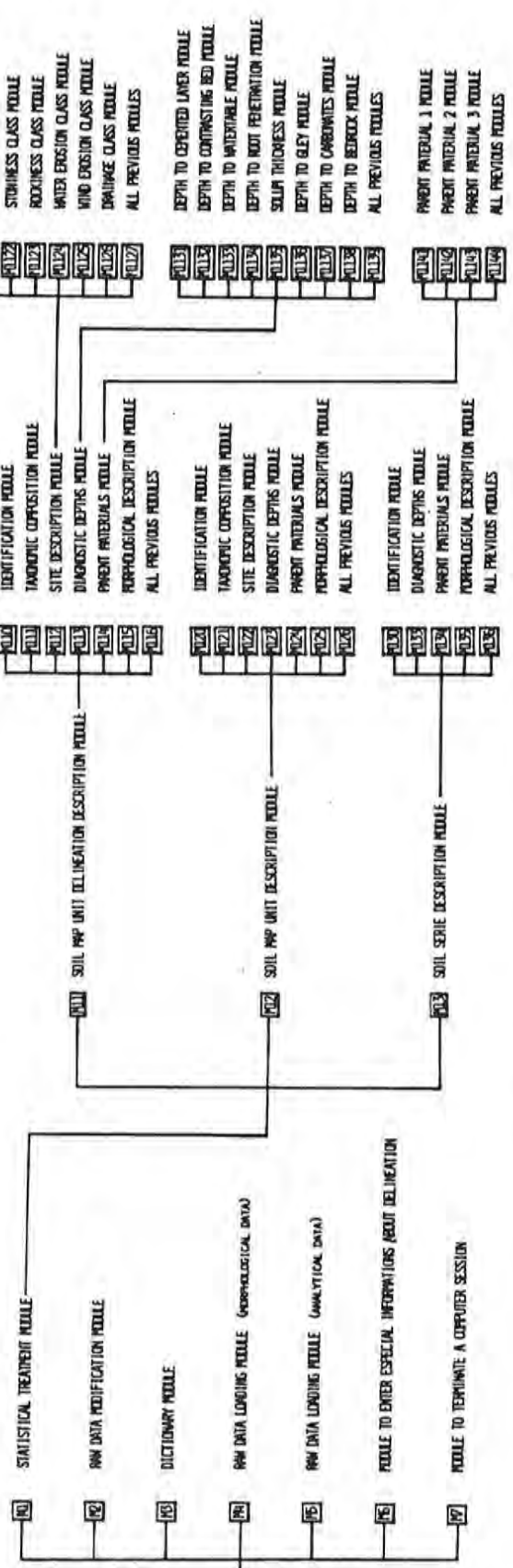


FIGURE 1. ORGANIZATION OF THE FIDDUCS SYSTEM.

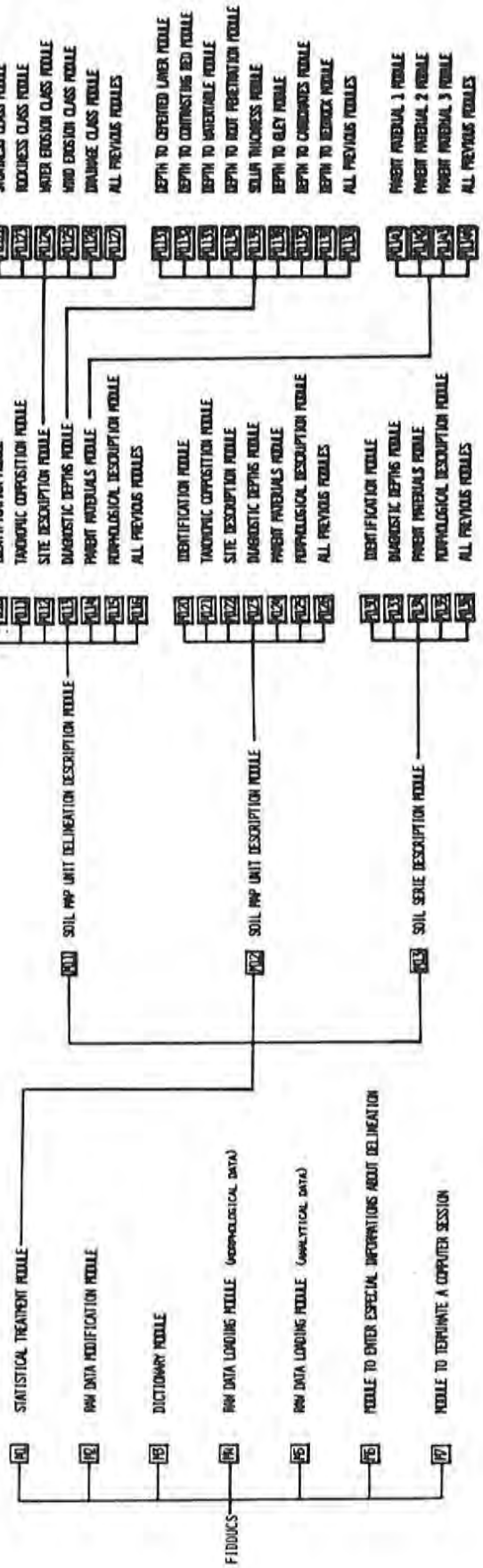


FIGURE 1. ORGANIZATION OF THE FIDDUCS SYSTEM.

TABLE 1. TAXONOMIC COMPOSITION OF THE TH1 MAP UNIT.

Sample Size: 288

Nomber of distinct values: 9

Frequency table:

CODE	F	P	Var (P)	$(P)^{80}$		$(P)^{90}$	
TH	260	0.903	0.000	0.879	0.927	0.872	0.934
MS	10	0.035	0.000	0.019	0.050	0.015	0.054
JS	5	0.017	0.000	0.006	0.029	0.003	0.032
SP	4	0.014	0.000	0.003	0.025	0.001	0.027
YK	3	0.010	0.000	0.001	0.020	0.000	0.022
AC	2	0.007	0.000	0.000	0.015	0.000	0.017
PR	2	0.007	0.000	0.000	0.015	0.000	0.017
ASc	1	0.003	0.000	0.000	0.010	0.000	0.011
P	1	0.003	0.000	0.000	0.010	0.000	0.011

Where F = frequency
P = proportion
Var (P) = variance of P
$(P)^{80}$ = confidence interval for the estimate of P at 80% confidence level.
$(P)^{90}$ = confidence interval for the estimate of P at 90% confidence level.

TABLE 2. DEPTH TO GLEY (M) OF THE DELINEATION NUMBER 1170 OF THE MS1 MAP UNIT

Sample Size:	32
Number of Distinct Values:	6
Maximum:	50
Minimum:	00
Mean:	0.250
Standard Deviation:	0.130
Confidence Interval (.90):	0.196 - 0.304

FREQUENCY TABLE:

VALUE	F	P	Var (P)	$(P)^{80}$		$(P)^{90}$	
00	4	0.125	0.004	0.032	0.218	0.009	0.241
10	2	0.063	0.002	0.000	0.135	0.000	0.152
20	7	0.217	0.006	0.106	0.332	0.077	0.360
30	13	0.406	0.008	0.275	0.537	0.241	0.572
40	5	0.156	0.004	0.055	0.257	0.030	0.283
50	1	0.031	0.001	0.000	0.088	0.000	0.100

Where F = frequency
P = proportion
Var (P) = variance of P
$(P)^{80}$ = confidence interval for the estimate of P at 80% confidence level.
$(P)^{90}$ = confidence interval for the estimate of P at 90% confidence level.

REGIONAL REPORT FROM ALBERTA ON CURRENT AND PLANNED COMPUTER APPLICATIONS FOR SOIL SURVEY

Background

Soil survey in Alberta has focused on both in house, project related data base management/statistical applications as well as a large province wide database. Large main frame computers, maintained by the province or the university, are used for these applications. Software used is generally 'canned' database or statistical packages as opposed to custom software. This year we have made considerable inroads in the use of micro computers and anticipate considerable development in this area.

Project Related Database Management and Statistical Applications

In response to a need for project related electronic data processing, facilities at the University of Alberta were adapted for use. These include MICRO - database management package and MIDAS - a statistical package. These software packages are very flexible and existing applications are easily modified to suit individual project requirements. As each new mapping project addresses computing needs, new and different applications are developed.

These facilities are used to store daily dig, transect, laboratory and soil climate data. Subsequent processing includes, sorting, summarizing, tabulating data as well as calculating statistics for map units and soil series.

With respect to future development it is anticipated that INGRES - database management and SAS - statistics, will be available for use in the next year. Investigation as to their use in soil survey applications will be carried out.

Text Processing

Several text processing packages are being utilized to generate project reports. The choice of package usually depends on the route to final publication i.e., Ottawa vs local publication. We have found that having reports in electronic form allows for some uniformity in report content and appearance. Sharing of glossaries, soil classification and genesis summaries, profile description formats and analytical data formats has resulted is a considerable reduction in redundancy of effort and consistency in report format.

Hand Held Data Collection

Hand held data collection devices (Polycorders from Omnidata) are being used in most soil mapping or mapping related projects to capture data in electronic form. Data is transferred directly to the computer thus eliminating key punching costs and turnaround time. Updating and processing of data can proceed on a daily basis if necessary.

The use of both hand held data collection devices and computing capabilities has changed our approach to the collection and use of soils data. This includes both which data are collected and the form in which they are collected. For example, coded or categorical data require less storage space, and are more space efficient.

Future developments in this area are likely to include the proliferation of hand held devices and the development of more efficient and error free data collection formats. Of specific note is the development of an optical wand-barcode application for daily dig data. One such application is under development in Alberta.

Remote Data Collection

Remote data collection devices (CR21's from Campbell Scientific) are being used in the Grande Cache area to collect soil climate data in support of soil interpretations. These installations provide the frequency of recording necessary for development of the relationship between climate, soil temperature and plant growth. Future developments include an expansion of the network and of the sensing devices utilized.

Plotting and Digitizing

We are currently developing digiting and plotting facilities to support soil survey activities. Two lines of investigation and development are underway. For the present, grid or raster based approaches are being used on an iterim basis. The first, utilizes the Vax11/780 and software developed at the Alberta Research Council. Digitizing in 10 acre cells is accomplished with the polycorder whereas processing and plotting are accomplished with the Vax11/780.

The second raster data set is the major province wide soil data base (SIDMAP) described below. These two raster based approaches have been used successfully to date. We anticipate investigating several options for polygon based digital input along the lines of the Collins and Moon software developed for use at Guelph. This approach is expected to supplant the raster method of digitizing.

Soil Inventory Database for Management and Planning (SIDMAP)

Of considerable importance in the Alberta EDP environment was the completion of SIDMAP in January 1984. A joint effort financed by several government departments, administered through the Alberta Institute of Pedology and managed by the Alberta Pedology Unit this project is a compilation of all soil inventories.

The database incorporates municipal boundaries, agroclimate, Canada Land Inventory Interpretation and soil map units. It can be linked to produce derivative maps, with any number of other data files such crop yield data, water erosion potential, suitability for deep plowing interpretations, to mention only a few. Based on the quarter section cell this database is intended for regional planning as opposed to site specific planning. The potential uses of this database are unlimited and adaptibility to different uses is an important asset.

CURRENT AND PLANNED LOCAL COMPUTER APPLICATIONS-SASKATCHEWAN

H.B. Stonehouse

CURRENT APPLICATIONS

1. Laboratory

A computerized system is presently in place which will allow for the collection of lab data from laboratory instruments, the calculation of results and storage of this data automatically. It involves the use of a CompuPro Model 816C computer hooked to the lab balances, the AA unit and two titrators, through custom-built interface units. The computer is currently using two 8" floppy disks but it is anticipated a hard disk will be added in the future. The hardware is currently in place but it will require another few months of software development to get the system fully operational. The system will allow for the automatic collection of data for all currently run analysis except pH and conductivity, which will have to be entered manually. It will also provide for direct entry of the data into CanSIS.

2. Daily Sheets

Daily field sheets have been used in Saskatchewan for some time for the purpose of characterizing soil series, map units and associated landscape characteristics. Originally the sheets were designed such that the data collected was in CanSIS-compatible form with the intention of manipulating the data using CanSIS hardware and software. However, with advances in microcomputer technology and associated software and for reasons of cost and ease of use, the CanSIS route has been abandoned and daily field data are now being manipulated or stored locally using a microcomputer and a few off-the-shelf software packages (CompuPro 816A Computer, DBASE II, ABSTAT).

3. Extended Legends

In the last few years the SIP has switched to a radically different type of soil survey report than had been traditionally produced over the previous twenty years. This new publication is much more interpretation oriented and covers much smaller areas—one municipality rather than a whole NTS sheet. Consequently we are generating many more reports with each report "or brochure" having a total of nine maps rather than the previous one. As well, more maps will be added in the future. These maps are all being produced by the Cartographic section in Ottawa which is moving toward computer-produced maps. Thus, it became necessary to develop computer legends which will allow for the production of soil maps as well as derived and interpretive maps. The format for these legends was worked out in co-operation with CanSIS and these are being generated using the university mainframe computer at present. If the cost of using the university computer becomes substantial, a switch to microcomputer(s) may take place in the future. This would be made possible either by upgrading the CompuPro to a multi-user unit or purchasing individual microcomputers for this and other uses.

PLANNED APPLICATIONS

1. Map Digitizing

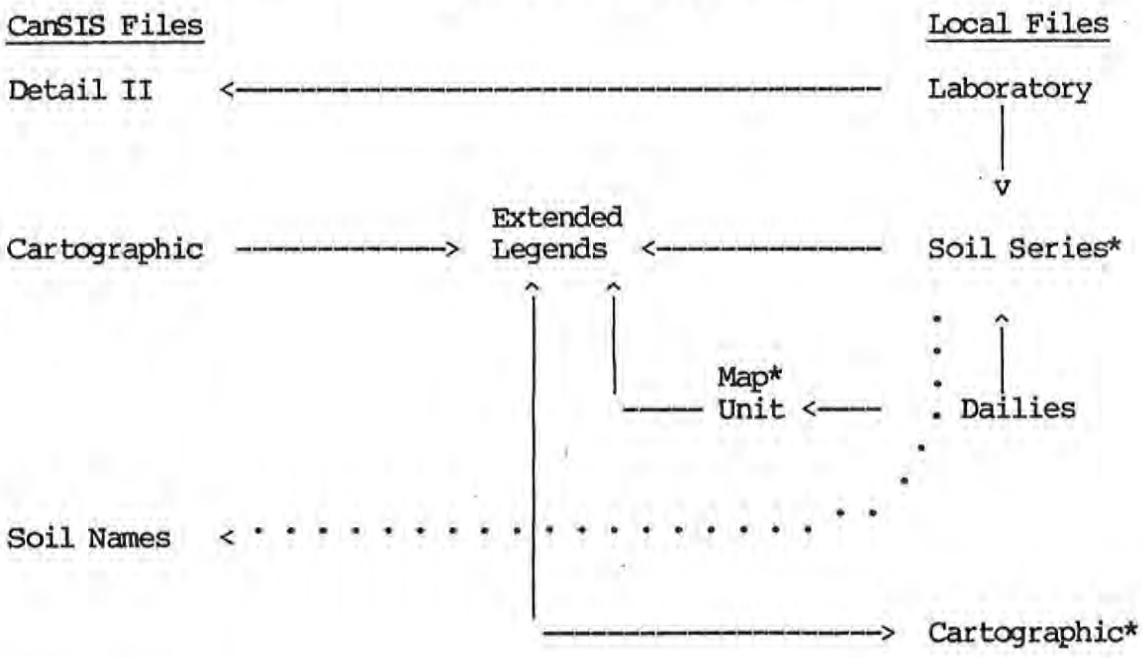
The SIP is scheduled to receive a stand-alone digitizing unit early in 1985 and will be operational sometime later in the year. All maps will then be digitized locally with the data forwarded to CanSIS on tape. Eventually the unit will also include a plotter which will enable the local plotting of maps as well.

2. Hand-Held Computers

If the expanded soil survey program presently being proposed for Saskatchewan goes ahead, some funds will be used, in 1985, to purchase several hand-held computers and their use in the field to record transect and single-site data, will be experimented with. This will be done in consultation with other units already experimenting with this type of computer application.

SUMMARY

Outline of Soil Survey Data Management System in Saskatchewan
Present and Planned



* proposed files

As outlined in the diagram, Saskatchewan, at present, has three areas in which local computers are being used to collect, store and manipulate soil survey data. These are:

1) **Laboratory** - collection, calculation, storage and manipulation of analytical data from soil survey samples.

2) **Daily sheets** - storage and manipulation of soil series data collected on transects and single site inspections during soil mapping.

3) **Extended legends** - preparation of computerized legends with which soil, derived and interpretive maps are produced for all current survey areas in Saskatchewan using the CanSIS Cartographic System.

In the future, a stand-alone digitizing system will be added that will enable the digitizing of all maps locally. Also, in the near future, the feasibility of using hand-held computers to collect and enter directly the information presently being collected on "daily coding sheets", will be examined.

REGIONAL PRESENTATION

ON GENERAL EDP PLANS AND APPLICATIONS - YUKON

C.A.S. SMITH

EDP FACILITIES

The Yukon Soil Survey Unit has access to the Yukon territorial government's computing facilities. At present this is composed of a IBM 4300 type mainframe with CMS-VM operating system mounted with SAS DBMS, statistical and graphics software. A number of IBM PC's have been interfaced with the mainframe. The acquisition of a microcomputer by the Unit should fit well into the present IBM environment. Some system analyst and programmer assistance is available.

PRESENT APPLICATIONS

i) Soil test information.
Two years data from approximately 50 sampling units is presently on file. Qualitative variables include available nutrients, soil chemistry and applied fertilizer rates. Data manipulation has been confined to the production of standard statistical summarizes, crosstibulation of variables and preparation of reports available to co-operating agriculturalists.

ii) Soil survey transect data.
In conjunction with a detailed soil survey in the Whitehorse area, transect data from selected polygons has been input to create polygon and map unit files upon which statistical summaries are prepared. Variables include soil chemistry and horizon thickness of surface horizons.

iii) Forage fertility trials.
A series of trials were conducted to correlate yield and protein content of bromegrass and oats to soil nutrient status. A randomized block design of 3 fertilizer treatments replicated four times at each experimental site was utilized to generate data under irrigated and non-irrigated conditions. The application of SAS regression and ANOVA procudures will be carried out.

PLANS

A tentative proposal exists to co-operate with a university research project to collect soil climate data using CR-21 systems. An IRAMS has been ordered for the unit. The collection of field data in electronic digital form, including the eventual use of hand held computers for survey use will place a strong requirement to have field equipment interfaced with both micro and mainframe hardware. Beyond the co-ordination of EDP aquisitions and configuration no EDP "R & D" activities are presently planned

CanSIS - Computer Working Group of ECSS
Newfoundland - Summary of Activities

Introduction

Historically, the provincial Soil Survey Unit in Newfoundland has been anything but active with CanSIS, either directly or indirectly. However, during the past few years communications have increased between CanSIS and the province and the future looks more promising.

Present Status

The complexion of soil survey in Newfoundland has changed dramatically over the last few years, with an increase in soil surveys, special projects and monitoring activities. This has resulted in the generation of large amounts of data and consequently a problem of how to handle and store it.

Two soil survey projects (Goose Bay and Pasadena - Deer Lake) were designed to have their data entered on field sheets so that they could be loaded into CanSIS for analysis and manipulation at a future date. However, the daily field sheet was not adequately designed and certain problems did take place.

During the past summer a representative of our soil survey unit travelled to Ottawa to meet with CanSIS personnel, for familiarization with the overall CanSIS system and the developing of a new daily field sheet.

The daily field sheet is similar to the Nova Scotia design, where data is entered into SD01, SD02 and SD03 with some flexibility for individuals and individual projects.

Future Request

- a concern has been expressed that the Soil Names File needs to be cleaned-up and up-dated, and this work could be started this winter.

- finalization of the Newfoundland daily field sheet.

Canada-Nova Scotia Soil Survey EDP Requirements

We are currently assessing our EDP requirements for present and future operations in Nova Scotia. These requirements will inevitably change over time so flexibility, compatibility with existing systems, and potential for system expansion are important to us. Our present facility consists of one hard-copy Decwriter with acoustic coupler, a Radio Shack programmable calculator, and an IBM-PC due to arrive this fiscal year. Our requirements fall under the four main headings outlined below.

(1) Office-clerical We have no unit clerk and have requirements for handling the office books (an accounting or spreadsheet package) as will as a rudimentary word processing package to handle short memos such as this one. Larger volumes of typing are to be contracted or handled by short term staff.

(2) Field data Our day to day field work will be handled by private industry at least until the present contracts expire in 1987. However, we do have requirements for manipulating our own transect data and for recording information (mainly soils) from correlation checks. We want to attempt field entry of data into an electronic notebook and later upload the information to a micro or a mainframe. The data would be used to produce summary reports, frequency distributions, descriptive and some analytical statistics.

Future work may entail pedon descriptions: these we want to enter directly into an electronic notebook. Another possible application is to monitor remote stations for soil moisture and temperature; however, we have no immediate plans to move in this direction.

(3) Laboratory Data The bulk of the samples presently collected are handled by contract. Circumstances may change in future work so we want to keep ourselves informed of automatic recording procedures that could be implemented if and when our laboratory facilities are expanded.

(4) Map Plotting The major products of soil survey units include maps -- generalized, single factor, and interpretive. In the long term, we want to be able to locally manipulate our own information to suit local and immediate needs in land use planning and in soil management. To this end we want to investigate procedures for downloading CanSIS maps to our micro either in polygon or raster (point) form.

A limited number of reconnaissance maps have been digitized on CanSIS. Maps from the contract areas are being digitized by the contractors in CanSIS compatible form. The problem of whether or not to pick up the backlog of undigitized sheets will be resolved after we assess the utility of the existing digital maps.

DBMS FEATURES FOR REGIONAL APPLICATIONS

D.E. Moon

INTRODUCTION

The Land Resource Research Institute is planning to install general purpose microcomputers in the Soil Survey units across Canada. There are a number of considerations which are important in selecting a Data Base Management System (DBMS) for these units. They fall into two major areas: 1) the level of computer expertise available in the units and 2) the data management requirements of the units.

The objective of this report is to outline some characteristics of both the potential users of these systems and of data base management systems which are relevant to the choice.

EDP Support in the Units

The importance of the level of expertise available to the units should not be underestimated. Some units will have personnel available who have limited programming experience and some facility with commercial software applications but all will have users who are inexperienced and who will require only infrequent access to the database. The first group presents no problem since any number of DBMS's will meet their basic needs. The latter group, by far the largest at the present time, presents more of a problem. Most DBMS's require a degree of skill developoment if the user is to manipulate, retrieve, or report data in an ad hoc manner. It is unlikely that many of this group will have both the time and desire to attain the required level of sophistication. The problem is further compounded when a lack of typing skill makes the entering of a significant amount of keyboard input difficult.

The unsophisticated users will require one of three things to realize the potential of a DBMS:

1) Training to bring them to the required level of sophistication,

2) In-house support to define, maintain, and operate the DBMS for their applications,

3) External support to define a DBMS which, once in place can, provide a wide degree of flexibility in maintenance and ad hoc retrievals, reports, and manipulation with a minimum of user sophistication required.

The Ontario Institute of Pedology at Guelph has opted for the second option. They currently have a full time EDP specialist and at least one part time programmer to support the unit. Either in spite of or because of the support available, few of the professional or support staff have developed the expertise neccessary to meet their own EDP needs. Most require menu-driven utilities to be developed by the EDP specialist so that they can address their data. For non-standard procedures they must

have the specialist define and run the procedures for them.

The choice of option should logically be the responsibility of each unit since it will be unit resources which will be committed to the problem. While the efficient use of EDP capabilities cannot be ensured, it is clear that it will require, at least initially, some units to depend on outside help in establishing the data management program and that once established it will have to be maintained by unit personnel as a proportion of thier duties. It is also clear that there are soil survey applications which will require custom design by experienced users or systems analyst/ programmers.

Most units will have similar applications and requirements for at least part of their programs (lab procedures will probably be the most standard) but many applications will be specific to one or a few units only. It would be highly desirable if each unit had the option of choosing to use procedures developed at other units where appropriate rather than have to develop their own. This exchange of procedures would be greatly facilitated if all units were using the same DBMS.

The above discussion indicates four primary concerns in choosing a data base management system:

1) It should be the same data base management program in all units so that they can have access to applications developed in other units and so that there will be a network of users to whom they can turn for help.

2) If any units opt for option 3, the DBMS should have a user friendly interface, preferably menu driven, that presents the ability for ad hoc retrivals, reports, and statistics across multiple files. It should require minimal training to deal with an established data base and should not require frequent use to maintain the skills necessary to do this.

3) It should have the capacity to deal with the number of files, fields, and records necessary to meet soil survey project needs.

4)It should have a powerful command language with retrievable program applications or an interface to a high level language with a program library for the execution of high level programs from within the data base management system so that sophisticated soil survey specific utilities can be developed.

DBMS REQUIREMENTS

User Interface

If the DBMS is to be able to meet all of the above options then it should provide two levels of user interface. There should be an interface suitable to the unsophisticated user who has minimal typing skills. This requires the ability to make ad hoc queries in a system-prompted and menu-driven manner. File relationships, field names, and key or index fields

should be available on screen when needed or easily retrived by the novice user. A second, more sophisticated interface is also necessary so that custom applications can be developed to augment the options offered as part of the system. This requires a powerful system command and programming language with executable macro facilities or a high level language interface with an in-system executable program library available to the unsophisticated user.

User interface options in order of preference for unsophisticated users are: menu > prompt > command > system programming language > high level language.

User interface options in order of preference for developing sophisticated user applications are likely to be: high level language > system programming language > command > menu > prompt.

The evaluation of DBMS requirements must be based on expected needs and applications. In order to provide a basis for assessing regional requirements a hypothetical project data base was defined.

Data and File Structure

Outlined below is an example of a plausable, if large, project data base with files, numbers of fields and records per file, and file access requirements which was used as the basis for defining system requirements.

Project files

Delineation file
- 30 fields
- 1000 records

access to: Modal file, Map unit file, Site file, Horizon (morph) file, Horizon (lab) file, Interpretations file, Land use file, Climate file

Map unit file
- 20 fields
- 100 records

access to: Delineation file , Modal file, Site file, Horizon (morph) file, Horizon (lab) file, Interpretations file, Land use file, Climate file

Modal soil file
- 90 fields
- 200 records

access to: Delineation file , Map unit file, Site file, Horizon (morph) file, Horizon (lab) file, Interpretations file, Land use

Site file
- 80 fields
- 5000 records

access to: Delineation file, Modal file, Horizon (morph) file,

Horizon (morph) file
~30 fields
~50,000 records
access to: Delineation file, Modal file, Site file, Horizon (lab)

Horizon (lab) file
~60 fields
~10,000 records
access to: Delineation file, Modal file, Site file, Horizon (morph) file

Interpretations file
~20 fields
~1000 records
access to: Delineation file, Modal file, Map unit file, Land use file, Climate file

Land use file
~50 fields
~1000 records
access to: Delineation file, Modal file, Map unit file

Monitoring file
~50 fields
~10,000 records
access to: Delineation file, Site file, Horizon (morph) file, Horizon (lab) file

Climate file
~30 fields
~100 records

This file structure would require ~ 16 megabytes of disk storage.

Restructuring files

It is certain that new fields will need to be added to existing files during the course of a project, that key fields and indexes will need to be redefined, and that in some cases new files need to be added. The DBMS must provide this capability without destroying and reloading the entire data base.

File merges

For large projects it is possible that space will become a limitation in disk storage. For this reason it is important that file merges produce virtual files not real files for report generation and analysis.

Data Input Requirements

Two methods are likely to be used to enter data into the computer. Data will be loaded into the DBMS from files produced by a handheld microcomputer programmed in Basic. The format of the data files can be dictated but Basic is limited to 256 characters per line of output. Since most applications will produce records longer than 256 characters it is essential that the DBMS accept multiple line data records from either a fixed format or delimited file. It is probable that data for more than one file will be encompassed in the output file record from the handheld computer. This means that the DBMS should have the ability to assign fields to the appropriate files from a single input record.

A significant amount of data will be input at the computer console. Since inexperienced users make fewer mistakes when entering data using a screen form template, the DBMS should provide a screen form option. In addition it should provide for validity checks of data type and, less importantly, data ranges. It should also provide for easy error recovery within field, within record, and within file.

Data Edit Requirements

Despite the availability of editing capability during data collection it is likely that mistakes will be found and corrections will be necessary. In addition, field estimates of data will be modified in light of laboratory verification. A number of editing capabilities will be required:

1) Global edits with screening criteria and the application of calculation results

2) Full screen editing with record selection or screening

3) File updating from external files.

Record Selection Criteria

Record selection whether for reporting, calculations, editing, or statistics should allow the following comparisons =, <>, <, <=, =>, >, and the option of having the opposite apply through the use of not as a preface. In addition the Boolean logic conditions of and, or, and xor should be available. Multiple selection criteria should be possible and the ability to use wild card matches is highly desirable. It should be possible to specify selection criteria across multiple files.

Calculations

Simple interactive definition of calculations from within the data base are mandatory. These include addition, subtraction, multiplication, and division and it should be possible to link a number of operations and fields together in a single calculation. There should be provision for

the storage and retrieval of temporary variables. The availability of more sophisticated functions is also mandatory but this can be provided either by a DBMS programming language or by interfacing to a high level language and access to a program library within the DBMS.

Statistics

Interactive calculation of basic univariate statistics such as count, min, max, and mean are mandatory. More sophisticated applications such as std. dev., regression, correlation, and contingency coefficients, and cross-tabulations are highly desirable but not mandatory. Also highly desirable is the ability to interactively define groups of records for analysis since this will aid in the definition and selection of possible soil classes.

Report Generation

The interactive definiton and generation of ad hoc retrievals and reports to screen or printer is mandatory. There should be simple access to multiple files via virtual file constructs since on line storage could be a problem for large projects. There should be a facility for more sophisticated report formats but simple interactive definition is not as important as for ad hoc retrievals. For all reports there should be the facility to report temporary calculations, totals, sub-totals, and counts and to screen records to be reported.

Features which may be considered highly desirable are the ability to incorporate statistics, tables, and graphs with text in the report and an interface with a word processor to produce DBMS generated values at appropriate places in the text.

EVALUATION OF DATA BASE MANAGEMENT PACKAGES

A number of commercial DBMSs for the IBM-PC were evaluated against the criteria outlined above. Unfortunately the packages are complicated and are not easily evaluated in a short period of time. Without familiarity with a system many ultimately simple tasks seem difficult and my evaluation must be viewed as the first impressions of a relatively experienced user of a variety of microcomputer software packages. While I did my best with the access and time available the following evaluation should not be considered definitive and may misrepresent the capabilities of some systems. Appended is a table listing minimum DBMS specifications as well as DBMS features identified as mandatory (M), highly desirable (HD), or desirable (D). In addittion there are specifications for a number of commercial software packages available for the IBM-PC given for each of the features in the table. The DBMSs evaluated are discussed below. There is no one fully satisfactory package, however one does meet the specicfications listed above.

Aladin

This evaluation is based on extensive use of the systemn to set up and use a multiple file data base for application to a soil survey project. **Aladin appears to be the easiest and most flexible system to use for ad hoc retrievals,** it has the easiest simple report generating facility for multiple file (up to 32 simultaneous files) access and provides for sophisticated report formating with somewhat less ease than R-Base 4000 but greater ease and somewhat less flexability than d-Base III or Revelation. User interface is via menu and prompt driven access which can not be by passed, although as with Lotus 1-2-3 a series of responses can be given in one sequence and executed from buffer. Aladin lacks a system command language but does offer non-interactive macro facilities. It also provides a Pascal interface and programming utilities (at extra charge) for the production of a system-executable Pascal program library for more sophisticated applications. The use of a macro processor, like ProKey from RoseSoft, can provide interactive macro applications. Aladin appears to be superior for use by infrequent or unsophisticated users and by programmers with some facility with Pascal. It is hampered by inadequate documentation for more sophisticated tasks. It is not as flexible as the other programs for intermediate users and its speed of processing for interactive data entry and editing is the slowest of the systems tested. **It meets all of the Mandatory system features and the largest number of the Highly Desirable category.**

R-Base 4000

This evaluation is based on extensive reading of the documentation and one session with the demonstration disk provided by the manufacturer. **R-Base 4000 is one of the easier DBMSs to use for ad hoc retrievals, it has the easiest and most flexible report formatting capabilities for sophisticated reports,** and it provides a combination of command and prompt driven facilities. It lacks a system programming language but can provide non-interactive macro execution of stored commands. It also provides an interface with a high level language (at extra cost) for sophisticated applications. R-Base has execellent documentation and is esily learned but it can only access two files simultaneously and it **fails to meet the Mandatory requirement for the use of virtual rather than real file constructs for multiple file access. It has a number of limitations in the Highly Desirable category of system provided features.**

d-Base III

This evaluation of d-Base III is based on a review of the program documentation, one session with the system, past use of d-Base II, and on discussion with users of d-Base III at the O.I.P. It should not be considered in any sense definitive or comprehensive. d-Base III is a significant improvement over d-Base II but is not as easy to use for **ad hoc retrievals as Aladin or R-Base 4000, its report formatting capabilities for simple reports is comparable to R-Base 4000 but sophisticated reports require much more effort.** It provides a combination of command and prompt driven facilities although the prompt

system does not appear as effective as R-Base 4000. d-Base III has a relatively powerful system programming language which can be used to generate interactive system-executable utilities but this requires programming skill. d-Base III is well suited to the intermediate user with some programming skill but its system language is not powerful enough for some of the more sophisticated applications. It does not offer an interface to high level languages. It can have up to 10 data files open and can use up to 7 index files (these must be split between a maximum of 15 open files). Its speed of operation for data entry and editing is relatively fast. **It fails to meet the Mandatory requirement for importing multiple line records from files and has a number of limitations in the Highly Desirable category of system features.**

Revelation

This evaluation of Revelation is based on extensive reading of the documentation and one session with the tutorial provided. **Revelation has the most powerful internal programming language of the DBMSs evaluated but it is somewhat more difficult to use for ad hoc retrievals and reports than d-Base III.** It provides a combination of command and prompt driven facilities although the prompt features are limited and less effective than d-Base III. The system programming language is an enhanced Basic (significantly more powerful than d-Base III) and it is compiled and stored for execution as object code by the system. It does not offer an interface to other high level languages. Revelation has no limitations on capacity or simultaneous file access other than those imposed by the hardware. **It fails to meet the mandatory specification for a system provided statistical utility for Min, Max, and Mean and provides a comparable number of the Highly Desirable system features to d-Base III and R-Base 4000.**

CONCLUSION

It would appear that, with the use of the Pascal interface and program utilities available at extra cost, Aladin provides the greatest flexibility for both; ease of ad hoc access, analysis and retrieval and sophisticated programming capability. Aladin is, however, poorly documented for the more intermediate user and may have the possible limitation of limited capacity in numbers of fields (512 per data base) and records (65,000 per file or 16 mega-bytes of data) although data bases of that magnitude more properly belong on mini or main-frame computers.

APPENDIX 1

Data Base Comparison Chart

M: mandatory, HD: highly desirable, D: desirable
+: feature present, -: feature not present

**: a mandatory feature has not been provided as a preprogramed utility by one of the DBMSs
***: a mandatory feature cannot be met by one of the DBMSs

With the exception of two mandatory features, all of the DBMSs evaluated below can provide the features listed. The difference in desirability for soil survey applications lies is in the degree of programming skill required on the part of the DBMS user. Features listed as being present are provided as executable functions within the DBMS and do not require the programming of executable utilities or macros. It should also be noted that due to a lack of time and ease of using the documentation some entries under d-Base III are listed as question marks and presumed to be not provided.

DATA BASE COMPARISON CHART

		Aladin:	dBase III:	RBase.:	Revelin:
User Interface					
Menu	HD	+	-	-	-
Command	HD	-	+	+	+
Prompt	HD	+	+	+	-
Macro exec	HD	+	+	+	+
Data Structure					
Specifications					
Max. files					
simultaneous access	2	32	10	2	unlim.
/data base	10	32	unlim.	40	unlim.
Variable field length	HD	+	?	-	+
Max. fields					
/file	100	512	128	400	unlim.
/data base	460	512	unlim.	400	unlim.
Max. records					
/file	50K	64K	1G	2.5G	unlim.
/data base	150K	20M	unlim.	100G	unlim.
Max. keys/relation	20	192	7	400	unlim.
Max. memory variables	20	512	256	0	unlim.
Field types					
character	M	+	+	+	+
integer	M	+	+	+	+
decimal	M	+	+	+	+
money	D	+	+	+	+
date	D	+	+	+	+
time	D	-	+	+	+
logical	D	-	+	-	+
Multiple drive file access	HD	+	?	-	+
*** File Merges					
virtual	M	+	+	-	+
File restructuring					
Adding/deleting fields	M	+	+	+	+
Adding/changing indexes	M	+	+	+	+
Input Specifications					
Methods					
Screen forms	M	+	+	+	+
Prompt	D	-	+	+	+
*** File (multiple lines/record)	M	+	-	+	+
Features					
Auto Advance	D	+	+	+	+
Validity Checks					
Range	D	+	-	+	-
Data type	HD	+	+	+	-
Wildcards	D	+	-	-	-
alpha-num. form (##CCCC)	D	+	-	-	-
Definable Null Entries	D	-	?	+	+
Record Duplication	D	+	?	-	+
Error Recovery					
Within field	M	+	+	+	+
Within records	M	+	+	+	+
Within relation	HD	+	+	+	+

		Aladin	dBase III	RBase	Revelation
Edit Specifications					
Methods					
Full screen	D	-	+	+	+
Single record	M	+	+	+	+
Screen form	HD	+	+	+	+
Line	D	-	+	+	+
Global	M	+	+	+	+
approval/no approval	HD	+	?	-	-
validation	D	+	?	+	+
masking	HD	+	?	-	+
From file	M	+	+	-	+
validation	D	+	?	-	+
masking					
partial field match	D	+	?	-	+
Record selection					
Command	HD	-	+	+	+
screen form	HD	+	-	-	-
prompt	D	-	-	+	-
Error recovery					
within field	M	+	+	+	+
within record	HD	+	+	+	+
Selection or Query					
no. of files	2	32	?	2	unlim.
operators					
no. of linked	5	256	?	10	unlim.
types					
=,><,<,<=,=>,>	M	+	+	+	+
Boolean logic	M	+	+	+	+
Save defn.	HD	+	?	-	+
Wildcards					
Strings	M	+	?	+	+
Alpha-numeric form	D	+	?	-	+
Calculations					
calc. across files	D	-	?	-	+
no. of linked	10	256	?	?	unlim.
operators					
+,-,/,*,	M	+	+	+	+
trig, log, mod, etc.	D	-	+	-	+
Stastics					
Grouping	HD	+	-	-	-
Count, Total	M	+	+	+	+
** Min, Max, Mean	M	+	+	+	-
Std. Dev.,	HD	+	-	-	-
Regression, Correlation	HD	+	-	-	-
Contingency, Cross-tabulation	HD	+	-	-	-
Report Generation					
Capabilities					
Mutiple field sort	HD	-	+	+	+
Aggregates	HD	+	?	+	+
Temporary calculations	M	+	?	+	-

		Aladin :	dBase III :	RBase :	Revelin :
Statistics					
Mean, Max, Min, Count	M	+	+	+	C.T
Std. Dev.	HD	+	-	-	-
Frequencies	M	+	-	-	-
Tables	HD	+	-	-	-
Graphs	HD	+	-	-	-
Cross-Tabulations	HD	+	+	-	-
Merge with Word processor	HD	+	?	-	-
Query Language					
Multiple file access	HD	+	?	-	+
Use temporary calculations	HD	+	?	-	+
Execute stored macros	HD	+	?	+	+
Report Formatter/Generator					
Headers/Footers	HD	+	+	+	+
Text insertion and headings	HD	+	+	+	+
pagination	HD	+	?	+	+
printer control	HD	+	?	-	-
page size					
width	M	+	+	+	+
length	HD	+	+	+	+
Screen dumps	HD	+	+	+	+
Special Features					
Macro execution or executable utilities	M	+	+	+	+
Custom prompts	HD	-	+	+	+
Custom help screens	HD	+	?	-	+
Interface to high level language	HD	+	-	+	-

DATA FILES OF LONG TERM IMPORTANCE

by K. Bruce MacDonald
with sections by P.A. Benson (Parks Canada) and
M. Brklacich *et al* (Guelph Land Evaluation Project)

Introduction

Resource inventory projects result in the collection of large quantities of field and laboratory data which is organized analysed, summarized and usually stored. For the most part the information can be grouped onto two types: viz. data which refers to an area or parcel of land or delineation and data which describes or characterizes a specific site.

From the standpoint of the inventory project and report, it is generally the area data which is the prime focus of interest. I would suggest that one of the primary objectives of a mapping resource inventory mapping project is the *DELINEATION OF RELATIVELY HOMOGENEOUS AREAS ACCORDING TO CRITERIA ESTABLISHED WITHIN A CLASSIFICATION SYSTEM*, e.g. CSSC, ELUC, Biophysical, etc. Furthermore, the rationale for delineating and characterizing homogeneous areas is to provide data to assist in resource management and planning. Each classification system identifies areas and properties which are appropriate for a range of applications.

Within this context, site information is collected for the purpose of interpreting and better describing an area. In reality, much of the raw data associated with an inventory project IS SITE SPECIFIC. Site information can be collected as part of:
(i) legend development
(ii) mapping - establishment and confirmation or boundaries
(iii) representative data collection to provide detail
(iv) characterize the variability within and between homogeneous areas.

Horizon (or depth and height) information is frequently collected at sample sites to assist in characterizing the site and through aggregation, generalization or other techniques to characterize the area.

Use of Computers to Store and Manipulate Soil Inventory Data

In former times when data from resource inventories were processed and manipulated by hand the data and analyses tended to be focussed on the specific project. The entire data collection and summary procedure was to provide data appropriate for presentation on the project map(s) and report.

Developments in survey methods and techniques have led to forms of sampling other than free survey and have also led to the collection of data of increasing amounts and complexity.

At some point in this development the organizational and analytical power of the computer was sought to manage the data. A positive feedback cycle resulted the computer generated the interest in collecting more and more complex types of data. The interest, however, was still primarily dedicated to the objectives of the survey project to delineate and characterize homogeneous units.

The use of the computer imposed some constraints on the ways in which the surveyors could record data; it required more discipline, more organization - in short - more work, however the benefits (for those who have chosen to enjoy them) have been greatly increased flexibility and power of analysis. For many others these benefits are not apparent, only the frustrations of the added discipline and constraints.

One possibility that computerized information offered was the ability to store large amounts of raw (disaggregated) data in an organized and defined form for applications over a longer time frame. One of the features of an organized, defined computerized data set is that the only restrictions on how the data may be used are
(i) obtaining access to the data and
(ii) obtaining accurate documentation on the data formats and organization
(iii) the capabilities of the programmer and computer systems

The types of uses may encompass more precise definitions of traditional applications or they may be uses not anticipated at the time the data were collected.

It is the possible types of data required for these longer term uses (both at a project level and at a level which encompasses many projects - national) which I wish to address in this presentation. Following sections will provide a comparison between data needs for analyses specific to a project and data longer term data uses; an example of developing computer files for long term analysis (Parks Canada) including comments and perceptions of the users; some examples of the concepts of a national file (topo surveys and mapping); some potential applications of national files (with a comment from the land evaluations group); some possible data sources and suggested organization; and finally some concerns about the organization format and specification of national files.

Regardless of the inventory project, procedures are required for data management during the course of the project and to

assist in the preparation of associated reports and maps. These can include some administrative types of files such as recording daily progress, areas sampled, transects run and id numbers assigned, label codes for sampling tags, etc. For all these applications a computer may be used to carry out the repetitive routine tasks. In addition, there is a relatively large quantity of site and sample data which is collected to support the mapping program. It is this latter type of data which I will be discussing.

Computerized Data Files for Short-term Use During The Course of a Project

The following generalizations apply to data and data handling procedures used during the course of an inventory project.

Function
-to replace procedures which were formerly carried out manually; such as, sorting (classifying), summarizing, and analysing.

Products
-a report describing the classification and characteristics of the project area including interpretations, a map, and legend.
-an archive of data in original form which can be used to confirm or verify conclusions and interpretations in the report i.e. be analysed again in the same fashion.

Focus
-local project specific i.e. 1 report and 1 map (series)
-singular in intensity namely the level and scale at which the survey was designed and the data were collected.

User Group
-soil surveyors i.e. users who are sensitive to the nature and limitations of the data.

THIS IS A STATIC SERIES OF DATA FILES WHICH REMAIN CONSTANT UPON COMPLETION OF THE PROJECT.

Life Expectancy
-the active useful life of the data runs through the course of the project and includes the period of active use immediately following completion of the project and publication of the report. After that, the data files fall into disuse and should either be archived properly (for longer term use) or be discarded.

Computerized Data Files for Long Term Use

Function
-to provide a reliable source of disaggregated (site) data from which
(i) different areal inferences can be made and
(ii) different classifications, analysis and summaries can be carried out.

Products
-there are no specifications or limitations on the possible products

Focus
-undefined, ranging from
(i) large scale for detailed analyses hopefully when augmented with additional sample data
(ii) very small scale for national or regional analysis
(iii) may be combined with other (sector) data sources such as AES, environmental, watershed, census

User Group
-surveyors, planners, correlators, ...modellers
-includes many people who are not familiar with the data and its limitations
-some users want actual data, MOST WANT REPRESENTATIVE DATA

Requirements
-fixed format rigorously defined
-better data integrity
-specific data rather than ranges or classes which are appropriate for the project and classification schema under which they are collected but are frustrating to inappropriate for broader long term use.

GENERALLY THESE FILES WILL BE DYNAMIC IN THE SENSE THAT NEW DATA WILL BE ADDED ON AN ONGOING BASIS either to broaden or intensify the areal coverage or for monitoring and time series studies.

Life Expectancy
-if these files are archived securely and with proper documentation of formats and origin, they wil remain useful for all applications where the data type and intensity are acceptable. If they are properly updated, they can remain relevant and useful for the forseeable future.

Data Files For Long Term Use Within a Defined Project - Parks Canada

EDP APPLICATIONS IN THE WESTERN REGION OF PARKS CANADA, CALGARY

A STATUS REPORT PREPARED BY P. A. BENSON FOR THE CANSIS COMPUTER WORKING GROUP OF ECSS, TO BE PRESENTED AT GUELPH, ONTARIO ON NOVEMBER 26, 1984 AT A SESSION ENTITLED: CURRENT AND PLANNED COMPUTER APPLICATIONS

HISTORICAL

Back in the early 70's, Parks Canada Calgary was looking for an agency to computerize its growing resource database. Because SRI (as it was known then) was available, because it was willing to commit pedological expertise to the field teams, and because we were not prepared to comprehensively evaluate all alternate systems, the CanSIS system was selected.

DATABASES

Warden Wildlife

As a replacement for McBee punch cards, the computerized system we initiated in 1972 was to standardize information collected by park wardens as well as accompany the upcoming resource inventory. The system had to accommodate seasonal abundance and distribution data in mountain and boreal environments of all wildlife species (ungulates, carnivores, birds, etc.) acquired by regular surveys as well as incidental observations. For the most part we are the collectors and users of this database. It is a growing database; approximately 62,000 records.

Biosphysical

In response to recommendations emerging during the public hearings on Preliminary Master Plans for the Mountain Parks, our Minister announced a policy to acquire a resource inventory for each national park as an essential step in preparing park master plans. A modified biophysical (ecological land classifcation) approach was the adopted method to provide an integrated landform, soil, vegetation and wildlife inventory at a scale of 1:50 000 with data presented in map and report format. We commissioned the Canadian Forestry Service, Canadian Wildlife Service, Agriculture Canada, Alberta Institute of Pedology, and the Atmospheric Environment Service as the lead agencies in obtaining this data according to our terms of reference.

Due to the massive scope of the resource inventory program in Banff and Jasper - covering 7500 sq mi of complex mountainous terrain - the early involvement of a computer system for storage, manipulation and retrieval of data was desired. Commencing 1975, we funded the refinement and expansion of CanSIS to meet our inventory needs. The initial intent was data support with the capacity to provide data management and manipulation to the field researchers. We did not achieve our goal of support to the field researchers, but are now working towards maximizing the data support, as a tool the field land manager uses in resource management and planning responsibilities.

Our biophysical resource base has three, relatively static, principal components. The first is the cartographic subsystem for handling data in map form and manipulating these to produce interpretive maps for specific uses. For example maps showing areas with limitations to aid in selecting campgrounds or areas along highway corridors where wildlife mortality is high can be prepared.

The second and third components utilize the data management system of CanSIS to handle the extended legend (parameters applicable to the entire polygon) and the site measurements. Here one can dissociate the map symbol into its parameters as they appear on the legend, as well as determine areal extent, or construct interpretive classes by applying various algorithms, and combine this with data from site specific files (e.g. pH, Atterburg limits).

RESOURCE MANAGEMENT

In anticipation of the completed inventory a national resource management process formalized the analysis and interpretation of the inventory data by the designated end user. Resource management as Parks Canada uses the term does not end with the collection of information. Rather, that begins the in-house responsibilities of understanding their relationships, the processes that affect their status, the ability to sustain impacts, and their significance in order to achieve our dual mandate of preservation and use. The subsequent analysis is performed to develop a plan for the management of national park resources, to indicate to master planners constraints that must be considered to maintain the integrity of the parks' resources. The analysis also identifies procedures for monitoring; or at a more finite or problem-solving level, the procedures for implementation, mitigation and evaluation.

Data stored in CanSIS are made accessible to Parks Canada personnel to facilitate land management decisions. Most park wardens, naturalists and their managers have learned to carry out data selection and display procedures interactively using simple software packages. Many are being trained to use more powerful software packages as more sophisticated techniques, but on applying and interpreting the resource data relevant to the problem at hand, and the extent site specific data can be extrapolated to broader ecological units.

OFFICE AUTOMATION

Our computer environment extends to office automation; we are participating in the field trials of OCRA. Department of Communications recognized a $6 billion annual trade deficit for office electronics and equipment by the mid-80's and in 1982 began a program to stimulate a Canadian source of supply for integrated office systems and to encourage the use of office system technology within government. Phase II is their $12 million field trial utilizing new technologies and assessing their behavioural and social implications. We use a fully integrated (no menus) system for mail, filing, editing, calendar and calculator. There are 24 terminals in the regional management to professionals to line managers to clerical support. All staff are encouraged to learn and utilize the system. The major drawback to OCRA is its user-driven approach in developing the system, with the result we are far behind off-the-shelf, state-of-the-art packages.

MILESTONES

May 78 - the first of compulsory semi-annual meetings

Jan 79 - pilot project to test the capability of CanSIS in manipulating resource inventory data
Nov 79 - remote TSO access; computerized legend available in batch mode

May 80 - park wardens saw for themselves the Ottawa operation; pilot finished
- * Savoie/Switzer report "CanSIS or CGIS for Parks Canada?"

Apr 81 - first terminals installed at park offices
May 81 - EASYTRIEVE training offered
Nov 81 - SAS added
- * Day/Tomlinson report "Does Parks Canada require computers to handle resource (including geographically referenced) data?"

Apr 82 - Pacific Rim National Park (last park) added
Nov 82 - enhanced extended legend available on TSO

Jun 83 - site specific soil & vegetation (Banff/Jasper) biophysical data available on tape; soil detail available on TSO

Nov 84 - * Welch/Simmons study to examine opportunities for local processing as an adjunct to central facilities and to recommend generic configurations for a site

* Parks Canada HQ have undertaken several national consultant studies to examine the use of computers in natural resource conservation.

SUMMARY AND FUTURE

Many problems were encountered along the way. Unrealistic promises were made that could not be kept; expectations were too high; we suffered during staff changeovers and as was the cause of many other failures, there was inadequate definition of needs. The spirit of a joint project persevered and carries us toward overcoming many of these issues. Although great emphasis has been placed on the requirement for sound data and the computer skills to manipulate, the process of computers in resource management must still be considered evolutionary.

We are now experiencing the previously forecast problems of monitoring and updating of the database, as well as trend analysis as changes with time occur. There is a need to overcome the inherent hesitancy to shun data which the user, the park warden, had no hand in collecting, and to replace it with an understanding and sense of responsibility to utilize the knowledge the database represents in more effective land management decisions.

Our short term goals are:

1. realignment of the Warden Wildlife Files to reflect more statistically-valid information;

2. continued testing and refinement of the extended legend; which may involve additional fields, possibly additional fieldwork

3. to commence testing of the manner in which site-specific data has been converted to canSIS formats and to identify improvements;

4. to pursue micro-computer manipulation of cartographic and data management subsystems.

Over the long term we will:

1. update, at regular intervals, the biophysical database;

2. use the classification system the extended legend now represents to develop management tools to aid decisions resource conservation is expected to make (e.g. add soil climate data for each ecosite, develop algorithms to apply construction constraints to various soils, develop ecologically defensible algorithms for soil and vegetation considerations for rehabilitation)

Data Files For Long Term Use at a Broad National Level

1. Soil moisture assessment

Currently R. de Jong is carrying out a project of soil moisture assessment across the important soil areas of Canada. For this he requires the following types of data at known and representative locations:
-Soil taxonomy at the subgroup level
-Horizon designation and depths (these must be continuous
-Mechanical analysis
-Organic carbon content
-Bulk density
-Soil moisture content at 1/10, 1/3, and 15 atmospheres suction.

This is the ideal data content for each site. The minimum amount of data is taxonomy, horizon designation and depths and mechanical analysis.

2. Crop modelling

Crop modelling activities in Manitoba are aimed at providing an indication of the potential for wheat production on the various generalized landscapes first in Manitoba and then across the great plains region. The data requirements are:
-a grouping or classification of the area into relatively homogeneous landscape units
-Soil moisture at seeding by layer
-Nitrate nitrogen by layer

If these are not available they must be estimated from available water holding capacity, field capacity, wilting point and bulk density or alternatively from mechanical analysis, organic carbon content and bulk density.

3. National Land Evaluation

REQUIREMENTS AND USE OF LAND RESOURCE DATA IN APPLIED LAND EVALUATION SYSTEMS[1]

M. Brklacich,[2] R. McBride,[3] M. Miller,[3] and B. Smit[4]

1 INTRODUCTION

1.1 The Land Evaluation Group and Its Activities

The Land Evaluation Group (LEG) is an interdisciplinary project team at the University of Guelph conducting applied research in the fields of land resource assessment and land use evaluation. Its overall objective is to develop information bases and analytical procedures which will assist resource analysts and policy formulators evaluate the long-term adequacy of the resource base under a wide range of conditions.

The LEG has developed a land evaluation system for Ontario (LEM 2) and applied it to several issues. This system is designed to assist policy formulators in two ways. First, it provides ready access to a land resource information base which includes consistent and province-wide coverage of data on the availability of different types of land for agricultural production and on the productivity of these lands for all major crops. Second, the system can integrate these data on resource availability and productivity with data on socio-economic conditions and requirements for land use (e.g. food production targets, land requirements, non-agricultural uses, regional development initiatives, and so on), and thereby evaluate the prospects for food production. By running the LEM 2 system under different scenarios, it is possible to examine the effects of changes in conditions relating to land, climate, or socio-economic conditions on production opportunities.

The LEM 2 system has been applied to a wide range of issues including:

- estimating the availability of land for agricultural production for Ontario counties, regional municipalities and districts,

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[1] Prepared for the Annual Meeting of the Expert Committee on Soil Survey, CanSIS Working Group, Guelph, Ontario, November 27, 1984

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[4] Department of Geography and LEG, University of Guelph

- examining the long-term opportunities for sustainable agricultural production,

- assessing the effects of alternative erosion control practices on food production potential,

- analyzing the impacts of alternative scenarios for urban expansion on food production prospects, and

- evaluating the effects of changes in the availability and quality of land resources on the feasibility of meeting projected targets for food production.

The LEG is currently working with the Land Resource Research Institute (LRRI) in designing a Canadian Land Evaluation System (CLES). The broad purpose of the CLES is to facilitate assessments of the long-term opportunities for food production under alternative sets of conditions. The issues this system will need to address are in many ways similar to concerns already examined by the LEM 2 system, and therefore the CLES will embody many of the resource assessment procedures implemented in the Ontario system. Out of necessity the CLES will operate at a broader scale than the LEM 2 system.

The LEG is also co-operating with the Lands Directorate, Environment Canada to determine the feasibility of classifying land resources in such a way that it would be possible to evaluate their use for forestry and for agricultural production.

These evaluation systems can be constructed only if suitable data on land resouces, productivities, production levels and so on are available. The major data requirements pertaining to land resources include information on the quality and availability of lands for the production of different types of commodities. In this respect, land evaluation systems represent applications of land inventories and classification systems to resource issues.

1.2 Purpose and Organization of the Paper

The purpose of this paper is to outline the land resource data that are required to implement a land evaluation system. Section 2 provides an overview of the land-related information requirements. Section 3 describes the LEG's experiences in developing a land resource data base for the LEM 2 system. Section 4 outlines the land resource requirements of the CLES and the prospects for compiling these data from existing resource inventories.

2 LAND EVALUATION SYSTEMS AND LAND RESOURCE DATA REQUIREMENTS

The LEG and land evaluation systems represent some of the many users of land resource data that are compiled by Soil Survey Units. As with many users, the LEG's requirements for land resource data are however rather specific. That is, the development of a land evaluation system is to a large degree dependent upon data describing those characteristics of the land base which affect productivity and production potential rather than a full characterization of all soil properties. Regardless of geographic scale (i.e. LEM 2 versus the CLES), the LEG has found that it is essential to delimit lands that are relatively homogeneous with respect to:

- current productivities for major agricultural uses,
- susceptibility to environmental change (either degradation or upgrading), and
- effects of environmental change on productivity.

Consultations with potential users have indicated that it is crucial that the land resource data include an administrative dimension such as census districts. Once the criteria upon which the land base is to be classified have been clarified, then estimates of the availability of land for food production need to be compiled.

Unfortunately some of the land resource data that are required for land evaluation purposes have not been routinely collected during soil surveys. Hence, the LEG has had to derive these required data from sources that are more readily available.

3 THE LAND RESOURCE DATA BASE AND THE LEM 2 SYSTEM

Development of the LEM 2 system commenced in 1979. At the outset, it was apparent that reliable estimates of the extent to which crop yields varied given differences in land quality and climate were not available on a province-wide basis. Therefore, one of the major thrusts in the LEG's research program at that time was the development of a crop productivity model which could be implemented using available land resource data.

The crop productivity model used in the LEM 2 system (McBride, 1983) estimates long-term crop yields as a function of plant-available water at the onset of the growing season (AW), moisture inputs during the growing season from precipitation, ground water sources and irrigation, potential evapotranspiration (Ep) and corn heat units (CHU).

Data relating to moisture inputs, Ep and CHU's are readily available. Estimates of AW however are not available and therefore these have to be inferred from other sources. For virtually all agricultural regions in Ontario, it is reasonable to assume that soil moisture will be fully recharged prior to the beginning of the growing season and therefore plant-available water holding capacity (AWHC) provides a reliable estimate of AW. Given this assumption, it was then possible to define lands which are relatively homogeneous with respect to AWHC and management limitations by aggregating CLI classes and subclasses (Table 1). This structuring of the land types is compatible with data stored in the Canada Land Data System (CLDS), allowing the LEG to estimate the availability of each land type throughout Ontario.

The land resource and productivity data bases developed for the LEM 2 system have proven to be extremely useful. The Regional Development Branch, Agriculture Canada has used these data to assess:

- the extent to which Ontario's land resources are currently being used for agricultural production,
- the productivity of different types of land for major crops, and
- the opportunities for sustainable agricultural production in different regions of Ontario.

The major limitations associated with these data for land evaluation purposes are:

- it is not possible to estimate the extent to which erosion would occur if soil conservation is not practised,
- the CLI classification system does not distinguish between lands which have and have not been artificially drained, and
- it is unlikely that soil moisture would be fully recharged during the winter period in much of the Great Plains Region.

The LEG has had some success in overcoming the limitations relating to erosion and to drainage by supplementing the original data base with information from other sources.

TABLE 1: LEM 2 LAND UNITS

LAND TYPE	CLI CLASS & SUBCLASS	BIOPHYSICAL CHARACTERISTICS
A	1, 2D, 2-3F, 2M, 2T	- well-drained loamy soils - relatively level topography
B	3-5D	- fine-textured clays - moderately well to well-drained
C	3-5M, 3-4P, 3-4R	- coarser-textured sands and gravels, or shallow soils (less than 1 metre to bedrock) - well to excessively well-drained
D	2-3W	- imperfectly drained soils
E	4-5W	- poorly to very poorly drained soils
F	5-6P, 5-6R, 5-6T	- extremely stony or shallow soils
G	3-4T	- well-drained loamy soils - rolling to hilly topography

4 THE CANADIAN LAND EVALUATION SYSTEM: REQUIREMENTS FOR LAND RESOURCE DATA AND PROSPECTS FOR USING EXISTING INVENTORIES

The LEG is currently designing a Canadian Land Evaluation System (CLES). A review of crop productivity models and estimates indicated that the FAO/LRRI crop productivity model (Stewart, 1981) has many characteristics which are desirable for broadscale evaluations of Canada's resource base including potential for expanded crop coverage, applicability to all regions of Canada and the capacity to estimate yield response to environmental stresses.

The FAO/LRRI crop productivity model is comprised of two components (Figure 1). The photosynthetic component of the model estimates the capacity of a particular crop to capture and transform incoming solar radiation into biomass, and the useable portion of the plant is reported as constraint-free dry matter yield. The agroclimatic-edaphic component estimates the extent to which climatic and soil conditions (e.g. capacity of the soil to retain and release moisture to plants and likelihood of a crop maturing and successful harvest) would reduce constraint-free yields. Anticipated dry matter yields represent yield levels that could be expected over the long-term given optimal farm management

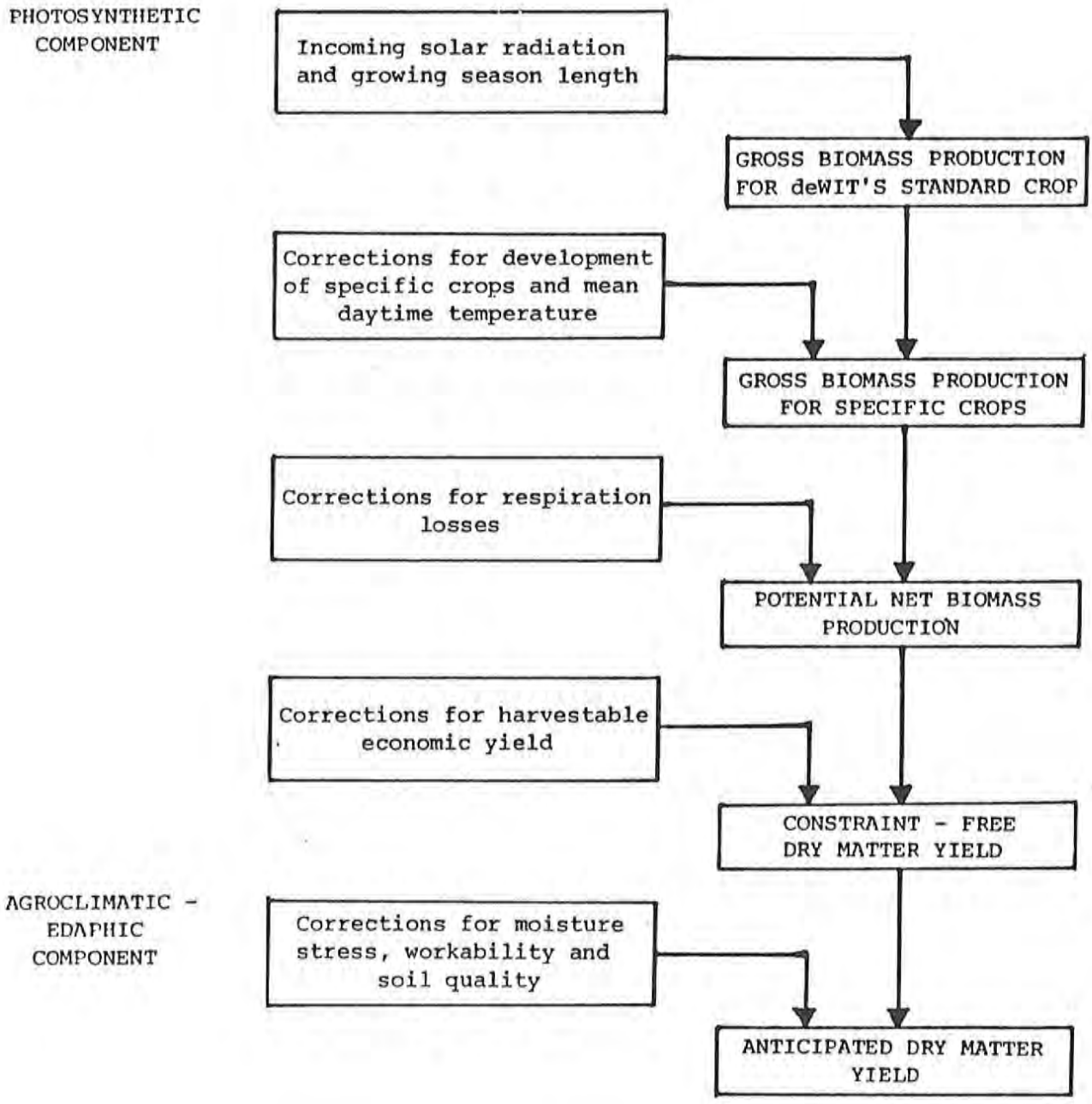
The photosynthetic component of the FAO/LRRI crop productivity model is suitable for use in the CLES. The general approach used to estimate the extent to which agroclimatic and edaphic conditions constrain crop yields is appropriate, but the intended use of the CLES requires that the procedures and coefficients be modified. In particular, field water supply should be estimated on a seasonal basis, available water holding capacity should be used in quantifying edaphic constraints, and the moisture stress factor should be extended to include surplus as well as deficit conditions (LEG, 1984).

Given the recommended modifications to the FAO/LRRI crop productivity model and the envisaged applications of the CLES (LEG, 1983), the land resource data should meet the following criteria.

National Coverage: Geographic coverage of land quality and land availability must extend to all current and potential agricultural regions of Canada.

Photosynthethic Variables: Implementation of the photosynthethic component of Agriculture Canada's crop productivity model (Figure 1) requires data on maximum and minimum air temperature, atmospheric vapour pressure, windspeed and incoming solar radiation. These data are either used directly or to derive required climatic data such as growing season length.

FIGURE 1: OVERVIEW OF THE FAO/LRRI CROP PRODUCTIVITY MODEL



Workability Parameter (WP): It is an agroclimatic constraint which estimates the probability of acquiring the required number of workdays for a successful harvest and is based upon a comparison of length of growing season to a crop's time requirements for maturing, and a soil moisture budget developed by Baier et al. (1979).

Moisture Stress Factor (MSF): It estimates the extent to which agroclimatic and edaphic conditions combine to restrict crop yields. For broadscale land evaluation purposes, MSF can be estimated as a function of the sensitivity of specific crops to water stress (Ky factor), soil moisture deficit or surplus (SMDS) conditions throughout the growing season, and coefficients to relate SMDS conditions to seasonal moisture requirements of particular crops (a, b coefficients). The Ky factor and a, b coefficients are estimated and available. SMDS can be estimated as a function of plant-available water at the beginning of the growing season, plus moisture inputs during the growing season (i.e. rainfall, irrigation, and contribution from ground water) less potential evapotranspiration (PE). Data on moisture inputs and PE are often available. However data on plant-available water, or available water holding capacity (AWHC)[1] which can be used to estimate available water at the beginning of the growing season, are not collected routinely during soil surveys. But at least two procedures can be used to estimate AWHC. A water retention model (McBride and Mackintosh, 1984a) can be employed, but this requires data on soil texture, volume of coarse fragments greater than 2mm, dry bulk density (all by horizon), and depth to ground water table at the beginning of the growing season. Alternatively, AWHC can be inferred from standard agricultural land capability ratings (McBride and Mackintosh, 1984b).

Topography: Topography is important as it has considerable influence on soil loss and long-term productivity. Development of crop rotations which will mitigate many of the problems of soil erosion will require data on slope length and gradient. At a minimum, data would be required to develop at least four or five categories of susceptibility to

[1] Assumes soil moisture is fully recharged prior to the onset of the growing season. When this is unlikely, then long-term data on precipitation during the post-harvest period could be used to estimate the extent of recharge.

erosion.

Administrative Units: It will be necessary to link biophysical descriptions of the resource base to broad administrative units, perhaps census districts or groups of census districts.

Land Availability: It will be necessary to estimate the current and potential availability of lands with relatively homogeneous biophysical characteristics in each administrative unit.

The LEG's assessment of selected land resource inventories maintained by Agriculture Canada and Environment Canada (LEG, 1984) indicated that much of the land resource information that would be required to implement the CLES could be obtained from the Generalized Soil Landscape Map (GSLM) and associated CanSIS files. The major limitations impeding the immediate use of these resource inventories within the CLES are incomplete geographic coverage, discrepancies in the data included in the extended legend, and in some instances, a lack of consistency in data collection procedures.

It would be feasible to estimate a MSF with the information compiled under the aegis of the Saskatchewan GSLM project. Data on AWHC is recorded for the dominant soil landscape unit in each polygon on the basis of 50mm increments from 50mm to 250mm. Given the intended broadscale use of the CLES, these data along with data on agroclimatic conditions available from the AES would be sufficient for estimating a MSF for the dominant soil landscape unit. However the AWHC has not been compiled for the subdominant area and therefore it would not be feasible to estimate a MSF for these areas. An even more serious limitation restricting the immediate use of the GSLM's outside of Saskatchewan is that the AWHC has not been added to the extended legend. The omission of these data and the absence of the required information on soil properties required to run a soil water retention model make it impossible to develop reliable estimates of a MSF at this time.

The slope and topographic information available from the GSLM's are well-suited for broadscale land evaluation. These data are recorded for both the dominant and subdominant areas, and could be used to estimate the susceptibility of each area to erosion given alternative cropping practices. Crop rotations and other management techniques which would conserve soil and hence maintain productivity levels over the long-term could be inferred. Furthermore, Shelton et al. (1984) have demonstrated the potential for using the slope and topographic information available from a GSLM to estimate the long-term potential for soil erosion.

The polygons on a GSLM tend to be irregular in shape, and do not conform to commonly used administrative regions. The GSLM project for Southern Ontario however has demonstrated that it is feasible to identify a polygon by its constituent enumeration areas, and thereby facilitate the creation of a link between a GSLM and other land or land use information systems such as the Census of Agriculture. This has proven to be extremely useful in compiling estimates of the area currently devoted to major cropping activities. These data, along with data on total area of the polygon and additional information on non-major agricultural land uses and on non-agricultural land uses could be used to compile estimates of the availability of land for agricultural production. While this would require decision rules regarding the distribution of uses among the dominant and subdominant soil landscape units, these generalizations would not be inappropriate for conducting resource assessments at the broadscale. In addition, it should be possible to extend this cross-referencing of the GSLM's and enumeration areas to identify traditional administrative units such as census districts, and develop procedures to estimate the distribution of polygons from a GSLM within a particular administrative unit.

As an interim step, the LEG will construct a prototype nation-wide land evaluation system and much of its land resouce data will be derived from the Land Potential Data Base (LPDB) (Kirkwood et al., 1983). This approach has been adapted for the following three reasons.

First, it is imperative to demonstrate that it is feasible to develop a land evaluation system at the national scale. Use of existing data will limit the issues which can realistically be assessed, but a system which can address only a few issues is much better than no system at all.

Second, application of the prototype system will encourage user evaluation of all aspects of the CLES. This will facilitate the development of a system which provides information in a format that is useable by a wide range of users.

Third, the LPDB represents a useable foundation estimating the required land resource data. It already contains much of the agroclimatic data that is required and output from the photosynthetic component of the FAO/LRRI crop productivity model. The land resource data is however too generalized and therefore these will need to be supplemented with other data sources. The LRRI is currently developing first approximations of the AWHC. The LEG is creating a link between the LPDB and Environment Canada's Rural Land Analysis Program (RLAP) (Manning, 1984), enabling the LEG to estimate the area of each map unit which is available for agricultural production.

The paper has provided an outline of the land resource data that are required to implement a land evaluation system. A full

description of the recommended structure for the CLES and a strategy for compiling the required land resource data are presented in recent reports by the LEG (Brklacich et al., 1984; LEG, 1984). Implementing the recommendations outlined in these reports would require an ambitious research and data collection program. It would appear however that much of the data could be collected under the aegis of established GSLM projects, or derived by creating explicit links among existing information sources. Co-ordination of data collection programs would certainly avoid unnecessary duplication of efforts, and enhance the overall quality of the information available for broadscale land evaluation purposes.

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National Files from Another Agency - The Surveys and Mapping Division of National Files of Long Term Importance

The surveys and mapping division of Energy, Mines and Resources has dealt with the problem of compiling and maintaining a national level data base of land information in their National Topographic Series of Maps.

Their objective has been to produce complete national coverages at acceptable resolution of features, accuracy and reliability within ***ONE COMMON DATA BASE STRUCTURE***. They have chosen to support two national levels of coverage, namely, the 1:250,000 for complete national coverage and 1:50,000 for selective coverage. All larger scales are provincial responsibilities. The standard formats for these coverages and the larger scale provincial ones are reviewed by the Canada Committee on Surveys and Mapping. They have also addressed the topic of exchange of these data in electronic format and have developed recommended standards for them.

In contrast, the soil inventory maps have no consistent national level coverage with the possible exception of the 1:5,000,000 and the developing 1:1,000,000. There appears to be little to no agreement on map scales for national use and consequently a designation of scales relevant for local and regional application. There also does not appear to be the same level of consistency in organization of the data associated with the maps. It would seem that as we move to long term data bases (simply by the fact that in order to computerize the data it will be more consistent and better defined), we should take the steps necessary to establish consistent data formats for national level files and to define clearly the data which should be compiled and archived nationally and indicate that all other data types are of local interest only and should be managed as such.

Requirements for Long Term Data Files

Complete definition of these requirements will require time and extensive debate. The following suggestions are offered as a starting point for the discussions:

1. Long-term data requires a *managed archive facility*. It is not acceptable to assume that every surveyor or every unit will automatically look after his own data. There are too many other local priorities. A central archive with a clearly defined library function must be supported and networked to the local units. This central archive will be

responsible for establishing mutually acceptable data formats, maintaining documentation on the data and their origin, discarding data which is no longer relevant.

2. As the long-term files start to build the concept of maintaining and renovating data bases should receive more attention. As inventory at some level is completed across major areas of Canada, the inventory function logically shifts to maintaining and updating the data bases. Monitoring data will be input to allow time series analysis, completed inventories will have an active follow-up program to verify their accuracy and to establish when major updates and revisions are required. Resurveys of an area will be carried out by using the existing data bases and hopefully their organization and adding to them so that the concept of dynamic data bases for local application as well as national becomes reality.

3. Specific tasks for the CanSIS-Computer Working Group resulting from this discussion are:
(i) to review existing CanSIS files and recomend which data should be mandatory, which are optional and/or redundant. This will be primarily for the Soil Data (DETAIL) file. The result will be a recommended format for site data to be archived nationally.
(ii) to establish a recommended coverage and sample procedure for collecting site data for archive (in contrast to the current somewhat random and biased one).
(iii) to consider the establishment of a soil map unit file and its content and forman (possible in the form of an expanded soil names file).

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Proceedings of the

SOIL CLASSIFICATION WORKING GROUP

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Chairman

Soil Classification Working Group

PROPOSAL OF IMPROVED CRITERIA FOR THE GLEYSOLIC ORDER

J.A. McKeague and C. Wang

INTRODUCTION

Dissatisfaction with criteria for distinguishing soils of the Gleysolic order from Gleyed subgroups of other orders has been expressed at many CSSC and ECSS meetings since 1970. Research to improve the criteria was assigned a high priority at these meetings in 1979, 1980 and 1981. Such work was initiated in 1981 with a field trip focused on gleyed soils in Manitoba and southeastern Saskatchewan, description and sampling of "problem" gleyed soils in B.C., and review of relevant literature. A preliminary report was distributed in 1982; it included some suggestions of improved criteria. These suggestions and others were tested by pedologists in several provinces. This report includes proposals for improvement that came from many sources across the country. We thank all those who contributed suggestions, criticized the preliminary report, and tested the proposals in the field.

RATIONALE

The concepts that provide the foundation upon which the proposals were built are summarized.

1. The concept of the Gleysolic order follows from our interpretation of the classification system (Canada Soil Survey Committee, 1978). It is stated (p. 16) that, "Taxa at the order level are based on properties of the pedon that reflect the nature of the soil environment and the effects of the dominant soil forming process". In the case of Gleysolic soils, the nature of the soil environment is wet for appreciable periods during the genesis of the soil, and the dominant soil forming process is gleysation (reduction or intermittent reduction and oxidation) close to the surface.

   Thus, in our view, the first step toward improved classification of Gleysolic soils is to cast off the idea that there is a 100% correlation between taxonomy and soil water regime. Gleysolic soils are those in which the imprint of reduction or reduction-oxidation cycles is dominant over evidence of persistent oxidizing conditions. Many Gleysolic soils are poorly or very poorly drained, some are imperfectly drained, and others, in which drainage has been markedly improved, are now well drained. Criteria for Gleysolic soil classification must be based on soil properties that indicate reduction during the genesis of the soil, not on the current soil water regime.

2. In cases where two or more apparently "dominant soil forming processes" have left their mark on the soil, it is essential to decide an order of precedence. The decision on this is reflected in the present "Key to soil orders" (Canada Soil Survey Committee, 1978). No change is proposed in the order implied previously. Hence, processes reflected by permafrost close to the surface, by the accumulation of organic material of specified

thickness, and by podzolic processes giving rise to soils that meet the specifications of the Podzolic order take precedence over evidence of gleysolic processes. Specified evidence of gleysolic processes, on the other hand, take precedence over processes leading to the development of solonetzic B, chernozemic A, Bt, Bm, or to weak evidence of soil genesis as in Regosolic soils.

3. Classification criteria are based on observable or measurable soil properties, not on vegetation, slope position or other non-soil properties that are commonly related to soil properties (CSSC, 1978). Relationships between these associated properties and degree of expression of gley features facilitate mapping. They differ from region to region and in different soil materials.

4. Criteria for the Gleysolic order, or other orders, should make sense from both practical and genetic points of view for soils of different horizon sequence, different parent materials, different climatic regions, etc. If they do not make sense in the collective view of Canadian pedologists, improved criteria should be sought, tested and put in place if suitable.

5. Pedons are classified according to the currently-accepted crietria, not on the basis of landscape features, vegetation, gut fealings, or local biases. If the criteria result in apparently illogical classification of the pedon, the facts are recorded and used in developing improved limits or improved criteria for testing.

   Unless we agree on these, or other definite groundrules, we are wasting our time in working on soil taxonomy.

SPECIFIC PROPOSALS

These proposals including ideas of pedologists from several provinces are aimed at fine-tuning of the present system. We did not develop new bases for criteria to separate Gleysolic soils from gleyed subgroups. In spite of the problems associated with its use, color is the best known simple indicator of long-term reduction-oxidation status of soil. Measurement of redox potential and use of dyes that react with Fe^{+2} are useful for some purposes but they do not indicate prevailing oxidation-reduction status during soil genesis.

A. The Gleyed Gray Luvisol - Luvic Gleysol split.

   Currently, a soil having a Bt horizon, and low chromas accompanied by prominent mottling (see p. 69, Publ. 1646 for details of colors) within 50 cm of the surface is a Luvic Gleysol. But some soils with brown chromas (approx. 3) and unmottled Bt horizons have Aeg horizons with chromas of 1 and prominent reddish brown mottles. By the book, these soils are Luvic Gleysols but they probably should be Gleyed Gray Luvisols (oxidation dominant).

The change required would be similar to that in Soil Taxonomy for Aqualfs. Essentially, for soils with Ae horizons underlain by a Bt horizons, or a relatively impermeable horizon of any kind, the low chroma and mottling criteria would have to be met by the horizon underlying the Ae. Note that an exception is made for soils developed in red materials (see F). If the Ae extends to a depth greater than 50 cm, however, perhaps prominent mottling within 50 cm of the surface in the Ae should be diagnostic of a Gleysolic soil.

B. Prominent mottles or low chroma and prominent mottles.

Publication 1646 is somewhat ambiguous on this point. The Gleysolic order criteria on p. 69 basically require within 50 cm low chromas and prominent mottling, or chroma of 1 or less. One paragraph, however, states, "either matrix colors of low chroma or distinct to prominent mottles of high chroma" (within 50 cm). Based on that statement, a soil having a B horizon 10YR 4/4 with a few mottles 10YR 4/8 could be classified as Gleysolic. In tune with a suggestion from the B.C. Group, we should insist on low chromas as specified on p. 69:

1 or less without mottles, or hues bluer than 10Y
2 or less in hues of 10YR or redder and prominent mottles
3 or less in hues of yellower than 10YR and prominent mottles

This does not go as far as the B.C. Group suggested and further testing is needed. It would avoid some problems; for example, sandy soils with matrix chromas of 4 accompanied by prominent mottles would be excluded from the Gleysolic order.

C. Soils with a calcic horizon within 50 cm

Calcic horizons or other horizons enriched in secondary carbonates underlying chernozemic A horizons commonly have chromas of 0 to 1. They meet the color criteria of Gleysolic soils. The low chroma may be due to the color of carbonates or to reduction, or both. In Soil Taxonomy, a calcic horizon with its upper boundary within 40 cm of the surface is diagnostic of Aquolls. Also, low chromas and prominent mottling within 75 cm of the surface of soils having a calcic horizon is diagnostic of Aquolls. The presence of a calcic horizon is thought to indicate high water table (and reduction) during the genesis of the soil. It is proposed that these criteria be tested particularly in southern Manitoba.

D. Low chroma mottles

Mottles with chromas of 2 or less are diagnostic of some Aquic subgroups in Soil Taxonomy. We have not paid much attention to mottles of low chroma except for reddish soils. It is proposed that common or many distinct or prominent mottles of low chroma in horizons of generally oxidized color within 1 m of the surface should be diagnostic of gleyed subgroups. An exception is made for reddish soils in which prominent low-chroma mottles at specified depths are diagnostic of Gleysolic soils.

E. Few distinct or prominent mottles

Currently a few prominent mottles within 50 cm may be diagnostic of Gleysolic soils (CSSC, 1978). Thus, one prominent mottle (7.5YR 5/6) in a 50 cm wide exposure of a grayish brown (10YR 5/2) horizon within 50 cm of the surface could be considered as diagnostic of a Gleysolic soil. It is proposed that at least 2% of the area exposed (at least 50 cm by 10 cm thick) must be occupied by prominent mottles to be considered as diagnostic of a Gleysolic soil. It is important to note here that a cleanly picked profile or broken peds should be examined to assess the precentage of the area occupied by mottles. Smearing a profile with a spade may exaggerate greatly the apparent area of mottles.

F. Color criteria for soils developed in red materials

Soils developed in reddish materials (5YR or redder and color does not fade rapidly on dithionite treatment) do not have subsoils of low chromas even if subjected to prolonged reducing conditions or alternating reduction-oxidation conditions. In such soils, the following moist color criteria within 50 cm of the surface are diagnostic of Gleysolic soils:

1. Common or many, distinct or prominent mottles of high chroma in a horizon within 50 cm of the surface.
2. Common or many, prominent mottles of low chroma in a horizon within 50 cm of the surface.

Gray streaks associated with ochreous material along fissures in fragipans are not diagnostic of Gleysolic soils.

G. The Humic Gleysol-Gleysol split

Currently, the Ah or Ap horizon of a Humic Gleysol must: contain more than 2% organic C, have a rubbed color value of 3.5 or less (moist) or 5 or less (dry) and have a lower color value than the underlying horizon. This has caused problems. Some Ap horizons containing much more than 2% organic C have color values (moist) of more than 3.5. Also, some Ah or Ap horizons no darker than the underlying material contain substantially more than 2% organic C. The solution proposed is to restrict the diagnostic criterion for a Humic Gleysol to: Humic Gleysols have no Bt horizon; they have either an Ah horizon at least 10 cm thick or an Ap horizon at least 15 cm thick with more than 2% organic carbon. (The same A horizon criteria would apply to Humic Luvic Gleysols). Color and other morphological properties would be used to aid pedologists in making field estimates of organic C. (A note on this has been prepared by Wang).

H. Add Solonetzic subgroups to the Gleysolic order

These would be parallel to the Luvisolic subgroups of Ferro-Humic and Humo-Ferric Podzols. They would identify soils that meet the criteria of Solonetzic soils except that they also meet the limits for Gleysolic soils. A decision would have to be made on the order of precedence of subgroups. Tentatively, we suggest that Solonetzic would take precedence

over Rego, Fera and Luvic. Thus a Gleysolic soil having a Bn or Bnt horizon would be a Solonetzic subgroup of the appropriate great group.

I. Chromas of Ae and Ah Horizons

Chromas of 1 occur in Ae and Ah horizons of some oxidized pedons classified as Chernozemic, Luvisolic, Podzolic, Solonetzic, etc. Strict application of the present criteria would result in misclassifying these pedons as Gleysolic. It is proposed that chromas of Ah and Ae horizons should not be diagnostic of Gleysolic soils except in red materials. (This proposal could be integrated with A).

J. Coastal Gleysolic Soils

Some Gleysolic soils in coastal sediments have black (N 2/) horizons that turn gray (5Y 6/1) on oxidation. The need of a new class for these soils was mentioned. It is proposed that this feature should be recognized at the series level.

TEST OF PROPOSED CRITERIA, OTTAWA AREA.

We applied the criteria proposed to a total of 27 pedons in four soil associations ranging from sandy to clayey. Twenty-one of the pedons were classified as expected by application of the criteria. In two fields considered to be dominated by Gleyed Melanic Brunisols, a total of six pedons met the criteria of Humic Gleysols. Water table data (5 yr) showed that the soils in one of the fields (Rideau clay) were saturated to the surface commonly in April. In the other field (North Gower sil) the maximum height of the water table now is approximately 20 to 50 cm from the surface. Both fields probably were under wetter conditions before the area was settled perhaps a century ago. Thus, the criteria seemed to result in an adequate classification of the soils.

ALBERTA REPORT TO THE SOIL CLASSIFICATION WORKING GROUP

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INTRODUCTION

The following queries and comments represent various positions taken by Alberta Pedologists on selected subject areas of the Soil Classification Working Group Meeting in Guelph, November 1984. The subject areas are:

I Improved classification of Gleysolic soils,
II Classification of Podzolic soils,
III Contrasting horizons and layers,
IV Definition of soil surface, and
V Other classification concerns.

I IMPROVED CLASSIFICATION OF GLEYSOLIC SOILS

Introductory Comments

The regional representative and other Alberta Pedologists did not participate in formal field testing of the proposals for "improved classification of Gleysolic soils" as requested by C. Tarnocai (Memo: 84-05-28). The following therefore are comments and queries regarding the proposals for improved classification criteria as documented by McKeague and Wang (84-09-12). The comments below correspond to and follow the same sequence as those in the McKeague and Wang document.

Comments on "RATIONALE"

Not all Alberta Pedologists agree with the concept of recognizing Gleysolic soils on the basis of morphological features alone. Concerns were not so much with drained soils that contain relict gley features

but with wet soils that have poor (weak) expression of gley features. Some pedologists felt that it is more practical to classify (and map) wet soils as Gleysolic regardless of the expression of gleization. Other pedologists indicated that if gley features are poorly expressed or absent in a wet soil, that soil should at least be classed in a Gleyed subgroup. From an interpretive point of view, wet soils with poor gley features react to management in the same way as Gleysols or Gleyed subgroups.

Comments on "SPECIFIC PROPOSALS"

A. Gleyed Gray Luvisol - Luvic Gleysol Split.

- general agreement with this proposal BUT should be extended to all other soils where similar features might arise because of a "perched water table"; for example;
  - textural disconformities of fine over coarse
  - shallow soils over bedrock
  - Solonetzic soils
  - soils with cemented layers

B. Prominent mottles or low chroma and prominent mottles.

- clarification needed as to what exactly is the proposed change.
- general agreement that the ambiguity on p. 69 of Publ. 1646 should be clarified, especially the phrase in the last paragraph of column 1 which states "...either matrix colors of low chroma or distinct to prominent mottles of...". The "distinct or prominent" adjective partly contradicts the five statements about Gleysolic colors that follow on p. 69.
- horizon suffix "g" should be more rigorously defined (p. 24, Publ. 1646) in terms of color in order to be compatible with the Gleysolic definitions.
- a statement that low chroma colors may result from things other than reduction (examples, organic staining, leaching,

dark colored bedrock and parent materials) should perhaps be added to the Gleysolic Order discussion, particularly for inexperienced users of the classification system.

C. Soils with a calcic horizon within 50 cm.

Several problems with this proposal:

- this apparently is not a proposal for changing criteria but for testing them.
- calcic horizon is not defined in the Canadian Taxonomy or accompanying documents (example, ECSS 1982, CanSIS Manual).
- incorrect statements about Soil Taxonomy re. Aquolls and calcic horizons:
  - Aquolls are Mollisols that lack an albic horizon and have an aquic moisture regime; a calcic horizon within 40 cm of the surface is one of several characteristics associated with wetness and is diagnostic of Calciaquolls only; note also Calciborolls, Calciorthids.
- a calcic horizon, as defined in the Soil Taxonomy (Soil Survey Staff, 1975), can form under a variety of conditions, including dry moisture regimes, and has various genetic implications.

D. Low chroma mottles.

- promotes inconsistency; proposed criteria are a departure from the 50 cm depth and faint to distinct versus prominent mottle criteria proposed for more commonly occurring conditions (see Item B); if the criteria are uniform, there would be no need for an exception that applies to reddish soils.

E. Few distinct or prominent mottles.

- this proposal requires clarification because the phrase "2 percent of the area" can be interpreted in different ways. Does this refer to 2 percent of all of the top 50 cm of a

profile, or 2 percent of a gleyed horizon within the top 50 cm of a profile, even if this horizon (or part thereof) is, for example, only 1 or 2 cm thick? Certainly, the latter is intended as suggested by the colour criteria for red soils in Proposal F below. Perhaps the phrase "in a horizon within 50 cm of the surface" should be appended to criteria for Gleysolic soils on p. 69 of Publ. 1646 and in Proposal B above.

- abundance of mottles is defined in terms of percent coverage of exposed surfaces on p. 75 of the manual for describing soils in the field (ECSS, 1982). Thus, the proposal could also be worded in terms of a requirement for common (2 to 20 percent) or many (greater than 20 percent) mottles, as it indeed is in Proposal F below. It should also be determined if the presence of few (less than 2 percent) mottles is a criterion for Gleyed subgroups.

F. Colour criteria for soils developed in red materials.

- the proposed criteria could be reworded as follows: Common or many, prominent mottles of either high or low chroma in a horizon within 50 cm of the surface.

G. The Humic Gleysol - Gleysol Split.

- there is general agreement with this proposal
- there is also some confusion regarding the definitions of Ah and Ap horizons. In particular, why should a Humic Gleysol with an Ap horizon require at least 2 percent C while an Ah horizon can have a considerably lower organic C level according to the definitons on p. 24 of Publ. 1646?

H. Add Solonetzic subgroups to the Gleysolic order

- there is general agreement with this proposal
- clarification is required in that part of the proposal which

suggests the precedence of subgroups. It is suggested that 'Solonetzic take precedence over 'Rego' and 'Fera' (which are used at the subgroup level). Precedence of 'Solonetzic' over 'Luvic' (great group level) is unclear. Since a Solonetzic subgroup may have either a Bn or Bnt horizon, and Luvisolic soils are characterized by Bt horizons, it seems that the 'Luvic' in Solonetzic Luvic Gleysol is redundant.

- how should Gleysols having B horizons indicative of intergrading to the Solonetzic order be handled; that is, Gleysols with Bgnj, Bgnjtj or Btgnj horizons? Should these also be considered as adequate criteria for Solonetzic subgroups within the Gleysolic order? This situation is analagous to that of Solonetzic Black or Solonetzic Gray Luvisol.

I. Other Concerns Regarding Gleysolic Soils

1. In the Brown and Dark Brown soil zones, soils with deep, dark organo-mineral, surface layers occur in depressions. Many of these have probably formed by slope-wash, but they may also have formed by processes involving deep percolation and leaching. These soils are apparently saturated for part of the year due to ponding but show no typical morphological expressions of gley features. The dark colors are due to humus incorporation and translocation. These soils can be classed as Gleysolic or Chernozemic but do not meet the mottling requirements for Gleyed Chernozems. From an interpretive point of view, these are best classed with Gleyed subgroups.

2. We would like to request clarification regarding criteria for Gleyed subgroups. Why isn't there more consistence in these criteria among the various orders? The criteria, in summary are as follows:

   Brunisolic Order: faint to distinct mottles at 0-50 cm, or

distinct to prominent mottles at 50-100 cm.
Chernozemic Order: faint to distinct mottles at 0-50 cm.
Luvisolic Order: distinct mottles at 0-50 cm, or prominent mottles at 50-100 cm.
Podzolic Order: distinct to prominent mottles at 0-100 cm.
Regosolic Order: faint to distinct mottles at 0-50 cm.
Solonetzic Order: faint to distinct mottles at 0-50 cm.

In particular, why aren't distinct to prominent mottles at depths of 50-100 cm criteria for Gleyed subgroups in the Chernozemic, Regosolic and Solonetzic orders as they are in the Brunisolic order?

3. Some Alberta pedologists were curious about the historical use of the 50 cm depth (from the mineral surface) as it is applied to the Gleysolic order criteria. A few, probably the minority, wondered if the 'gley' color criteria shouldn't be applied to the soil control section to be more in line with "processes" and classification criteria of other soils. Further, for many non-agricultural interpretations, the 50 cm depth can be exceedingly shallow.

II CONTRASTING HORIZONS OR LAYERS

The general opinion on the new definition (C. Tarnocai, Memo: 84-10-29) of contrasting horizons or layers is that while it is an improvement on the original definition, it still leaves the process of recognizing lithologic discontinuities a very subjective one. The defintion and guide to differentiating lithologies is still not clear at this stage. Perhaps efforts should be made to develop more rigid criteria.

The third paragraph is useful for the guidelines it provides but its inclusion in a definition is questionable. The first two paragraphs could substitute for the definition on p.30 of Publ. 1646. The third paragraph could be the basis of an expanded guide which should also

include application to situations such as cumulic layers in alluvium and delta deposits, organic deposits, and so on.

It should also be noted that regular script numbers should be used instead of subscripts in the last sentence of paragraph 1.

III DEFINITION OF SOIL SURFACE

There is some dissent on this proposal within the Alberta Soil Survey Group (see C. Tarnocai, Memo: 84-10-29). While some feel that changing the definition of the soil surface would lead to problems in using information collected by the current system over the last several decades, others think that it is time to start calling a surface a surface. It was pointed out that there is basically an inconsistency in the system when shallow organic over mineral material is handled differently from organic or mineral material alone.

It would seem that if the present system were retained, then perhaps recording of thicknesses should be encouraged. Thickness data should then be easy to convert to depths with zero at the surface.

IV CLASSIFICATION OF PODZOLIC SOILS

Two main areas of concern here also directly relate to the classification of Brunisolic soils.

A. Numerous upland (moderately well to rapidly drained) Cordilleran soils, both calcareous and noncalcareous, have B horizons that meet the chemical criteria for "Bh" horizon (greater than 1 percent org. C, less than 0.3 percent pyrophosphate-extractable Fe, ratio of org. C to pyro-extr. Fe greater than or equal to 20; CSSC 1978). These horizons were labelled "Bm" in the ecological land classifications of the mountain national parks (Holland and Coen, 1982; Achuff et al., 1984a, b) because chroma and value were, in most cases, higher than generally accepted for Bh horizons. Color, however, is not a rigorous criterion for Bh.

Further to the problem, such B horizons meet the criteria for "podzolic Bh" when greater than or equal to 10 cm thick and the soils containing such horizons would therefore be Humic Podzols. However, the soils in question certainly don't occur in the wet, humid environments normally associated with Humic Podzol development nor do they resemble Humic Podzols as generally described (p. 96, CSSC 1978).

Descriptions (plus analytical data) of several pedons with humus-rich, low-Fe B horizons are attached. These occur under a wide range of environmental conditions except for reasonably similar drainage (well to rapid). In particular, note that parent materials range from alkaline, highly calcareous (Alberta-1978-No. 25) to acidic, noncalcareous (Alberta-1983 No. 45). Physical accretion processes such as soil creep likely account for much of the organic matter in B horizons of some of these pedons (for example, Alberta-1979-No. 88, Alberta-1983-No. 43), but in other profiles (for example, Alberta-1978-No. 38, Alberta-1983-No. 45) B horizon humus appears to be illuvial. The Alberta-1983-No. 45 pedon is of particular interest. Its Bm1 horizon would be "Bf" except that pyrophosphate-extractable Fe is less than 0.3 percent and the ratio of organic C to pyrophosphate-extractable Fe is greater than 20. Thus, its chemical characteristics meet the criteria for "Bh" but its color is significantly brighter than generally accepted for "Bh".

There are many more example profiles available from the mountain national park inventories. As a very rough estimate, about one-third to one-half of all pedons sampled and classed as Brunisolic have humus-rich, low-Fe Bm horizons that could be called "Bh".

B. Podzolic and Brunisolic soils that have Ahe horizons are a problem to classify because the occurrence of Ahe has essentially been ignored in the taxonomy. For example, does a Podzolic

profile that has 10 cm of Ahe rather than Ah overlying Ae belong to the Sombric subgroup or one of the others (for example, Orthic). The problem is magnified in the Brunisolic Order where one must decide between Great Groups (for example, Melanic versus Eutric) or where Ah and Ahe is less than 10 cm thick, between the Orthic and Eluviated subgroups.

In the ecological inventories of the mountain national parks, mappers subjectively evaluated each soil with an Ahe as to strength of eluviation versus humus accumulation, primarily on amount of graying. The problem was that there were no consistency or standarization checks.

V. OTHER CLASSIFICATION CONCERNS

A concern about the Cumulic subgroup in the Regosolic order was expressed by some Alberta pedologists. The following reasons were given:

- Regosolic is the only order of mineral soils that has a "cumulic" subgroup but "cumulized" profiles, classed in other orders, can and do occur. This is especially true in the mountains where numerous "cumulized" profiles of various description are common, but of no particular interpretive value concerning current stability.
- "Cumulization" is felt to be the result of geomorphic rather than pedogenic processes.

Perhaps "cumulic" could best be used as a phase and be applied to any taxon in the system.

REFERENCES

Achuff, P.L., W.D. Holland, G.M. Coen and K. Van Tighem (editors). 1984a: Ecological land classification of Kootenay National Park, British Columbia. V. I: Integrated resource description. Alberta Inst. of Pedol. Publ. M-84-10. University of Alberta, Edmonton, 388 pp.

Achuff, P.L., W.D. Holland, G.M. Coen and K. Van Tighem (editors). 1984b: Ecological land classification of Mount Revelstoke and Glacier National Parks, British Columbia. V. I: Integrated resource description. Alberta Inst. of Pedol. Publ. M-84-11. University of Alberta, Edmonton, 274 pp.

CSSC (Canada Soil Survey Committee). 1978: The Canadian system of soil classification. Agr. Can. Publ. 1646, 164 pp.

ECSS (Expert Committee on Soil Survey). 1982: Manual for describing soils in the field. Agr. Can. LRRI Contribution no. 82-52.

Soil Survey Staff. 1975: Soil Taxonomy. Soil Conservation Service, USDA, Agr. Handbook no. 436.

(Alberta 1978 No. 25)

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC MELANIC BRUNISOL. SOIL MAP UNIT: NOTATION: B51.

LOCATION: MILITARY GRID REF. 11 UMH 8790 8365; NTS MAP AREA 83C 3W.

CLIMATE: 2320 METERS ABOVE MEAN SEA LEVEL. STATION AT COLUMBIA ICEFLD HAS GOOD RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 2 DEG(C) AT 50 CM IN AUGUST, NO. 2 WAS 2 DEG(C) AT 20 CM IN AUGUST.

VEGETATION: VPN=SJ8096*VTH=L4-H4*.

SOIL SITE: PARENT MATERIAL 1: UNSPECIFIED WEATHERING, COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), COLLUVIAL, LIMESTONE; LANDFORM CLASSIFICATION: COLLUVIAL, INCLINED; SLOPE: 40% SIMPLE SLOPE OF CLASS 7 (31-45%), FACING NORTH, SITE AT UPPER SLOPE POSITION; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED AND WELL DRAINED, RAPID SURFACE RUNOFF, SEEPAGE ABSENT, SLIGHT WATER EROSION; SLIGHTLY STONY; EXCEEDINGLY ROCKY.

SPECIAL NOTES: SSN=DA8068*APN=010-195*LFM=EV/CB/RI*

AH: 0 TO 10 CM, RANGE 7 TO 13 CM; MATRIX MOIST 7.5YR 3/2; SILT LOAM; STRUCTUPELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM, HORIZONTAL ROOTS; 10% ANGULAR GRAVELLY COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BM: 10 TO 16 CM, RANGE 5 TO 8 CM; MATRIX MOIST 5YR 4/6, MATRIX MOIST 7.5YR 6/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM, VERTICAL ROOTS; 10% ANGULAR GRAVELLY COARSE FRAGMENTS; SMOOTH, ABRUPT HORIZON BOUNDARY.

2CK: 16 TO 60 CM; MATRIX MOIST 10YR 5/3; COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; VERY FEW, VERY FINE, VERTICAL ROOTS; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 60% ANGULAR GRAVELLY AND COBBLY COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%
AH	6.9	7.70	
BM	7.2	3.50	34.8
2CK	7.6		93.5

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
AH				
BM	0.1		-.1	
2CK				

PHYSICAL DATA (SURVEY)

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
AH								4	8	12		78	10	
BM						1	1	4	13	19		71	10	
2CK	99			39	15	15	12	11	6	59		36	5	

PHYSICAL DATA

	MOISTURE STATUS (%)					ATTERBURG	ATTERBURG	SHRINKAGE	OPT MOIST	MAX DRY	ENGINEERING		
HORIZON	0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	LIMIT (%)	CONTENT (%)	DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
AH		49.8	34.4										
BM													
2CK		8.5	1.1									12	

(Alberta 1978 No. 38)

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ELUVIATED EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: BY1.

LOCATION: MILITARY GRID REF. 11 UNH 1680 5320; NTS MAP AREA 82N 15W.

CLIMATE: 1800 METERS ABOVE MEAN SEA LEVEL. STATION AT LAKE LOUISE HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 4 DEG(C) AT 50 CM IN SEPTEMBER.

VEGETATION: VPN=JE8153*VTN=C14*.

SOIL SITE: PARENT MATERIAL 1: COARSE LOAMY AND COARSE SILTY (<18% CLAY), UNDIFFERENTIATED, EOLIAN; PARENT MATERIAL 2: SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY CALCAREOUS (>40% CACO3), MORAINAL (TILL); LANDFORM CLASSIFICATION: MORAINAL, BLANKET; SLOPE: 34% SLOPE OF CLASS 7 (31-45%), FACING NORTH, SITE AT UPPER SLOPE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,200 M LONG; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, MODERATELY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY.

SPECIAL NOTES: SSN=TA8144*APN=010-203*PCF=2GR(3-4)4GR,3CB,1ST(5)3GR,2CB,2ST(6)*RLU=15*DATE=SEPT. 18,1978*LFM=EV/MB/RI*

LF: 15 TO 0 CM, RANGE 11 TO 17 CM; MATRIX MOIST 10YR 2/2; ABUNDANT, VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AE: 0 TO 5 CM, RANGE 4 TO 11 CM; MATRIX MOIST 10YR 8/1; SILT LOAM; WEAK, COARSE, PLATY STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; COMMON, FINE AND MEDIUM PORES; IRREGULAR, ABRUPT HORIZON BOUNDARY.

BM1: 5 TO 12 CM, RANGE 3 TO 18 CM; MATRIX MOIST 5YR 4/6; SILT LOAM; WEAK, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM ROOTS; COMMON, FINE AND MEDIUM PORES; 10% GRAVELLY COARSE FRAGMENTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

BM2: 12 TO 19 CM, RANGE 8 TO 11 CM; MATRIX MOIST 10YR 7/6; SILT LOAM; VERY WEAK, MEDIUM, PLATY STRUCTURE; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, MEDIUM ROOTS; COMMON, FINE AND MEDIUM PORES; 10% GRAVELLY COARSE FRAGMENTS; BROKEN, CLEAR HORIZON BOUNDARY.

2BCK: 19 TO 41 CM, RANGE 13 TO 30 CM; MATRIX MOIST 10YR 4/4; SILT LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE; FIRM CONSISTENCE; FEW, MEDIUM ROOTS; COMMON, FINE AND MEDIUM PORES; STRONG EFFERVESCENCE; STRONGLY CALCAREOUS; 40% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, GRADUAL HORIZON BOUNDARY.

2CK: 41 TO 80 CM; MATRIX MOIST 10YR 5/3; GRAVELLY SILT LOAM; WEAK TO MODERATE, FINE TO MEDIUM, SUBANGULAR BLOCKY STRUCTURE PSEUDO; STRUCTURELESS, MASSIVE SECONDARY STRUCTURE; FIRM CONSISTENCE; VERY FEW, MEDIUM ROOTS; FEW, FINE AND MEDIUM PORES; STRONG EFFERVESCENCE; EXTREMELY CALCAREOUS; 30% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG
LF	4.6	44.00			
AE	5.4	1.80		7.0	
BM1	5.5	3.30		30.0	
BM2	5.2	3.10		29.0	
2BCK	6.9		22.0		
2CK	7.1		75.0		

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AE				
BM1	0.2		0.2	
BM2	0.1		0.2	
2BCK				
2CK				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	.75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	PARTICLE SIZE ANALYSIS % OF SAMPLE V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70- 2U SILT	50- 2U SILT	2U CLAY	0.2U CLAY	BULK DENS G/CC
LF															
AE										33		75	2		
BM1										24		67	9		
BM2										16		76	8		
2BCK										27		58	15		1.60
2CK	99			81						35		57	8		1.70

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	ENGINEERING SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE		5.5	1.8										
BM1													
BM2		18.0	8.1										
2BCK													
2CK		13.0	3.2			0.0	0.0					40	07

(Alberta 1979 No. 88)

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ORTHIC EUTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: SBS.

LOCATION: MILITARY GRID REF. 11 UNG 9620 9310; NTS MAP AREA 82O SE.

CLIMATE: 1950 METERS ABOVE MEAN SEA LEVEL. STATION AT BANFF HAS POOR RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 9 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: GRASSES AND FORBES, MATURE. VPH=JD9079*VTN=H14*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), MODERATELY TO VERY STRONGLY CALCAREOUS (6-40% CACO3), COLLUVIAL, SEDIMENTARY; LANDFORM CLASSIFICATION: ACTIVE COLLUVIAL, VENEER; SLOPE: 65% SLOPE OF CLASS 8 (46-70%), FACING SOUTHWEST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY,500 M LONG; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, VERY RAPID SURFACE RUNOFF, SEEPAGE ABSENT; VERY STONY; SLIGHTLY ROCKY.

SPECIAL NOTES: SSN=WT9147*APN=010-160*RLU=15*PCF=2AG,1AC(2.5)3AG,3AC(3,4,6)4AG,3AC(7)5AG,4AC(8)*LFM=CV/RI*TURFY AH+BM1*CHARCOAL IN AHB*SOME COARSE FRAGMENTS IN LF FROM ACTIVE COLLUVIATION*DATE=AUG.27,1979*

LF: 3 TO 0 CM, RANGE 2 TO 4 CM; MATRIX MOIST 10YR 2/1; MODERATE EFFERVESCENCE; WAVY, CLEAR HORIZON BOUNDARY.

AH: 0 TO 8 CM, RANGE 6 TO 10 CM; MATRIX MOIST 10YR 3/1; SILT LOAM; WEAK, VERY FINE, GRANULAR STRUCTURE; SOFT CONSISTENCE; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BM1: 8 TO 16 CM, RANGE 5 TO 9 CM; MATRIX MOIST 7.5YR 3/2; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, GRADUAL HORIZON BOUNDARY.

BM2: 16 TO 27 CM, RANGE 9 TO 14 CM; MATRIX MOIST 7.5YR 3/3; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

AHB: 27 TO 34 CM, RANGE 3 TO 7 CM; MATRIX MOIST 10YR 3/1.5; SILT LOAM; WEAK, VERY FINE, GRANULAR STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE AND MEDIUM ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

BMB1: 34 TO 47 CM, RANGE 10 TO 16 CM; MATRIX MOIST 5YR 4/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; WAVY, GRADUAL HORIZON BOUNDARY.

BMB2: 47 TO 68 CM, RANGE 19 TO 25 CM; MATRIX MOIST 7.5YR 4/4; SILT LOAM; STRUCTURELESS, MASSIVE STRUCTURE; SOFT CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; WAVY, CLEAR HORIZON BOUNDARY.

CK: 68 TO 115 CM; MATRIX MOIST 10YR 4/2; GRAVELLY COARSE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; LOOSE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; WEAK EFFERVESCENCE; STRONGLY CALCAREOUS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	CALC CARB EQU.%	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	6.6	30.90							
AH	6.3	14.50		58.3		39.5	8.1	-.1	1.3
BM1	6.3	6.10		26.0		19.8	5.0	0.1	0.4
BM2	6.4	3.10		17.8		15.3	3.6	0.2	0.2
AHB	6.4	10.10		47.7		36.6	9.6	0.2	0.2
BMB1	6.7	1.50	0.6	9.2		7.2	1.7	0.1	0.2
BMB2	6.7	1.00	1.0	9.2		7.0	2.3	0.1	0.1
CK	7.5		19.8						

CHEMICAL DATA (SURVEY)

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2
LF				
AH				
BM1	0.2		0.1	
BM2	0.2		0.1	
AHB				
BMB1	0.1		-.1	
BMB2	0.1		0.0	
CK				

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AH					2	1	1	5	10	19		64	17	
BM1					2	3	2	8	16	31		60	9	
BM2					2	2	2	5	14	25		66	9	
AHB					1	2	2	7	14	24		68	8	
BMB1					8	9	4	7	16	44		54	2	
BMB2					3	3	2	6	18	32		60	8	
CK	99	79	56	47	16	12	6	7	10	51		44	5	

PHYSICAL DATA

HORIZON	ENGINEERING ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF								
AH								
BM1								
BM2								
AHB								
BMB1								
BMB2								
CK	20.0	26.0		19.0	1.7		12	18

(Alberta 1983 No. 43)

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978, SUBGROUP: ORTHIC DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: NC6.

LOCATION: MILITARY GRID REF. 11 UNG 3400 5700; NTS MAP AREA 82N 4W.

CLIMATE: 1000 METERS ABOVE MEAN SEA LEVEL. STATION AT REVELSTOKE HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 13 DEG(C) AT 50 CM IN AUGUST.

VEGETATION: VPN=MF3015*VTN=015 CLOSED VARIANT*.

SOIL SITE: PARENT MATERIAL 1: MODERATE CHEMICAL WEATHERING, SKELETAL (>35% OF PARTICLES 2-25 CM) AND COARSE LOAMY AND COARSE SILTY (<18% CLAY), EXTREMELY TO STRONGLY ACIDIC (PH.5.5), COLLUVIAL, METAMORPHIC; LANDFORM CLASSIFICATION: COLLUVIAL, VENEER; SLOPE: 65% SIMPLE SLOPE OF CLASS 9 (71-100%), FACING SOUTHEAST, SITE AT MIDDLE POSITION; SOIL MOISTURE AND DRAINAGE: RAPIDLY DRAINED, MODERATELY PERVIOUS, RAPID SURFACE RUNOFF, SEEPAGE ABSENT; EXCEEDINGLY STONY; MODERATELY ROCKY.

SPECIAL NOTES: SSN=NT3015*DATE=82/08/03*LFH=CV/RI*BC FRAGMENTAL, NO SAMPLE*PH=5.3 AT 25 CM*APN=391-033*

LF: 6 TO 0 CM, RANGE 2 TO 8 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 3/1; PLENTIFUL, FINE AND MEDIUM AND MICRO AND VERY FINE, RANDOM ROOTS; 10% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

AB: 0 TO 11 CM, RANGE 8 TO 15 CM; HORIZON MOIST; MATRIX MOIST 5YR 4/5; LOAM; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; MODERATE, FINE, GRANULAR SECONDARY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM AND COARSE AND MICRO AND VERY FINE, RANDOM ROOTS; 50% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BM1: 11 TO 63 CM, RANGE 45 TO 70 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 4/6, MATRIX MOIST 7.5YR 5/6; FINE SANDY LOAM; VERY WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; WEAK, FINE, GRANULAR SECONDARY STRUCTURE; FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM AND COARSE AND MICRO AND VERY FINE, RANDOM ROOTS; 50% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; IRREGULAR, CLEAR HORIZON BOUNDARY; STRONGLY ACID 5.1-5.5 FIELD PH.

BM2: 63 TO 92 CM, RANGE 15 TO 35 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3; FINE SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, FINE AND MEDIUM AND COARSE AND MICRO AND VERY FINE, RANDOM ROOTS; 70% ANGULAR GRAVELLY AND ANGULAR COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; IRREGULAR, CLEAR HORIZON BOUNDARY.

BC: 92 TO 105 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/3; SANDY LOAM; STRUCTURELESS, MASSIVE STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, FINE AND MEDIUM AND COARSE AND MICRO AND VERY FINE, RANDOM ROOTS; STONY (BOULDERY) COARSE FRAGMENTS.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	5.2	52.8						
AB	5.4	5.7	17.9		6.5	0.7	-.1	0.4
BM1	5.1	2.8	32.0		1.9	0.2	-.1	0.2
BM2	4.8	0.7	14.1		0.9	-.1	-.1	-.1
BC								

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2	EXTR MN (%)
LF					
AB	0.2		0.5		-.1
BM1	0.1		0.3		0.0
BM2					
BC					

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
LF														
AB					2	8	12	15	13	50		43	7	
BM1					6	12	12	14	12	56		38	6	
BM2	99	64	52	40	1	6	17	28	15	67		30	3	
BC														

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AB													
BM1													
BM2		13.5	4.7			0	0						SM
BC													

(Alberta 1983 No. 45)

CLASSIFICATION: TAXONOMIC SYSTEM OF THE YEAR 1978. SUBGROUP: ELUVIATED DYSTRIC BRUNISOL. SOIL MAP UNIT: NOTATION: LR1.

LOCATION: MILITARY GRID REF. 11 UMH 6630 10; NTS MAP AREA 82N 6*.

CLIMATE: 830 METERS ABOVE MEAN SEA LEVEL. STATION AT ROGERS PASS HAS MODERATE RELEVANCE TO THE SOIL SITE. SOIL TEMP READING NO. 1 WAS 7 DEG(C) AT 50 CM IN JULY.

VEGETATION: VPN=HD3001*VTN=C44*.

SOIL SITE: PARENT MATERIAL 1: WEAK CHEMICAL WEATHERING, STRATIFIED (MINERAL) AND SANDY, EXTREMELY TO STRONGLY ACIDIC (PH.5.5), FLUVIAL, MIXED AND METAMORPHIC; LANDFORM CLASSIFICATION: FLUVIAL, ERODED(CHANNELLED), FAN; SLOPE: 3% SIMPLE SLOPE OF CLASS 3 (2-5%), FACING SOUTHEAST, SITE AT MIDDLE POSITION, SLIGHTLY MOUNDED MICROTOPOGRAPHY.; SOIL MOISTURE AND DRAINAGE: WELL DRAINED, RAPIDLY PERVIOUS, MODERATE SURFACE RUNOFF, SEEPAGE ABSENT; MODERATELY STONY; NONROCKY; PRESENT LAND USE: OUTDOOR RECREATION.

SPECIAL NOTES: SSN=BW3001*DATE=83/07/26*APN=BCS391-217*POSSIBLY EOLIAN MATTER INCLUDED IN AE & BM1* THIN DISCONT 5YR4/6M BAND AT TOP BM1*WEAK PATCHY BRITTLENESS IN BC1*

LF: 5 TO 0 CM, RANGE 3 TO 9 CM; MATRIX MOIST 10YR 2/2; ABUNDANT, MICRO AND VERY FINE AND FINE ROOTS; WAVY, ABRUPT HORIZON BOUNDARY.

AE: 0 TO 4 CM, RANGE 1 TO 11 CM; HORIZON MOIST; MATRIX MOIST 5YR 5/1, MATRIX MOIST 10YR 4/2; GRAVELLY SILT LOAM; WEAK, VERY FINE TO FINE, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; 40% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, ABRUPT HORIZON BOUNDARY.

BM1: 4 TO 21 CM, RANGE 12 TO 28 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 5/6, MATRIX MOIST 5YR 4/6; GRAVELLY SILT LOAM; WEAK, MEDIUM, SUBANGULAR BLOCKY STRUCTURE; VERY FRIABLE CONSISTENCE; ABUNDANT, MICRO AND VERY FINE AND FINE AND MEDIUM AND COARSE ROOTS; 50% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BM2: 21 TO 41 CM, RANGE 16 TO 30 CM; HORIZON MOIST; MATRIX MOIST 7.5YR 4/6; GRAVELLY LOAMY COARSE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; PLENTIFUL, MICRO AND VERY FINE AND FINE ROOTS; 60% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; WAVY, CLEAR HORIZON BOUNDARY.

BC1: 41 TO 49 CM, RANGE 8 TO 15 CM; HORIZON MOIST; MATRIX MOIST 10YR 5/4; GRAVELLY LOAMY COARSE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; VERY FRIABLE CONSISTENCE; FEW, MICRO AND VERY FINE ROOTS; 70% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; BROKEN, ABRUPT HORIZON BOUNDARY.

BC2: 49 TO 60 CM, RANGE 8 TO 22 CM; HORIZON MOIST; MATRIX MOIST 10YR 6/4; VERY GRAVELLY COARSE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, MICRO AND VERY FINE ROOTS; 70% GRAVELLY AND COBBLY COARSE FRAGMENTS; BROKEN, CLEAR HORIZON BOUNDARY.

BC3: 60 TO 90 CM; HORIZON MOIST; MATRIX MOIST 10YR 5.5/4; GRAVELLY LOAMY COARSE SAND; STRUCTURELESS, SINGLE GRAIN STRUCTURE; LOOSE CONSISTENCE; VERY FEW, MICRO AND VERY FINE AND FINE ROOTS; 70% GRAVELLY AND COBBLY AND STONY (BOULDERY) COARSE FRAGMENTS; STRONGLY ACID 5.1-5.5 FIELD PH.

CHEMICAL DATA (SURVEY)

HORIZON	PH 1	ORG C (%)	C.E.C. (ME/100G) BUFF.	C.E.C. (ME/100G) PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
LF	4.2	60.1						
AE	3.3	2.0	17.9		0.8	0.1	-.1	0.2
BM1	4.8	4.6	54.9		0.5	-.1	-.1	0.2
BM2	4.5	0.6	6.8		0.2	-.1	-.1	-.1
BC1	4.6		2.8		0.2	-.1	-.1	-.1
BC2	4.6		2.4		0.1	-.1	-.1	-.1
BC3	4.7		4.2		0.1	-.1	-.1	-.1

HORIZON	EXTRACT IRON (%) 1	EXTRACT IRON (%) 2	EXTRACT ALUMINUM (%) 1	EXTRACT ALUMINUM (%) 2	EXTR PH (%)
LF					
AE					
BM1	0.2		0.7		-.1
BM2	0.1		0.1		0.0
BC1					
BC2					
BC3					

PHYSICAL DATA (SURVEY)

HORIZON	% PASSING 3" SIEVE	% PASSING .75" SIEVE	% PASSING NO.4 SIEVE	% PASSING NO.10 SIEVE	PARTICLE SIZE ANALYSIS V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	% OF SAMPLE 70-2U SILT	% OF SAMPLE 50-2U SILT	2U CLAY	0.2U CLAY
LF														
AE					1	4	4	12	15	36		61	3	
BM1					4	8	6	9	12	41		53	6	
BM2					18	23	16	14	9	80		17	3	
BC1					6	21	21	19	12	79		18	3	
BC2					30	32	14	7	4	87		11	2	
BC3	99	51	32	21	12	26	26	15	7	86		12	2	

PHYSICAL DATA

HORIZON	MOISTURE STATUS (%) 0.1 ATM	0.33 ATM	15 ATM	HYGR. MOIST	FIELD MOIST	ATTERBURG PLASTIC LIMIT (%)	ATTERBURG LIQUID LIMIT (%)	SHRINKAGE LIMIT (%)	ENGINEERING OPT MOIST CONTENT (%)	MAX DRY DENSITY (G/CC)	COLE VALUE	AASHO CLASS	UNIFIED CLASS
LF													
AE													
BM1													
BM2													
BC1													
BC2													
BC3		4.1	1.8			0	0						01

REGIONAL PRESENTATION

ON IMPROVEMENTS IN THE CLASSIFICATION OF GLEYSOLS - YUKON

C.A.S. SMITH

INTRODUCTION

Within the zone of discontinuous permafrost in the southern Yukon landscape positions with high soil moisture regime are most often characterized by Cryosolic soils. Gleysols may be uncommon in level to depressional positions, and restricted to active permafrost free alluvial landforms subject to periodic saturation. These Alluvial Gleysols are morphologically similar to those of southern Canada and present no unique taxonomic concerns. However, on upland positions, under mature closed canopy boreal forest on northerly aspects, permafrost or seasonal frost can persist within the soil control section for much of the growing season (late July, early August). Under some northern semi-arid and subhumid climates forested soils which are temporarily saturated following frost thaw exhibit colors of low chroma, lack prominent mottles, and have seasonally-variable soil moisture regimes. Depending on the depth of the permafrost table and soil color soils have been classified as Cryosols, Gleysols or gleyed subgroups of the Brunisolic order.

DISCUSSION

The gley morphologies observed in some upland northern soils have been colloquially referred to as "frost gleying". This phenomenon is controlled by two major factors: the dynamic nature of the impending layer, and the soil temperature at the time of saturation.

A frost table acts as an impeding layer in a similar fashion to that in surface water gleys or pseudogleys. Unlike static impeding layers, the frost table drops continuously throughout the growing season and with it a zone of temporary saturation. Reduction occurs not within one portion of the solum but rather at different depth intervals at different times of the year. The rate of frost thaw, the thickness of the saturated zone, the date of frost dissappearance from the control section and the final location of a permafrost table varies annually and are influenced by a host of environmental factors. Because the zone of saturation lies immediately above a frozen layer, soil temperatures during saturation are always low, generally $< 5^{o}C$.

These conditions produce marginal gley morphologies with B horizon matrix colors typically recorded as 10 YR 4/2, 4/3 or 2.5 Y 4/3, 4/4. Mottles, if present, are generally distinct or faint. Even though these soils may be saturated for periods of time similar to Gleysols in temperate environments, they do not always meet the color criteria for inclusion within the Gleysolic order. This lack of strong gley coloration is presumed to result from very cold soil temperatures limiting reduction processes.

Soil moisture conditions and the impression of soil moisture regime vary with the date of observation. Medium to coarse textured soils can appear poorly drained in June, well to rapidly drained in September. Relatively productive boreal forest stands are found on these soils. The use of soil moisture keys, found in a number of provincial field manuals has proven to be generally unsatisfactory when attempting to characterize drainage conditions.

RECOMMONDATIONS

1. It was recognized during the establishment of the Cryosolic order that gleysolic subgroups (as opposed to gleyed) were required to classify soils that exist in continuum with those of the Gleysolic order proper. These taxa are controlled by an arbitrary depth limit of permafrost. A statement acknowledging the fact that in northern Canada, soils exist that meet all the criteria of the Gleysolic order, but are not classified as Gleysols because of the presence of permafrost, should be included in the introductory section of the revised classification of the Gleysolic order.

2. While a number of conditions can exist whereby saturation of the soil does not necessarily lead to strong reduction, it is recommended to review the requirement for prominent mottling as it might apply to northern soils.

3. Consider incorporating to some limited degree soil climate when specifying gley color criteria for the order. One set of criteria applied nationally may not be comprehensive enough to satisfactorily classify all soils affected by microbial reduction.

AN ASSESSMENT OF THE GLEYSOLIC ORDER CRITERIA AND SUGGESTIONS FOR IMPROVEMENT

W. Michalyna

The objective of this paper is to report on some activities related to the testing of the present criteria of the Gleysolic Order on soils traditionally classified as the Gleyed subgroups and Gleysols in Manitoba. The report will cover the general approach used, comment on the problems encountered, and provide some suggestions or alternatives to the classification of moist to saturated soils.

Activities

During 1984, there was limited activity on the field testing of the criteria (as proposed by McKeague and Wang) for Gleysolic soils. However, the following was done:

a) some of their pertinent suggestions, as well as the criteria in CSSC 1978, were examined, discussed and debated during field correlation activities,
b) several tests were made on 50 profiles consisting of those recently sampled from the well to poorly drained soils (with 18 Orthic types, 24 Gleyed subgroups, and 8 Gleysols as classified in Manitoba) ;these were summarized as to horizon, depth, moist colors, mottles if present, $CaCO_3$ content, and in some cases, conductivity. These records were given to several pedologists to classify into three general groups as 1) oxidized Orthic or Calcareous, 2) Gleyed subgroup, and 3) Gleysol on the basis of traditional judgement; then, they were asked to classify the soils according to the guidelines in the key CSSC 1978,
c) a review and application of the present criteria was conducted on an additional 179 soil descriptions from the Detailed CanSIS File.

Background

In Manitoba, the current approach to the classification of Gleysols follows from early concepts that Gleysolic soils developed under poorly drained, saturated conditions in level to depressional topographic positions in the landscape, and under hydrophytic vegetation. Ancillary criteria frequently included reference to a peaty surface, limnic features, and low chromas with or without prominent mottling (glei horizon) below the mineral surface layer. Soils which were considered to have developed under temporary saturated conditions and adequate aeration (based on vegetation indicators) were considered as intergrades of other Orders.

The consistent separation of the soils classified as intergrades and Gleysols is a continuing problem in Manitoba. The reasons for this are:

firstly, the relationship between the period of soil saturation and the associated morphological expression appears to vary with other soil properties such as clay content, organic matter content, and level of calcium carbonate,

secondly, attempts at local soil correlation usually emphasized properties of soil series or associates established prior to the adoption of the present Gleysolic criteria in order to achieve consistency in mapping and interpretations.

Correlation Activity

During field correlation, the classification of Gleysolic soils was made on the basis of both soil morphology as well as awareness of the location in the landscape. Primarily, pedologists infer the degree of wetness (or former wetness) based on landscape features. Since most areas of recent survey activity are in cultivated Black and Dark Gray soils, the major differentiating characteristics were the color and depth of the A horizon, and other solum characteristics such as the presence of carbonates. Within this continuum of soils with Chernozemic A horizons, the so-called Gleyed soils were separated from Gleysols. A majority of the soils mapped and classified in the field as Gleysols meet the present color guidelines described for the Gleysolic Order.

In addition, a substantial number of the intergrade Gleyed soils, particularly those with secondary carbonates or dark B horizons, also met the present Gleysol criteria. Traditionally, imperfectly drained soils with relatively low value and low chroma (dark) B horizons were classified as Gleyed subgroups (Gleyed Black or Gleyed Solonetzic Black); these soils with B horizons of low chroma of 1 would presently classify as Gleysols.

However, during these correlations, there were a number of occasions where differences of opinions amongst pedologists occurred for soil colors and application of the criteria.

Results on the Fifty Profiles

On the classification exercise on the fifty soil profiles, the pedologists classified the soils similarily to the way they were called at the time of sampling; 8/8 were classified as Gleysols; 1/24 of the Gleyed subgroups was called a Gleysol, and 2/24 were called Rego Blacks; 1/18 of the oxidized soils was classified in the Gleyed subgroup. When the pedologists were asked to try to Key the soils of the Gleyed subgroup, the classification varied considerably from:

1) all soils Key out as Gleysols because of low chromas (there was no guidelines as to which horizons within 50 cm the color criteria were applicable),

2) approx. one-half of the Gleyed soils (11/24) would classify as Gleysol when the criteria were applied to the soil zone below the A horizons (AP, Ah, Ahe, Ae, Aegj, Aeg) and the 50 cm depth below the mineral suface.

Two of the eight soils classified as Gleysols did not meet the present color criteria; these soils had peaty layers (Of, Om) above the mineral surface.

A Solodic Dark Gray soil developed on shale clay over residual shale near 1m (well drained, mid to upper slope position) had a Bn horizon with colors of 10YR5.5/1 exped, 10YR2/1 inped that would meet the present color criteria of the Gleysol. The color of the C horizon was 2.5Y4/4 with mottles 10YR5/6; the 2C was 5Y5/1 with mottles of 10YR5/6. In this case, the color should be judged in relation to the parent material which has undergone a considerable oxidation with the formation of jarosite and iron compounds.

Test of Criteria on Detailed Profile Descriptions

The other 179 profiles were examined in relation to the present Gleysol criteria; color criteria were applied below the A horizon to a referred 50 cm depth of the mineral surface. A summary of this evaluation indicates 51/104 soils of the Gleyed subgroups met the present Gleysolic criteria and 23/104 were considered as possible Gleysols, but lacked sufficient color information about the mottles. From the soils originally classified as Gleysols, 24/41 profiles satisfied the present criteria and 6/41 could not be positively keyed out because of insufficient morphological information. If the presence of an O horizon (Of, Oh, Om, Ol) were included with the criteria, 40/41 profiles would classify as Gleysols.

The application of color criteria alone does not consistently differentiate the soils classified as Gleysols or Gleyed subgroups; a slight majority of the soils (over 50%) within each of the above soil groups met the present criteria of the Gleysol.

Concerns

These numbers indicate that more than a fine-tuning of the color criteria and application guides are required for the satisifactory separation of the soils under varying degrees of reduction in the moist to saturated continuum, particularly if the color alone remains as the dominant differentiating, diagnostic property. There are several questions and concerns that need to be addressed:

1. Stratification

a) the adequacy of, and the precedence of, the "glei colors" as diagnostic properties in the stratification process in relation to other diagnostic properties of succeeding Orders,

b) whether the Gleysol should be extended into the landscape continuum of the Gleyed subgroup soils (Manitoba) that have been developed under the regional vegetation and not hydrophytic types (as illustrated in Figure 1a),

c) whether the properties of the Gleyed subgroups should be broadened to apply to the moist and the saturated soils in the continuum (as the Gleyed subgroups with drainage or moisture regime phases (as illustrated in

Figure 1b); for example, in the Black continuum the Gleyed Eluviated Black-poorly drained phase, would replace the Humic Luvic Gleysol; the Gleyed Rego Black-poorly drained phase, would replace the Rego Humic Gleysol). On the basis of the Manitoba practice, the pedologists identify properties of the Chernozemic Order readily, they utilize relative drainage, topographic position and solum properties to differentiate "Gleysols" in the continuum.

2. Diagnostic Properties

Peaty and limnic features have been diagnostic soil parameters in the past for the classification of Gleysols and should be re-instated. There are a number of soils that have developed under poorly drained conditions, hydrophytic vegetation, and have a peaty layer (O horizon that formerly has been called LFH). Several examples are provided for: a) the Kerry series of SE Manitoba (Tables 1,2) in which the colors did not meet the Gleysol criteria for 2 of 3 profiles reviewed, b) Malonton series (Table 3), and c) Sprague series (Table 4). The thickness of the peaty layer in the Sprague soil was thin (2 cm), but it may also be judged in relation to the amount of organic carbon present if mixed with mineral soil (plowed). In Soil Taxonomy, this plowed layer has: greater than 8% C if no clay is present, 8-16% C if clay is 0-60%, and above 16% C if the clay is greater than 60%, in the mineral layer, respectively.

3. Color Criteria Application

The Key to soil classification does not provide guidelines for color criteria application within the 50 cm depth from the mineral surface, but one may assume that any soil that is temporarily saturated or considered to be formerly influenced by periods of saturation would qualify for the color treatment. To which horizons do they apply:

a) Surface mineral horizons - most surface mineral horizons have low chromas due to organic matter or eluviation. The guidelines do not indicate whether the colors of the A horizons commonly with chromas of 1 qualify or exempt from the criteria "chroma of 1 or less without mottles" (note examples in Tables 1, 2, 4, 5, 6, 7, 8, 9, 11, 12). These include the various A horizons: Ap, Ah, Ahk, Ahegj, Aheg.

b) Transitional horizons - may also have low chromas due to some organic matter, eluviation products, or presence of carbonates (Tables 5, 7, 8, 9). The colors in the transitional horizons have chromas of 1 and meet the criteria of the Gleysol. In areas of dominantly Chernozemic soils, should the transitional horizon be exempt? (In this review, the transitional horizon AC was not exempt; however, this horizon may be considered as part of the Chernozemic A if the stratification was altered and took precedence over present Gleysol criteria.

c) Dark colored B horizons - within the general context of imperfectly to poorly drained, and possibly moderately well drained landscapes, there are a number of soils that have dark colored B horizons that would meet the "chroma of 1 or less, without mottles" criteria (Tables 11, 12). These are soils that have developed under the regional vegetation (dominantly trembling aspen). This was typical of the Framnes series

(Table 11) where 3 of 3 profiles reviewed had low chroma B horizons; the fine silty subsoil had chromas of 2 or more with few, fine, faint mottles.

Fine loamy and clayey soils with appreciable magnesium of magnesium and sodium have a Bnj or Bn horizon with a low chroma that met the criteria for Gleysol. The Thalberg soil (Table 12) was developed on glacial lake clays, under regional vegetation (dominantly trembling aspen). Soluble salts are present in the subsoil; the B horizon had adequate sodium and clay increase to qualify as a Bnt. The color of the C horizon did not meet the color criteria of the Gleysol.

Most of the soils classified as the Gleyed Solonetzic Black, Gleyed Solonetzic Dark Gray, or Gleyed Black Solonetz had a B horizon that met the criteria of Gleysol. Should these soils be considered as part of the continuum as Gleysols or should the stratification procedure be altered and the definition of the Gleyed subgroups broadened to include the poorer drained members (as a drainage phase) of the continuum, if solum characteristics are similar?

Two of 3 soils described as the Piney series, Gleyed Gray Luvisols on very strongly to extremely calcareous (high lime), loamy till in SE Manitoba also had a Bt with a chroma of 1 (Table 10), Colors in the C horizon below 23 cm did not meet the criteria of the Gleysol. (These 3 profiles will also be discussed with other high lime tills of the Interlake area).

d) Very shallow high lime soil soils - based on a review of 25 soils on high lime tills, the major impact of soil formation occurs within 30 cm of the mineral surface; subsoils below this depth commonly have chromas of 3 and 4 regardless of the drainage conditions (there were a few exceptions). The moderately well to well drained Black, Dark gray, Gray Luvisol, and Eutric Brunisol soils have chromas of 3 or 4 in the shallow 25-30 cm solum and no mottles; the solum is depleted of most of the primary carbonates except for the pebbles and larger fragments.

The imperfectly drained soils developed under the regional vegetation such as the Inwood series had 3 of 6 profiles with Bmgj or Btjgj with chromas of 1.5 to 3, and 1 of 6 with an AC horizon with a chroma of 3, that did not meet the Gleysol criteria; 2 of 6 with AC horizons with chromas of 1, met the criteria. (The Piney soil, a Gleyed Gray Luvisol mentioned previously, had 2 of 3 profiles with chromas of 1 in the B horizon). The Lundar soil, called Gleyed Rego Blacks, had 2 of 3 profiles with AC horizons with a chroma of 1 (Table 9). These soils with low chroma AC horizons meet the criteria of Gleysol.

Rego Humic Gleysol soils developed under poor drainage and hydrophytic vegetation (4 profiles reviewed) had a peaty layer and commonly contained remains of aquatic organisms. Colors below the Ah horizons would not meet the criteria of Gleysol; all had peaty layers.

Conclusions

Based on a considerable review of detailed profile descriptions, the conclusion is that color criteria alone and the guidelines for their application

for the Gleysolic Order are not adequately defined nor understood in order to identify, classify and separate soils within moist to saturated landscapes. An attempt to fine-tune the present definition without adequate understanding and agreement on the present concept, sequence of stratification at the Order level, and adequate validation of the color guidelines within a regional context could only lead to greater apathy and minimal adherence to published guidelines.

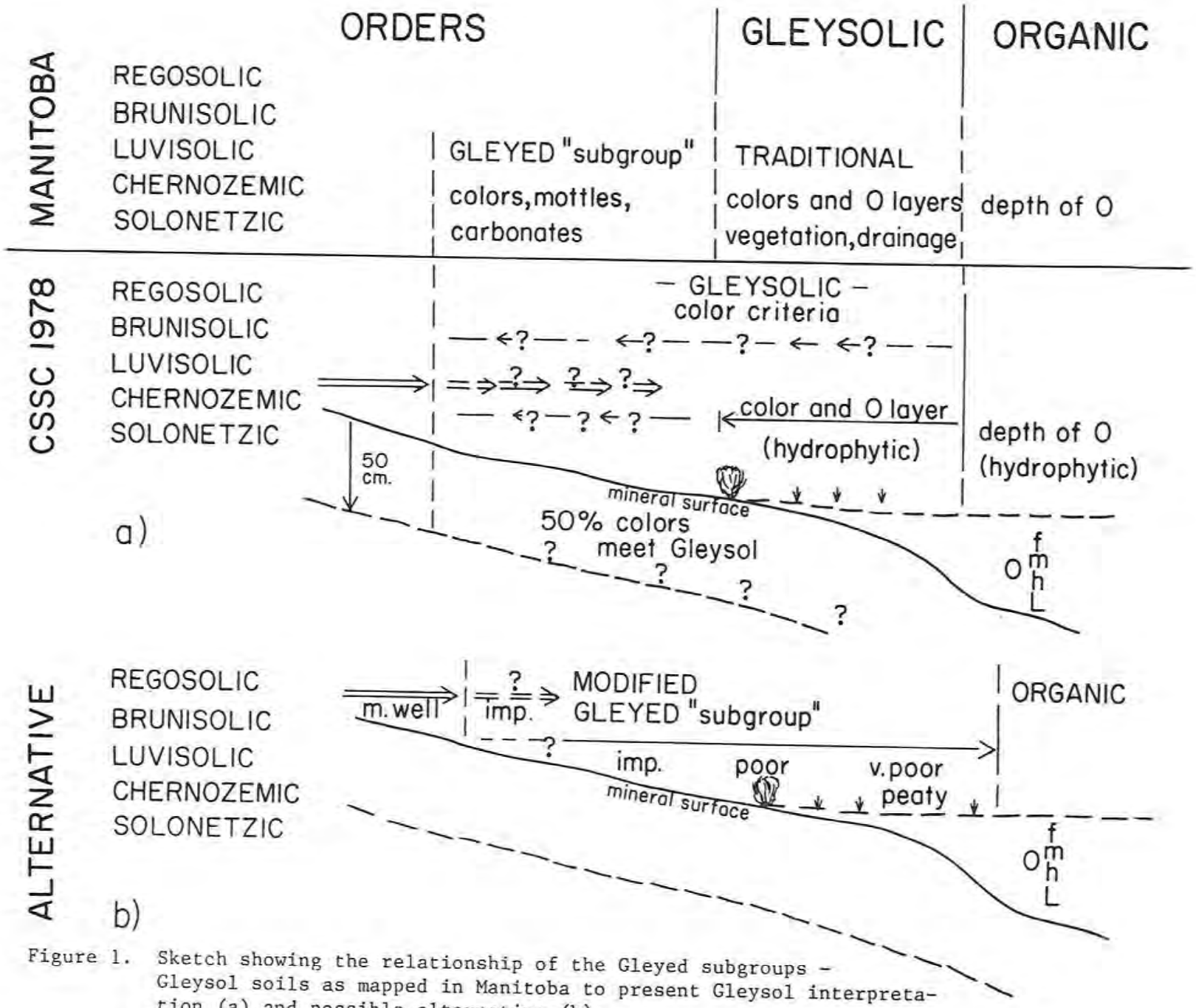

Figure 1. Sketch showing the relationship of the Gleyed subgroups - Gleysol soils as mapped in Manitoba to present Gleysol interpretation (a) and possible alternative (b).

Table 1. Kerry Series, Rego Gleysol, sandy

I.D. 1960-30 poorly drained	Hor.	Depth	Color(m)	Mottles
	(LH)	4-0	5YR 2/2	
	AHG	0-4	10YR 3/1	
	CG_1	4-43	10YR 6/3	c.d
	CG_2	43-133	5YR 5/8	c.d 7.5YR 6/8
	CG_3	133+	2.5Y 6/4	

Table 2. Kerry Series, Gleysol, sandy

I.D. 1960-38 poorly drained	Hor.	Depth	Color(m)	Mottles	$CaCO_3$
	(LH)	30-0	10YR 2/2		
	AHG	0-1	10YR 2/1		
	AEG	1-18	10YR 7/2	f.f	
	BTG	18-30	2.5Y 5/4	c.f	
	BC	30-56	10YR 6/4	c.f	
	CKG_1	56-71	2.5Y 7/4	c.f	5.8
	CKG_2	71+	2.5Y 6/2	c.f	15.7

Table 3. Malonton, Rego Humic Gleysol, sandy/clayey

I.D. 1979-12 poorly drained	Hor.	Depth	Color(m)	Mottles	$CaCO_3$
	Om_1	0-35	5YR 3/2		
	Om_2	35-40	2.5YR 2/2		
	AHG	40-70	10YR 3/2	cmf	
	CKG	70-80	2.5Y 6/4	cmp 7.5YR 6/8	13.8
	CKG	80-100	5Y 5/1		15.0

Table 4. Sprague Series, Rego Humic Gleysol, sandy/high lime till

I.D. 1980-19 poorly drained sedge, willow	Hor.	Depth	Color(m)	Mottles	$CaCO_3$
	(FH)	2-0			3.2
	AHK	0-12	10YR 1/1		10.8
	AHK	12-25	10YR 3/1.5		10.7
	AC	25-36	2.5Y 3/2		18.2
	CKG_1	36-55	10YR 5/6		35.2
	CCAG	55-60	10YR 7/1		19.2
	CKG	60-95	10YR 5/4	mmp 7.5YR 4/6	18.8
	2CKG	95-115	5Y 4/1		39.0

Table 5. Neuenberg Series, a Gleyed Rego Black, coarse loamy

I.D. 1961-5	Hor.	Depth	Color(m)	Mottles	$CaCO_3$
imperfectly drained	Ap	0-15	10YR 2/1		2.1
	AHK	15-31	10YR 2/1		2.7
	AC	31-61	10YR 4/1	C..	8.1
	CKG_1	61-76	10YR 4/3	C..	12.9
	CKG_2	76+	2.5Y 5/4	C..	15.9

Table 6. Neuenberg Series, Gleyed Rego Black

I.D. 1978-50	Hor.	Depth	Color(m)	Mottles	$CaCO_3$
imperfectly drained	Ahk	18-30	10YR 2/1		15.5
	Aca	30-38	2.5Y 5/2	ffp 10YR 5/6	22.2
	AC	38-48	2.5Y 5.5/2	ffp 10YR 5/6	17.3
	CKG_1	48-54	2.5Y 5.5/2	cmp 10YR 5/6	19.9
	CKG_2	54-80	2.5Y 5.5/2	mmp 10YR 5/6	22.7
	CKG_3	80-100	2.5Y 5.5/2	m.. 10YR 5/6	19.2

Table 7. Reinland Series, Gleyed Rego Black, coarse loamy

I.D. 1978-56	Hor.	Depth	Color(m)	Mottles	$CaCO_3$
imperfectly drained	Apk_2	12-30	10YR 2/1		10.0
	AC	30-38	10YR 4/1		17.3
	CcaGJ	38-45	10YR 4/2	fff	18.1
	$CKGJ_1$	45-57	10YR 5/4	cff	24.9
	$CKGJ_2$	57-70	2.5Y 5/4	cff	22.3
	AHBK	70-90	10YR 3/3		22.3
	CKGJ	90-120	2.5Y 5/4	cmf	15.5

Table 8. St. Claude Series, Gleyed Rego Black

imperfectly	Hor.	Depth	Color(m)	Mottles	$CaCO_3$
	Ahk	14-30	10YR 2/1		30.5
	AC	30-48	10YR 3.5/1 & 4/1		29.7
	$CKGJ_1$	48-60	10YR 6/3		19.9
	$CKGJ_2$	60-95	10YR 6/2	10YR 5/6	33.9

Table 9. Lundar Series, Gleyed Rego Black (high lime till)

I.D. 1979-26 imperfectly drained	Hor.	Depth	Color(m)	Mottles	$CaCO_3$
	LFH	3-0	10YR 2/2		10.8
	AHK	0-15	10YR 2/1		9.7
	AC	15-20	10YR 4.5/1		23.3
	CCAGJ	20-24	10YR 6.5/2		46.2
	$CKGJ_1$	24-45	2.5Y 4.5/4	fff	47.2
	$CKGJ_2$	45-90	2.5Y 4/3	cff	39.3
	$CKGJ_3$	90-100	7.5YR 6.5/4	cff	38.0

Table 10. Piney Series, Gleyed Gray Luvisol (V. strongly calc. till)

I.D. 1980-19 imperfectly drained	Hor.	Depth	Color(m)	Mottles	$CaCO_3$
	LH	5-0	10YR 2/2		
	AHEG	0-10	2.5Y 4/2		
	BTG	10-18	10YR 3/1	c.d	
	BCKG	18-23	2.5Y 5/2	c.d	8.7
	CKG	23+	2.5Y 7/2	c.d	26.7

Table 11. Framnes Series, Gleyed Dark Gray, clay/fine silty

I.D. 1980-32 imperfectly drained	Hor.	Depth	Color(m)	Mottles	$CaCO_3$
	LFH	8-0			
	AHEGJ	0-8	10YR 5/1		
	BTJGJ	8-18	10YR 2/1		
	BCGJK	18-22	10YR 4/2	fff	
	CKGJ	22-60	10YR 6/2	fff	31.4
	CKGJ	60-100	10YR 5.5/3	fff	42.4
	CKGS	100+	2.5Y 4/3	fff	45.1

Table 12. Thalberg Series, Gleyed Solonetzic Dark Gray, clayey

I.D. 1980-28 imperfectly drained	Hor.	Depth	Color(m)	Mottles	$CaCO_3$	Cond.
	AH	0-17	5YR 3/1			0.7
	BNTG	17-35	5Y 2.5/1			0.6
	CKG_1	35-70	5Y 2.5/2	fff	4.1	3.4
	CKG_2	70-100	5Y 2.5/2	fff	10.1	6.2

PRELIMINARY REPORT ON DRAINAGE CLASSIFICATION PROBLEMS OF COLD SOILS

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Canada-Manitoba Soil Survey

INTRODUCTION

A toposequence of soils developed on fine textured moderately calcareous lacustrine sediments has been established as a benchmark site to characterize soil and vegetative conditions and monitor soil thermal and moisture relations in the Thompson clay belt of northern Manitoba. The objectives of the study are to investigate some of the relationships between soil climate and soil classification as well as soil climate and hydrology in landscapes containing discontinuous permafrost. The influence that vegetative cover and successional trends has on these relationships is also being studied.

The objective of this paper is to present some preliminary observations on problems associated with the drainage classification of soils in the toposequence. In particular, the influence of soil temperature on development of soil colours diagnostic for classification of Gleysolic soils is examined.

DESCRIPTION OF STUDY AREA

The toposequence is located 16.5 km northeast of Thompson along the Thompson-Split Lake highway in northern Manitoba at approximately lat. 55°54'N long 97°43'W (Figure 1). The study site measures 100 m x 225 m on a gently sloping clayey lacustrine blanket with a north aspect. The study area occurs in the Nelson River Section of the Boreal Forest Region (Rowe, 1972) and is characterized by discontinuous permafrost (Brown, 1970).

The toposequence descends from a gently sloping upland through a very gently sloping bog veneer and terminates in a slightly raised peat plateau (Figure 2). Maximum relief is 2.5 m over the 225 m transect. The upland sites do not contain permafrost within 2 m of the soil surface whereas the bog veneer portion is characterized by discontinuous permafrost associated with non-frozen collapse areas. The peat plateau is continuously frozen.

From upper to lower topographic position the toposequence consists of the following soil types:

- the upland is characterized by dominantly Solonetzic Gray Luvisol soils with a small area of Orthic Luvic Gleysol at the toe slope position
- the bog veneer is characterized by Terric Organic Cryosols associated with Brunisolic Static Cryosols where the organic veneer is thin
- collapse areas in the bog veneer are non-frozen and characterized by very poorly drained Terric Fibrisol or Rego Gleysol peaty phase soils
- Terric Humic Organic Cryosol soils occur on the peat plateau

Soil drainage ranges from good to poor on the upland surface and imperfect to poor and very poor on the bog veneer. The peat plateau is moderately well to imperfectly drained.

Coniferous forest comprised of black spruce-ericaceae-mixed moss vegetation typical of central and northern portions of the Boreal Forest dominates the bog veneer and mixed jack pine and black spruce occur with occasional aspen on the better drained portions of the upland.

Detailed soil, site and vegetation descriptions were made for each of 5 major soils in the toposequence. Instrumentation at each site utilized thermocouples and frost tubes to monitor soil temperature and permafrost characteristics. Shallow water table observation wells and piezometers were installed to study near surface groundwater hydrology. The soil colours observed for 5 main soil types in the toposequence are related to soil temperature, water table fluctuation and permafrost characteristics at each site. These relationships are discussed for each site and the soil morphology is related to the present drainage classification.

PRELIMINARY RESULTS AND DISCUSSION

The soil thermal regime is initially a function of the prevailing climate. Mean annual air temperature in the Thompson area is -3.9°C (Figure 3). Mean annual soil temperature and mean summer soil temperature determined from measurements at the 50 cm depth in well drained clayey textured soils in the Thompson area are 2.1°C and 4.5°C respectively (Mills et. al., 1977). Associated soils with poor drainage commonly have peaty surface layers which result in colder temperatures and the development of persistently frozen soil. Poorly drained, forested, organic soils developed on deep peat commonly contain permafrost.

The fluctuation pattern of soil temperature in all soils follows seasonal trends in aerial climate as modified by soil drainage, thickness of peaty surface layer and density of vegetative cover. Greatest temperature fluctuation occurs near the soil surface, decreases with depth and becomes minimal in perennially frozen subsoil. The thickness of active layer (surface layer of soil which thaws in summer and freezes in winter) in soils containing permafrost varies seasonally and from year to year. Soils with warmer thermal regimes and no permafrost are subject to water table fluctuations with generally high levels during the growing season. Soil colour and mottle descriptions derived from the drill logs for 5 sites in the toposequence are presented together with fluctuations in water table and soil temperature in Figures 4-8.

All soils regardless of position in the landscape appear oxidized with exception of site C3. Soil colours have 10YR hue with values ranging from 4 to 5 and chromas from 2.5 to 6. The soil at site C3 on the other hand, has neutral colours and low chroma occurring immediately below the peaty surface layer but colours with higher hue and chroma occur below the 125 cm depth.

The time period and number of days that soil temperature exceeds 5°C at depths of 20, 50 and 100 cm are summarized in Table 1. Short term weather characteristics during the monitoring period have resulted in considerable fluctuation in thickness of active layer (Table 2). The relationship between soil temperature, period of saturation and soil morphology as shown in Figures 4-8 are discussed for each site as follows.

Site C10 (Figure 4) - The water table in this Solonetzic Gray Luvisol soil remains below 60 cm except for brief intervals in August and September. Soil temperature exceeds 5°C at 20 cm for 138 days and for 120 days at 50 cm (Table 1). The 100 cm depth is below the water table for some portion of the 92 days when the soil temperature exceeds 5°C but does not indicate any characteristics of poor drainage. Soil colours below the solum and extending to 3.2 m exhibit chroma ranging from 3 to 6. Prominent mottles occur below 2 m. The colour characteristics of this soil reflect the observed water table characteristics and are properly classified as a well drained soil in The Canadian System of Soil Classification (C.S.S.C., 1978).

Site C9 (Figure 5) - The water table associated with the Orthic Luvic Gleysol soil occurs within 50 cm of the soil surface for about 173 days from June to November. Soil temperature at this depth exceeds 5°C for 103 days. Temperatures at the 100 cm depth exceed 5°C for only 59 days (Table 1). However, matrix soil colours are of 10YR hue and chromas are 3 and 4 with the exception of a chromas of 2.5 in the 95-150 cm depth. Mottles are absent or faint except at depths below 175 cm. Although this soil is saturated for much of the growing season, the colour morphology does not meet the criteria defined for soils developed under saturated conditions (Gleysolic Order, C.S.C., 1978).

Site C5 (Figure 6) - This soil contains permafrost and an active layer ranging from 34 to >150 cm. There is no groundwater table but saturated conditions occur in the active layer as a result of receding permafrost and periodic perching of meltwater or runoff above the frost table. Soil temperature below 50 cm does not rise above 5°C at this site. Soil colours in the active layer and in the perennially frozen subsoil exhibit chroma of 3 and 4. Mottles are absent or faint to the 2.4 m depth becoming prominent between 2.4 and 2.8 m. This soil is classified in the Cryosolic Order as the presence of permafrost takes precedence over degree of saturation (C.S.S.C., 1978). However, the matrix colour of this soil does not meet the criteria defined for Gleysolic Cryosolic soils developed under saturated conditions (C.S.S.C., 1978).

Site C3 (Figure 7) - The water table associated with the shallow Terric Fibrisol soil at site C3 is at or above the organic soil surface throughout the year. Soil temperature exceeds 5°C for a period of 117 days at the 50 cm depth immediately above the organic-mineral contact (Table 1). Temperature exceeds 5°C for 89 days at 100 cm. Strongly gleyed colours with many distinct mottles occur throughout the 45 cm of mineral soil immediately below the peaty surface layer. Brown matrix colours with high chroma and no mottles occur below 125 cm and extend to 230 cm. Soil temperature in this layer is expected to exceed 5°C for less than 89 days.

Site C1 (Figure 8) - This soil is perennially frozen with an active layer ranging from 77 to 85 cm. There is no groundwater table but saturated conditions occur in the active layer as a result of seasonal melting of the permafrost and perching of meltwater or runoff above the frost table. Soil temperature below 50 cm does not rise above 5°C at this site (Table 1). Soil colours have a 10YR hue with chromas of 3 to a depth of 2 m although distinct mottles were evident at 55-75 cm and 95-130 cm depths. The presence of permafrost in this soil classifies it in the Cryosolic Order but the soil matrix colours preclude use of Gleysolic Subgroups. Varying periods of saturation occur above the frost table throughout the growing season.

The classification of the soils in this benchmark site presents problems because the saturated soil conditions at sites C9 and C3 and the periodic saturation above the frost table at sites C5 and C1 are not associated with neutral soil colours, low chroma and mottles. Soil material at lower depths at sites C9 and C3 appear to be permanently saturated but high chroma soil colour persists.

Comparison of this morphology with the thermal and moisture regime at each site suggests that the morphology is influenced by the thermal regime associated with each soil. Soils at sites C1 and C5 experience cold soil temperatures, contain permafrost and warm up for shorter time periods than do soils at sites C10, C9 and C3 without permafrost. The soil temperature gradient decreases rapidly in proximity to the frost table. The frozen soil acts as a "heat sink" for energy flowing into the soil and prevents the soil in the active layer from warming to the same extent as in soils without permafrost. In years that the active layer deepens, the associated warmer soil temperatures do not persist for sufficient time period to enhance the level of soil microbial activity. It appears that temperature of the soils in the toposequence remain below 5°C or biologic zero for sufficient time to reduce microbial activity, associated depletion of oxygen and development of reducing conditions.

Vegetation and ground cover have a strong influence on soil temperature and soil moisture in the study area. The cool, humid climatic conditions in the Thompson area result in vegetation development characterized by thin organic veneers which move out from poorly drained depressions and gradually cover the lower positions in gently sloping terrain. Such paludification by peat accumulation modifies the soil moisture and thermal regime in affected portions of the landscape. The organic veneers retain precipitation, reduce surface runoff and act as a thermal insulation barrier. The resulting cold soil temperature and associated permafrost limit microbial activity and the reduction processes normally associated with the extended periods of saturation resulting from the peat accumulation. Therefore, neutral colours and soil mottling do not develop in the mineral soils beneath the organic veneer even though they are now saturated for much longer periods than prior to paludification by the peat.

CONCLUSIONS

Preliminary evaluation of the data from this benchmark site suggests that the soil moisture regime and soil morphology observed at most sites in the toposequence are influenced by the thermal regime associated with these soils. Although a saturated moisture regime persists through a good portion of the growing season within 50cm of the soil surface at site C9, at the soil surface at site C3 and periodically above the frost table at sites C5 and C1, gleyed colours and low chroma occur only at site C3. The cold soil temperatures in these soils restrict microbial activity and development of low chroma characteristic of the reduced conditions normally associated with saturated soils.

The dominance of oxidized colours in all soils at all depths examined indicates that early stages of soil development in the area took place under different climatic and vegetation condition than which occur at present. Current climatic conditions have resulted in sufficiently cold soil temperatures that reduction processes are restricted and the high chroma may be relict soil features.

RECOMMENDATIONS

Improvement to the drainage classification of soils developed under saturated conditions in cold environments depends on further monitoring and analysis of soil morphology and site characteristics. Significant areas of soils with saturated conditions close to the surface or perched above the frost table do not satisfy the colour criteria presently established to describe poor soil drainage. Adjustment to the current colour criteria are required when applied to cold soils. Soil Taxonomy (Soil Survey Staff, 1975) presently has tailored specific criteria to suit the soils of different soil orders. Such criteria should reflect the morphological characteristics resulting from saturated water regimes in different materials and in different environments.

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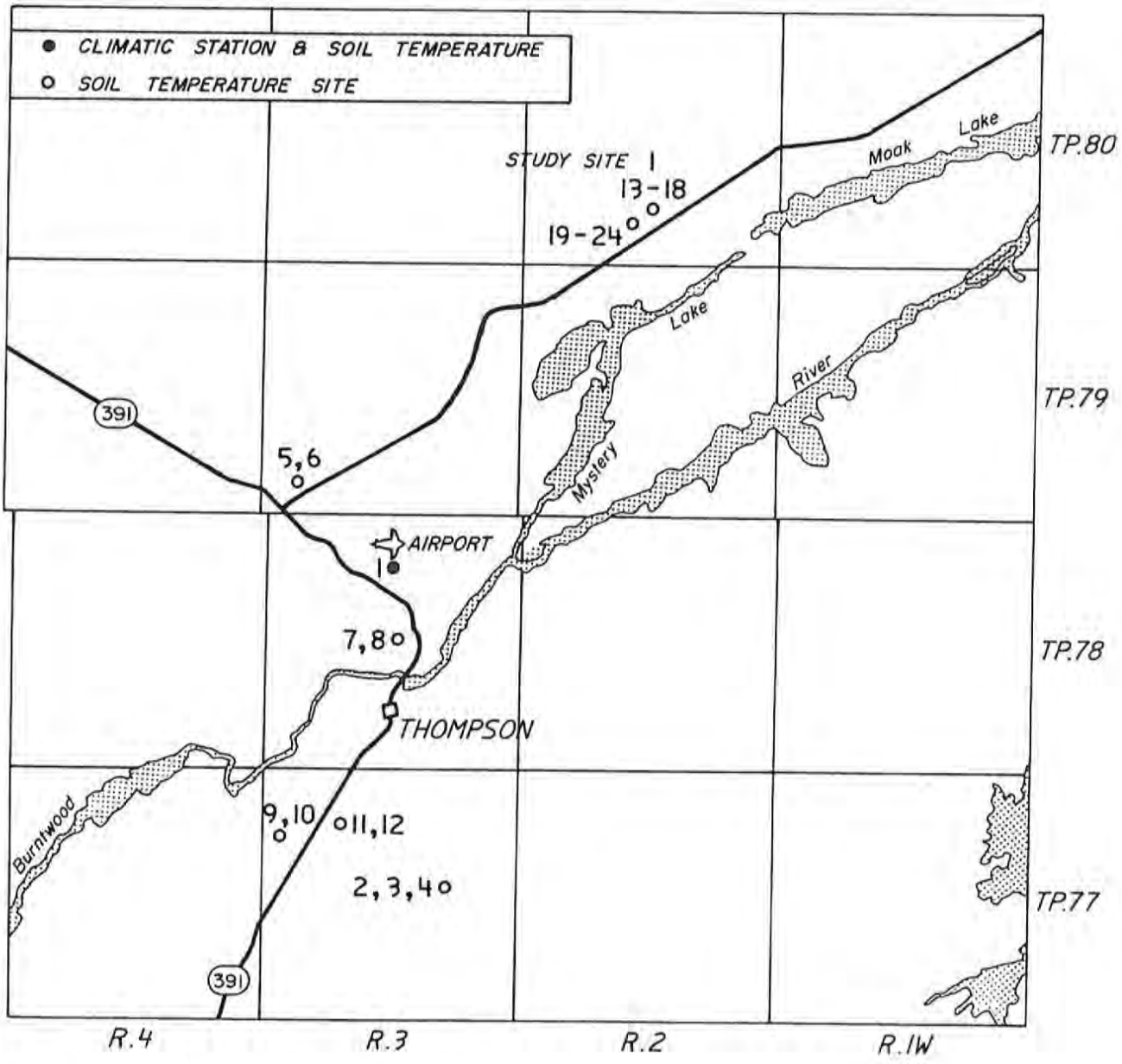


Figure 1. Location of Study Area

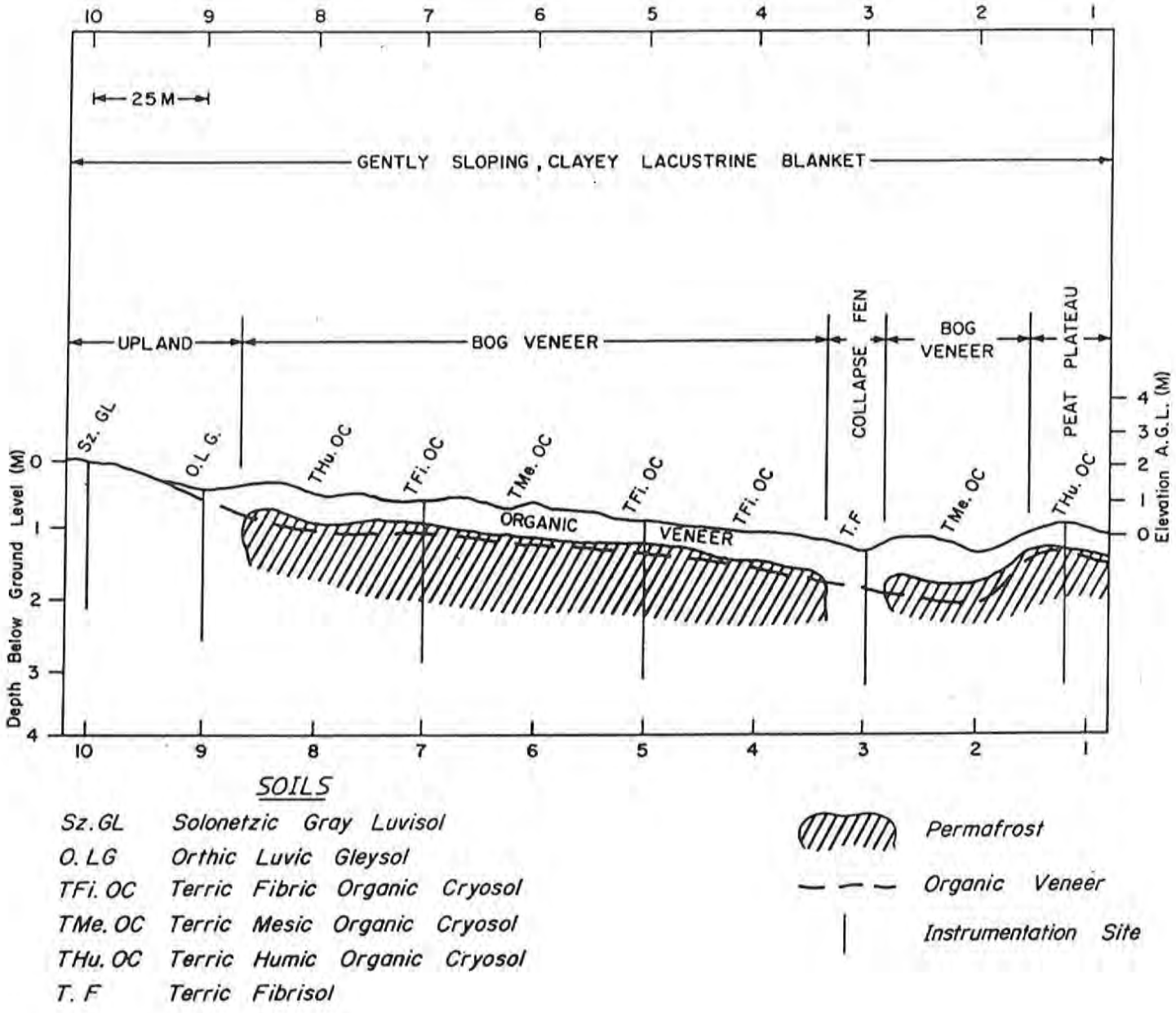


Figure 2. Cross-section along Transect C, Site 1

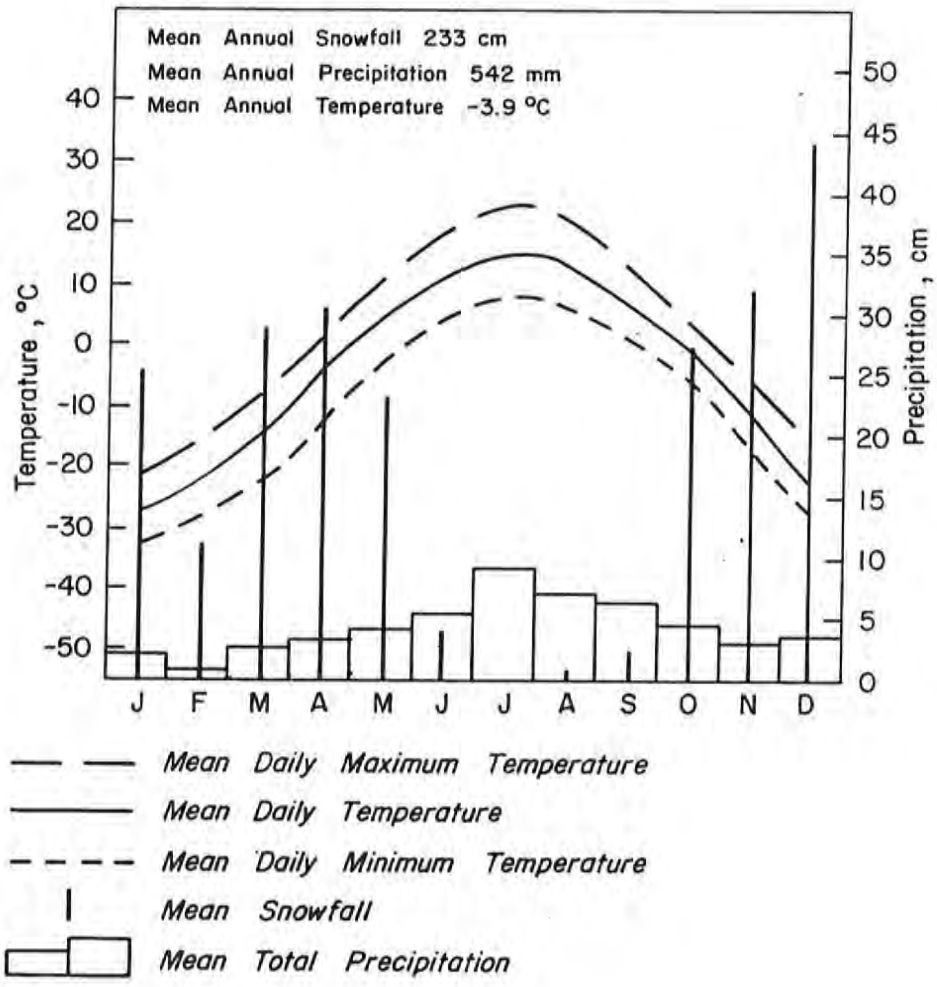


Figure 3. Climatic Characteristics, Thompson, Manitoba

Source: Canadian Climate Normals: Vol 2 Temperature, Vol 3 Precipitation, 1951-1980. Atmospheric Environment Service, Environment Canada

SCTC-1 Site C10 Solonetzic Gray Luvisol

DRILL LOG

Depth (cm)	Texture	Colour	Mottle Description			
			Abund.	Size	Contrast	Colour
10-50	C	-	-	-	-	-
50-70	C	10YR 4/3	-	-	-	-
70-100	C	10YR 5/6	-	(Gray Bodies)		10YR 4/2
100-150	C	10YR 4/4	-	-	-	10YR 4/3
150-200	C	10YR 4/4	few	fine	faint	7.5YR 5/6
200-250	C	10YR 4/3	many	fine	prominent	7.5YR 5/6
250-320	C	10YR 4/3	many	medium	prominent	10YR 6/8

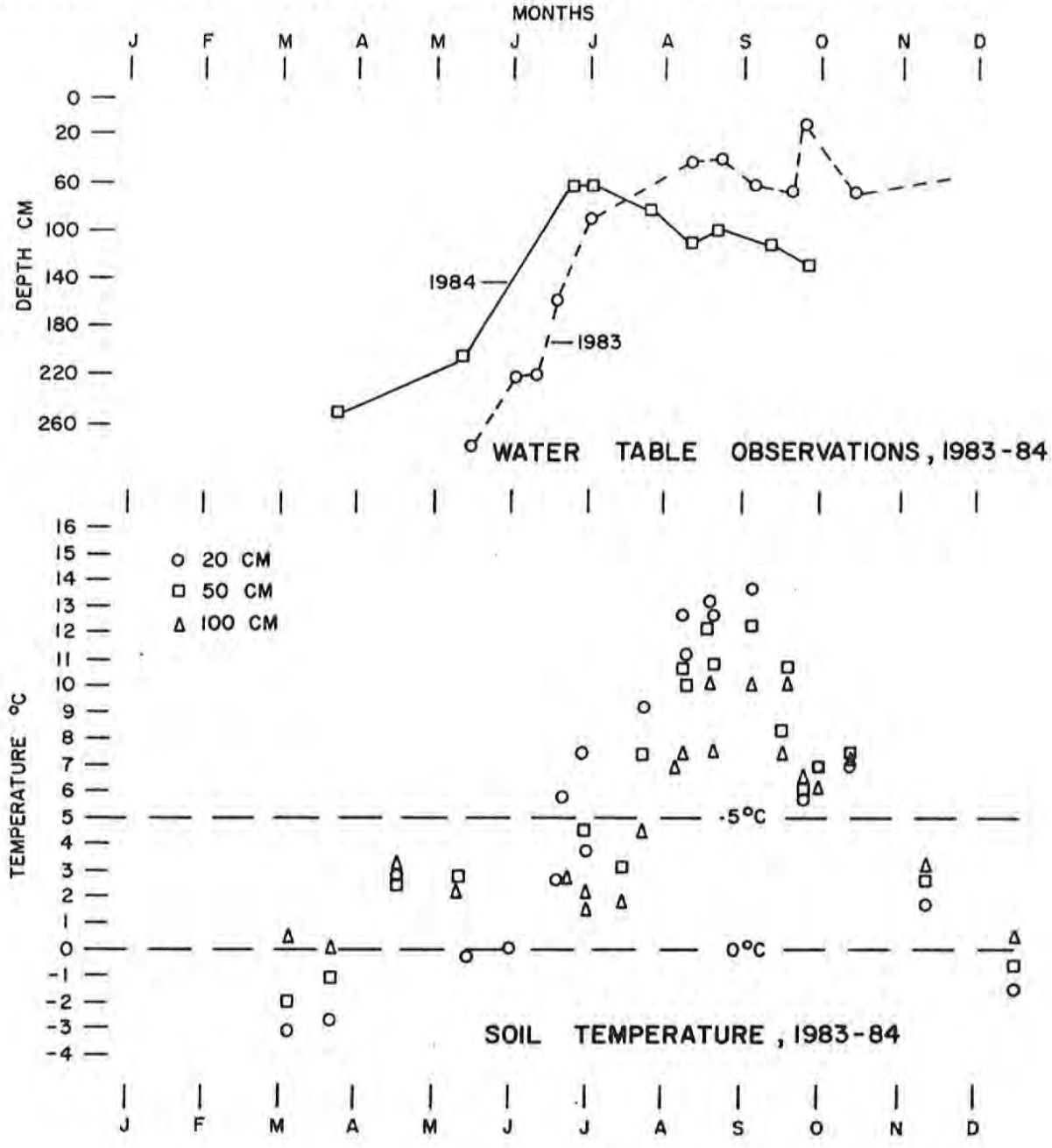
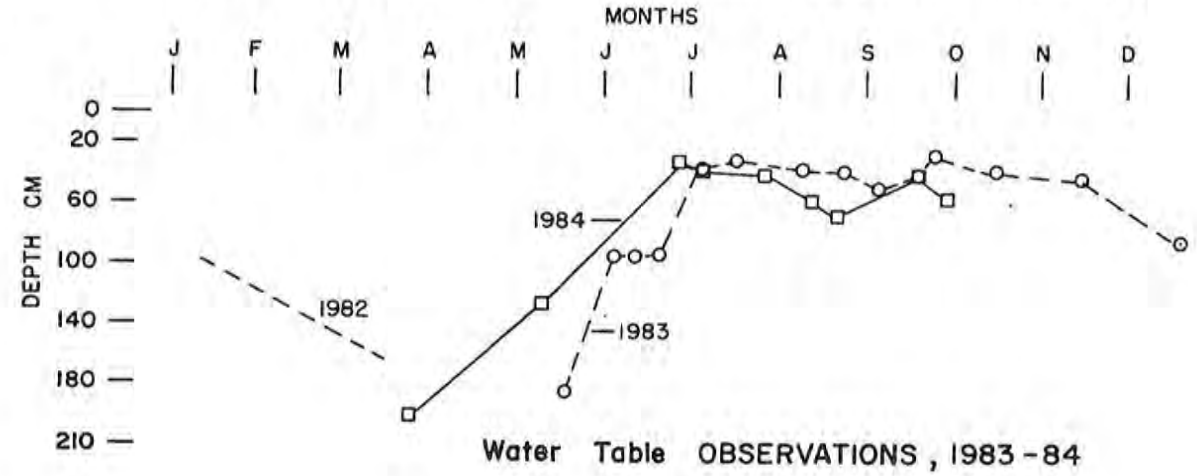


Figure 4. Drill Log, Water Table and Soil Temperature Observations for Solonetzic Gray Luvisol (Site C10)

DRILL LOG

Depth (cm)	Texture	Colour	Mottle Description			
			Abund.	Size	Contrast	Colour
0-25	Organic	-	-	-	-	-
50-65	C	10YR 4/3	-	-	-	-
65-95	C	10YR 5/4	v. few	fine	faint	-
95-150	C	10YR 4/2.5	-	-	-	-
150-175	C	10YR 5/3	-	-	-	10YR 4/2
175-	C	10YR 5/4	few	medium	distinct	7.5YR 5/6



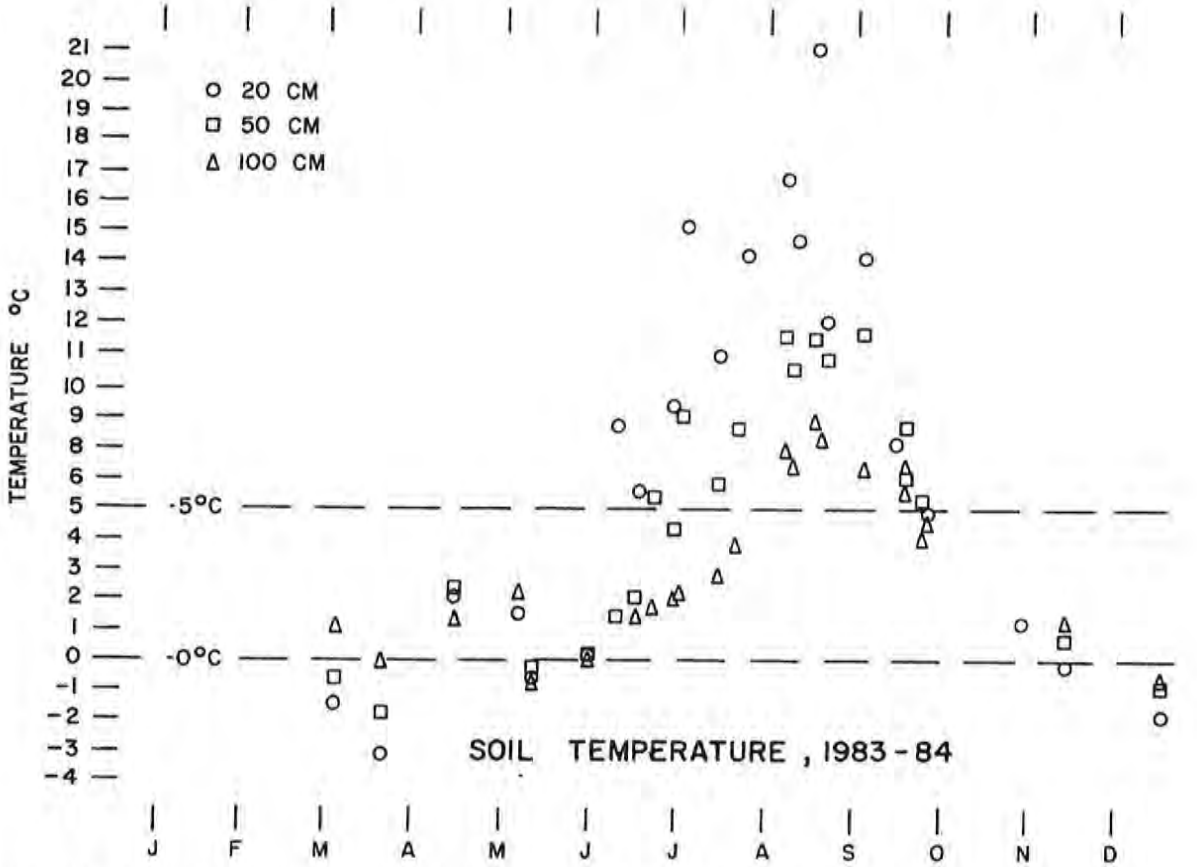
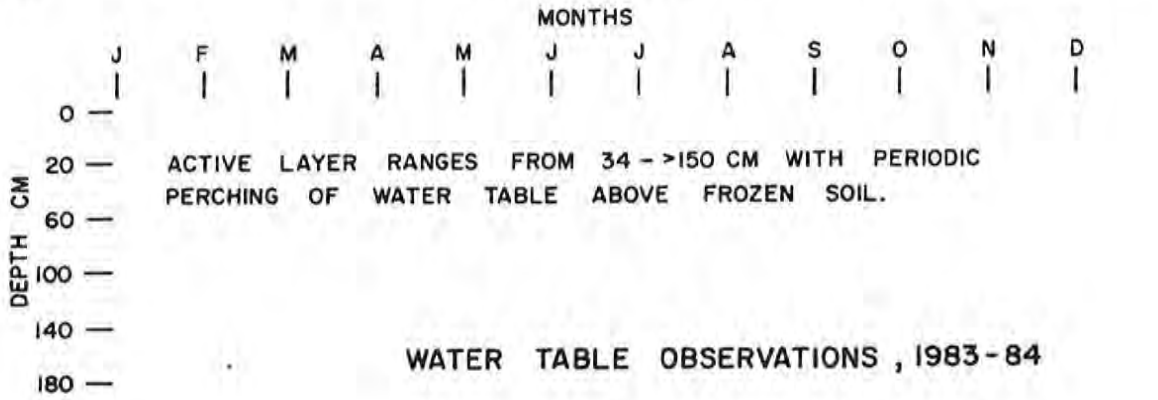


Figure 5. Drill Log, Water Table and Soil Temperature Observations for Orthic Luvic Gleysol (Site C9)

SCTC-1 Site C5 Terric Fibric Organic Cryosol

DRILL LOG

Depth (cm)	Texture	Colour	Mottle Description			
			Abund.	Size	Contrast	Colour
0-55	Organic	-	-	-	-	-
55-75	C	-	-	-	-	-
75-100	C	10YR 5/4	-	-	-	-
100-150	C	10YR 5/4	-	-	-	-
150-200	C	10YR 5/4	-	-	-	10YR 4/1
200-240	C	10YR 5/3	many	medium	faint	10YR 5/8-7.5YR 5/4
240-280	C	-	many	medium	prominent	7.5YR 4/4



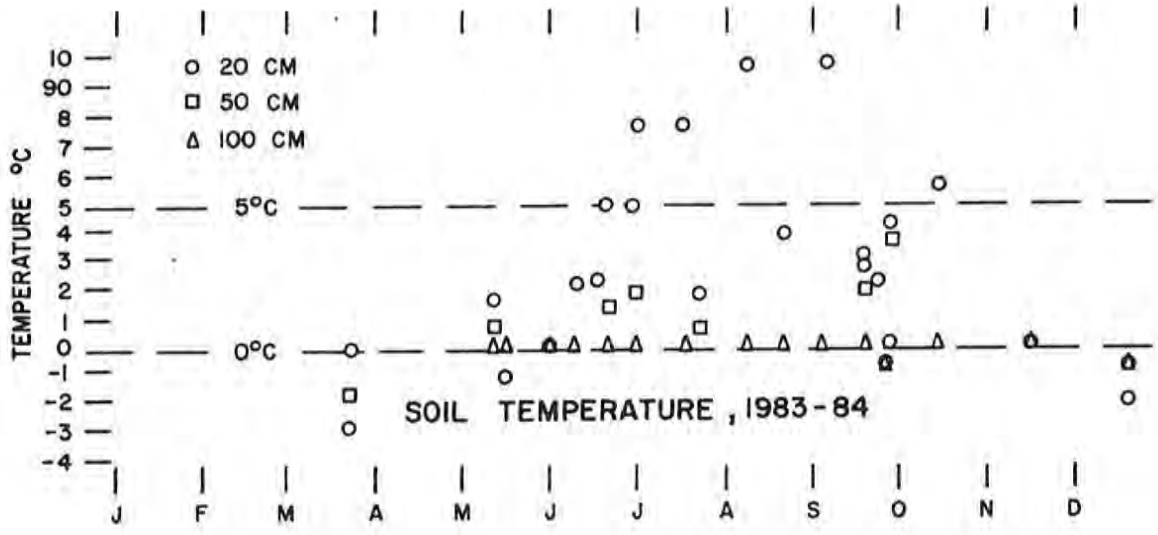


Figure 6. Drill Log, Water Table and Soil Temperature Observations for Terric Fibric Organic Cryosol (Site C5)

SCTC-1 Site C3 Terric Fibrisol

DRILL LOG

Depth (cm)	Texture	Colour	Mottle Description			
			Abund.	Size	Contrast	Colour
0-55	Organic					
55-80	C	strongly gleyed below organic contact with				
80-100	C	with many medium distinct mottles				
100-150	C	matrix colours become brown at 125cm				
150-200	C	high chroma brown, no mottles				
200-230	C	high chroma brown, no mottles				

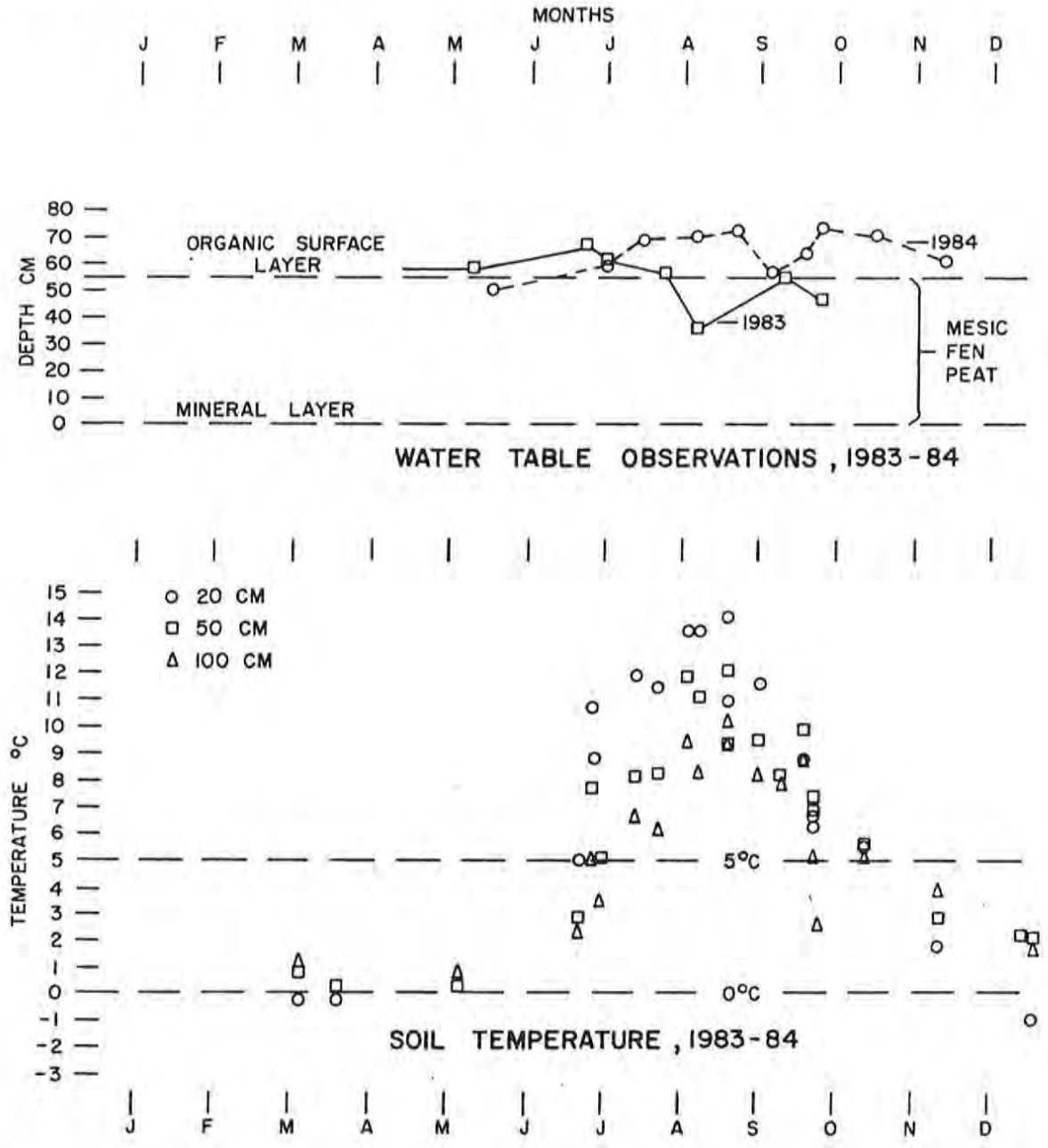


Figure 7. Drill Log, Water Table and Soil Temperature Observations for Terric Fibrisol (Site C3)

SCTC-1 Site C1 Terric Humic Organic Fibrisol

DRILL LOG

Depth (cm)	Texture	Colour	Mottle Description			
			Abund.	Size	Contrast	Colour
0-30	Organic	-	-	-	-	-
55-75	C	5YR 4/2	few	fine	distinct	2.5YR 5/4
75-90	C	10YR 4/3	-	-	-	10YR 4/4
90-95	C	10YR 4/3	-	-	-	-
95-130	C	10YR 4/3	many	medium	distinct	10YR 4/6
130-175	C	-	-	-	-	-
175-200	C	10YR 4/3	few	medium	faint	10YR 4/2

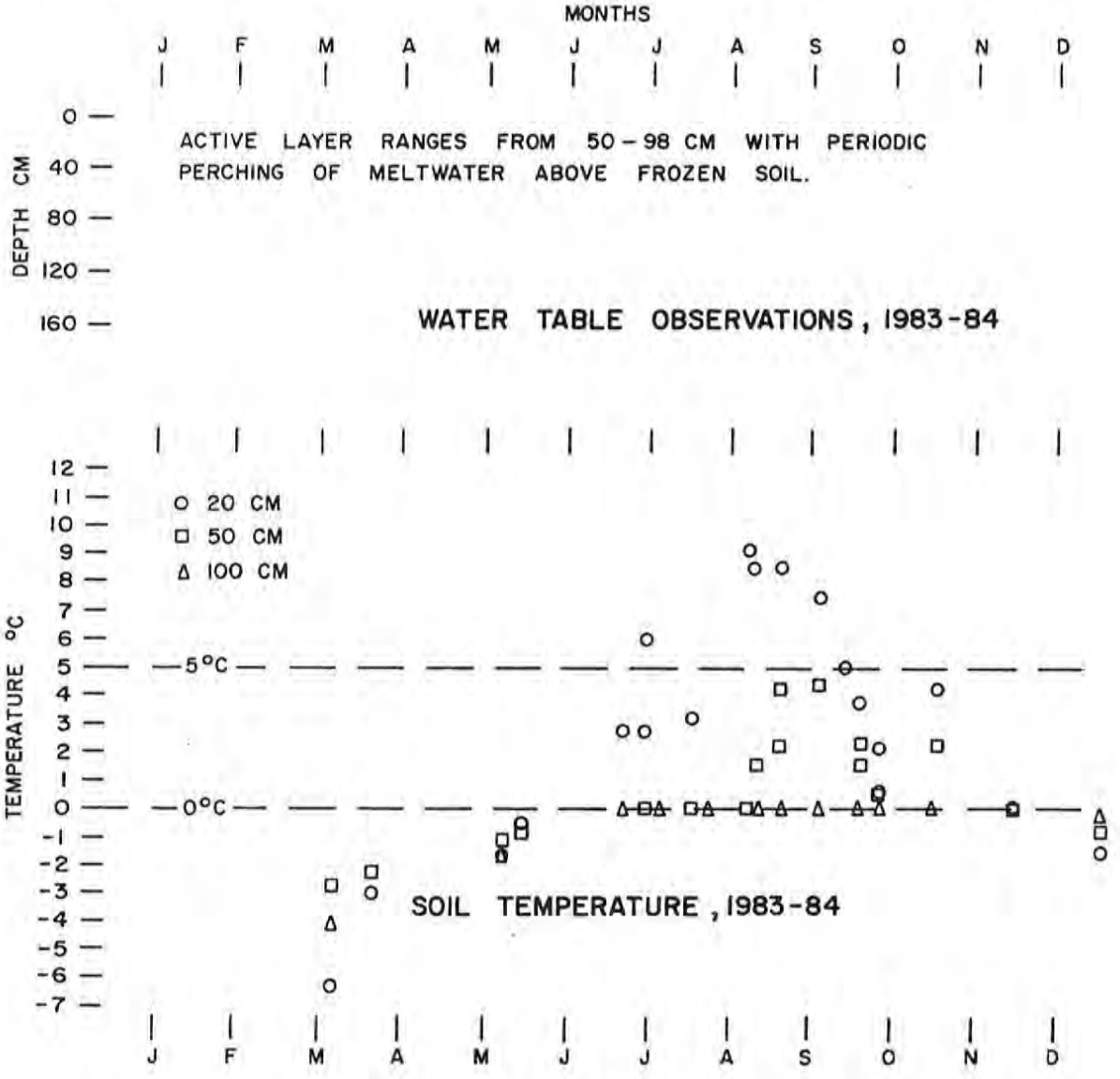


Figure 8. Drill Log, Water Table and Soil Temperature Observations for Terric Humic Organic Cryosol (Site C1)

Table 1. Time period and number of days soil temperature exceeds. 5°C

Site No. and Sub. group*	Depth of Organic	Depth in Soil, cm					
		20 cm		50 cm		100 cm	
		Period	Days	Period	Days	Period	Days
C10 Sz.GL	10	June 5-Oct. 21	138	June 27-Oct. 25	120	July 25-Oct. 25	92
C9 O.LG	25	May 21-Sept. 26	128	June 15-Sept. 26	103	July 20-Sept. 17	59
C5 TFi.OC	55	June 19-Sept.11	84	-	0	-	0
C3 T.F	55	June 21-Oct. 20	121	June 25-Oct. 20	117	June 25-Sept. 22	89
C1 THu.OC	30	June 25-Sept. 15	82	-	0	-	0

*Sz.GL Solonetzic Gray Luvisol
O.OG Orthic Luvic Gleysol
TFi.OC Terric Fibric Organic Cryosol
T.F Terric Fibrisol
THu.OC Terric Humic Organic Cryosol

Table 2. Thickness of active layer, cm

Site No. and Soil Subgroup*	Depth of Organic (cm)	Depth to permafrost table (active layer, cm)			
		DATE			
		81-09-17	82-09-14	83-09-20	84-09-16
C10 Sz.GL	10		No Permafrost		
C9 O.LG	25		No Permafrost		
C5 TFi.OC	55	60	>150	88	>150
C3 T.F.	55		No Permafrost		
C1 THu.OC	30	50	50	60	98

* Sz.GL Solonetzic Gray Luvisol
O.LG Orthic Luvic Gleysol
TFi.OC Terric Fibric Organic Cryosol
T.F. Terric Fibrisol
THu.OC Terric Humic Orgnic Cryosol

AN ASSESSMENT OF THE SPECIFIC PROPOSALS FOR CHANGES TO THE GLEYSOLIC ORDER AS APPLICABLE TO ONTARIO SOILS

L.J. EVANS

Introduction

Gleysolic soils are extensive in Ontario, being developed primarily in heavy textured glaciolacustrine and glaciomarine deposits, and on level to undulating glaciofluvial sand plains. It is estimated that approximately one quarter of the province of Ontario was inundated by glacial lakes and seas in the immediate post-glacial period.

The major heavy textured deposits upon which Gleysolic soils have developed are:

i) Southeastern Ontario - glaciomarine deposits of the Champlain Sea.

ii) Southcentral Ontario - glaciolacustrine deposits of Lake Iroquois and Lake Peel.

iii) Southwestern Ontario - clayey tills derived from deposits of Lake Warren.

iv) Northeastern Ontario - Glaciolacustrine deposits of Lake Algonquin and Lake Barlow-Ojibway.

v) Northwestern Ontario - glaciolacustrine deposits of Lake Agassiz.

vi) Hudson Bay-James Bay Lowland - glaciomarine deposits of the Tyrrel Sea.

In the agricultural areas of southern Ontario, the total hectareage of Gleysolic soils has been estimated at over one million hectares (southwestern Ontario - 580,000 ha; southcentral Ontario - 120,000 ha; southeastern Ontario - 400,000 ha). The major soil series classified as Gleysolic soils in the agricultural areas of Ontario with hectareages in excess of 25,000 are listed below:

Brookston - clayey till (560,000 ha)
Granby - sandy glaciofluvial outwash (92,000 ha)
North Gower - clayey glaciomarine deposits (89,000 ha)
Bearbrook - clayey glaciomarine deposits (87,000 ha)
Parkhill - loamy till (56,000 ha)
Napanee - clayey glaciolacustrine deposits (53,000 ha)
Clyde - clayey glaciolacustrine deposits (30,000 ha)
Osgoode - clayey glaciolacustrine deposits (29,000 ha)
Lyons - loamy till (29,000 ha)
Jeddo - clayey till (25,000 ha)

As should be apparent from the above, Gleysolic soils are of major interest in Ontario and hence any revisions to their classification is of concern to pedologists in Ontario. The specific concerns and proposals outlined below are a consensus of views expressed at a meeting of the Ontario Institute of Pedology called specifically to discuss the proposed revisions to the classification of the Gleysolic order.

Specific proposals

A. The Gleyed Gray Luvisol - Luvic Gleysol split

1) As Gray Brown Luvisols are a significant component of the Luvisolic Order in Ontario it was felt that the proposal, if implemented, should be extended to include both Great Groups of the Luvisolic Order.
2) No definitive concensus was reached on the proposal to change the classification of soils with prominently mottled Aeg horizons overlying unmottled Bt horizons from Luvic Gleysols to Gleyed Gray (Brown) Luvisols, with opinions about equally divided between the present classification and the proposed revision. It was however felt that the proposed revision did not tackle the perennial problem in the Canadian System of Soil Classification of not distinguishing between ground water gleys and surface water gleys. The present proposal was suggesting that the surface gley phenomena associated with a perched watertable is not sufficient to place the soil in the Gleysolic Order.
3) It was also possible that a similar problem could arise in the Gleyed Subgroups of the Podzolic Order. For example, a perched watertable above a placic, duric or ortstein horizon could lead to the manifestation of gley features in the Ae horizon above the restricting layer in what is in all other respects a well-drained soil.

B. Prominent mottles or low chroma and prominent mottles

1) It was agreed that this proposal should be implemented as outlined in the document by McKeague and Wang.

C. Soils with calcic horizon within 50 cm

1) Calcic horizons with secondary accumulations of calcium carbonate do not appear to be common in the soils of Ontario and, where present, are generally not sufficiently thick to be of particular concern from the point of view of soil classification.

D. Low chroma mottles

1) Mottles with low chroma do not appear to be of particular importance in Ontario soils and hence there was little or no discussion on this proposal.

E. Few distinct or prominent mottles

1) It was agreed that few mottles within an otherwise well drained horizon should be ignored.
2) However concern was expressed that there is no minimum thickness for mottled horizons. For other diagnostic horizons there is a minimum thickness of 10 cm - why not a minimum thickness for 'g' horizons of 10 cm?.

F. Colour criteria for soils developed in red materials

1) In the Niagara Region of southwestern Ontario there are many soils developed in glacial materials containing significant proportions of reddish Queenston shale. These soils often have matrix colours of 5YR4/4 or 5YR4/3. In low landscape positions these colours are often accompanied by mottle colours of 5YR5/6 and/or 5YR4/6.

2) It was felt that the proposal to drop the requirement for low chromas for poorly drained soils was useful for soils with reddish colours, but that the proposal could be improved for Ontario if both distinct and prominent mottles were included in the revised proposal.

G. Humic Gleysol - Gleysol split

1) In Ontario the major problem with differentiating the Humic Gleysols from the Gleysols is not so much with the colour values but with the content of organic C in the Ap horizons.

2) For example, in the intensively cultivated soils of southwestern Ontario there are now many soils which presumably at one time met the requirements for Humic Gleysols but which now have organic C contents less than 2%. In the Regional Municipally of Niagara, for example, 19% of 517 profiles classified as Humic Gleysols in the field had less than 2% organic C in their Ap horizons. Similarly, 39% of 141 profiles classified as Humic Gleysols in The Regional Municipally of Haldimand-Norfolk and 14 out of 50 in Elgin county had Ap horizons with less than the required amounts of organic C. However if the lower limit for organic C contents in Ap horizons of Humic Gleysols was lowered, for example, to 1.5%, then these figures reduced to 2%, 13% and 8% respectively. It was suggested that in these intensively cultivated Humic Gleysols a lower limit for organic C contents in the Ap horizons should be investigated.

H. Add Solonetzic subgroups to the Gleysolic order

1) No problem in Ontario!

REPORT ON FOLISOLIC SOIL CLASSIFICATION IN CANADA

R. Trowbridge[1], H. Luttmerding[2], and C. Tarnocai[3]

FOREWORD

This report addresses Folisolic soils in Canada. It is a review of the deficiencies in their treatment in the Canadian System of Soil Classification (Canada Soil Survey Committee 1978), and proposals developed for improvements to the classification. The report is based on the results obtained by the Working Group on Organic Horizons, Folisols, and Humus Form Classification over a period of five years (1979-1984).

INTRODUCTION

Folisolic soils were first identified in the Canadian soil classification about 15 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.

Classification problems concerning Folisols and L, F, and H horizon designations were identified following a soil correlation tour (September 13-17, 1979) "to examine podzols, folisols, gleysols and organics in the Prince Rupert - Queen Charlotte Island areas" (B.C. Ministry of Environment memorandum Sept. 6, 1979). Members of that tour were T. Lord and C. Tarnocai of Agriculture Canada, H. Luttmerding, A. Harcombe, and V. Osborne of the B.C. Ministry of Environment, and R. Trowbridge of the B.C. Ministry of Forests.

In a memo to Dr. J.S. Clark (October 1, 1977), C. Tarnocai stated, "It has become increasingly evident that the definition and classification of humus horizons (LFH) and the classification of Folisols require modification." That memo defined the objective of the working group: to set up guidelines and to suggest modifications to the current classification of humus forms, Folisols, and L, F, and H horizons. It also requested that the working group make a presentation during the Expert Committee on Soil Survey (ECSS) meetings in March, 1980.

Initially the working group came under the sponsorship of the B.C. Soil Science Lead Committee and then was to become a working group under the ECSS (minutes of the B.C. Pedology Subcommittee, T. Lord, October 16, 1979). R.

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Trowbridge was asked to chair the working group. Members of the group were B. Green and K. Klinka of the B.C. Ministry of Forests, A. Harcombe and H. Luttmerding of the B.C. Ministry of Environment, T. Ballard and L. Lowe of the University of B.C., and D. Moon of Agriculture Canada. T. Lord and C. Tarnocai acted as senior advisors and a "corresponding" membership of nine other B.C. soil scientists and plant ecologists was established. The first meeting of the working group was in November, 1979, and the last meeting of the complete group was in January, 1983. Following that T. Lord, H. Luttmerding, C. Tarnocai, and R. Trowbridge continued to work on the modification of the Folisolic soil classification.

During the past two years, field work and data analysis have been carried out under the direction of C. Tarnocai in order to test and verify the recommendations of the working group and to satisfy comments by reviewers on the working group's two progress reports (Trowbridge 1980, 1981). This report reviews the initial recommendations and review comments and presents the final recommended modifications to the classification of Folisolic soils. Another report (C. Fox, Land Resource Research Institute) will detail the recent field work and data analysis.

REVIEW OF THE PERIOD 1979-1984

The first progress report (Trowbridge 1980) dealt with the current classification of Folisols, problems relating to the classification, and suggestions for improvement. It solicited support for classification modification in the next version of the Canadian System of Soil Classification.

Several inconsistencies were identified in the classification procedures. The first was that the thick organic (L, F, and H) surface horizons (folic), 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 was that poorly drained organic soils (with diagnostic O horizons) are classified in the Organic order when the depth of peat material over mineral soil exceeds 40 cm; this parallelism does not exist when the organic material is of the folic type.

Another inconsistency found in the present classification was 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 upland origin (folic material) in contrast to wetland origin (peat material); and 4) subject to upland accumulation and decomposition processes rather than to peat-forming processes associated with wetland conditions.

The report described the type of environments in British Columbia where soils with deep folic material have been described and surveyed. These areas include the west coast of the B.C. mainland, the northern and western parts of Vancouver Island, and the Queen Charlotte Islands. In these areas the climate is cool and wet. The soils rarely freeze or completely dry. Under these conditions forest fires are rare occurrences and therefore do not significantly contribute to organic soil horizon reduction. Also, these conditions do not favor high rates of decomposition. Concurrently, these areas are Canada's most productive forests and the folic accumulation rate is

comparatively high. Deep folic materials are also frequently encountered in the northern part of the province and appear to be associated with discontinuous permafrost. Decomposition of the folic material is so slow (probably due to cold soil temperatures) that accumulation of the folic soil material predominates.

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

Because of the importance of the folic material, it appeared that it should be identified as a diagnostic feature in the classification system. This already occurs for folic material over bedrock (Folisol great group) but not for deep L, F, and H accumulations over mineral or peat soil.

The first progress report suggested some possible alternatives for classification improvement. These were:

Option 1: Expansion of the current Folisol great group of the Organic soil order to include soils with thick L, F and H horizons over unconsolidated mineral material;

Option 2: Defining "Folisolic" subgroups for existing great groups in the established soil orders; and

Option 3: Defining a new soil order which would consist of Folisolic soils.

These options were presented in detail at the March, 1980 ECSS meetings by R. Trowbridge. There was a discussion period following the presentation and the report was later printed and circulated for review.

Response to the first progress report by members of the Expert Committee (and others) was gratifying and generally supported the premise that the classification of Folisolic soils requires modification and improvement. Constructive comments, suggestions, and criticisms were received from W. Baril, J.H. Day, L.J. Evans, C.A. Fox, K. Jones, T. Lewis, T. Lord, J.A. McKeague, W.W. Pettapiece, J. Shields, R.J. St. Arnaud, C. Tarnocai, L. Turchenek, T. Vold, and M.A. Zwarich.

The second progress report (Trowbridge 1981) was a substantial revision of the first and attempted to rectify the deficiencies noted by the reviewers as well as to take into account suggestions and requests of the respondents. Discussion was expanded, a map showing the general distribution of depth of folic material (in B.C.) was included and several soil profile descriptions with analyses were appended. Option 2 was deleted as a possible method of modifying the Folisolic classification - it found disfavor with almost all reviewers.

Because of the perceived importance of the deep folic surface material in the soil forming process, as well as its importance in land management and utilization, it appeared that the material should be identified as a consistent diagnostic feature in the Canadian soil classification. Currently, the organic material is diagnostic when it overlies bedrock but not if it is

underlain by mineral or peat soil. The consensus of the respondents to the first progress report strongly supported the principle that deep, folic surface horizons should be diagnostic regardless of the kind of underlay.

As mentioned earlier, soil surveys and other studies, both on the coast and in the northern interior of British Columbia, have established that substantial areas of soils with deep folic horizons occur, that the thickness of these horizons is at least 15 cm and often between 40 and 100 cm, and that the thick folic horizons overlie bedrock, fragmental, mineral, and peat materials. Respondents to the first progress report stated that soils with relatively thick L, F and H horizons have also been observed in parts of Ontario and Quebec. As well, Soil Taxonomy (1975) indicates Folists occur in Alaska and have been identified in the northern lake states.

This indicates that Folisolic soils are not unique to the west coast of Canada. Several reviewers expressed concern that if Option 3 (new Folisolic order) were adopted, the areal extent of the new order would be small. In relation to the extent of some orders, this is probably true. Other soil orders (the Solonetzic order, for example), however, are also limited in area. The main criteria for the definition of a new soil order should be the soil forming process and its products which are to be characterized and classified. Areal extent, at best, should only be a secondary consideration.

A reservation expressed by a few reviewers was that surface organic horizons are readily manipulated and altered by management practices (eg. logging and prescribed burning) making Folisolic soils prone to taxonomic changes. This can be said of other soil orders as well. The very shallow Podzols in the Rockies and the thin Luvisols in Manitoba, for example, are also subject to drastic taxonomic changes through disturbance and manipulation. Shallow organic soils, after draining and subsidence, may no longer meet the depth criteria of the Organic order. A soil survey and its associated soil classifications should characterize the soil conditions at the time of the survey, not the potential product of some sort of modification.

The second progress report provided two options for modification to classification of the Folisols. Option A proposed the expansion of the current Folisol great group of the Organic order to include soils with thick L, F and H horizons over unconsolidated mineral soil. It required redefinition of both the Organic order and Folisol great group to include soils with accumulations of folic material thicker than 40 cm over unconsolidated mineral or peat material.

Option B proposed the definition of a Folisolic soil order. The existing Folisol great group would be deleted from the present Organic order and form part of the new order. The Organic order would be redefined (possibly re-named) and would be composed only of soils with diagnostic O (peat material) horizons. The Folisolic order would consist of soils with folic accumulations greater than 10 cm thick if over bedrock (or fragmental rock) or greater than 40 cm thick if over unconsolidated mineral or peat material.

The members of the working group unanimously agreed to support and recommend the creation of a new Folisolic soil order. This point was stressed and made clear to C. Tarnocai (chairman, Soil Classification Subcommittee) and T. Lord (chief correlator for British Columbia), since they were to make the presentation of the group's report to the ECSS in March, 1981. In addition, the B.C. working group indicated that their initial objectives had been achieved and recommended that further work be the responsibility of a national group.

Following the submission of the second progress report, the working group members concentrated on related studies. The B.C. Ministry of Forests published Taxonomic Classification of Humus Forms in Ecosystems of British Columbia (Klinka et al, 1981). L. Lowe began analyzing the chemical data from 265 organic horizon samples collected by B. Green and R. Trowbridge. Both of these studies further supported the evidence that 1) folic material is present in British Columbia and 2) folic and peat materials are not only differentiated chemically, but pedologists are able to distinguish them in the field with a high degree of accuracy. Both reports were made available to the ECSS in April, 1982 at the meetings held in Victoria.

Staff from the Soil Classification and Soil Inventory sections of the LRRI (J. Day, J. McKeague, J. Shields, C. Tarnocai, and C. Wang) met in June, 1982 to discuss the classification of Folisols. There was no clear decision as to which modification should be selected. Half of the staff (Tarnocai not included) favoured the creation of a Folisolic order and half favoured keeping Folisols in the existing Organic order (minutes from the meeting, June 2, 1982). They concluded that C. Tarnocai should prepare a new proposal and submit it to the National Soil Classification Working Group (NSCWG) for comment and suggestions.

The B.C. working group met in early 1983 to discuss the above and update related work. B. Green had completed the editing of an internal report (B.C. Ministry of Forests), Organic Materials in Forest Ecosystems - An Annotated Bibliography (Hope 1983) and L. Lowe had completed his report, Organic Horizons in British Columbia, Their Properties and Classification. Both of these reports were submitted to the working group and were forwarded to the NSCWG.

C. Tarnocai organized a field trip to British Columbia during the 1983 field season to describe and sample representative Folisols. Locations for the sampling were selected in areas identified by the B.C. Ministry of Forests' ecologic classification studies. In addition, B. Green and R. Trowbridge supplied the Land Resource Research Institute (LRRI) with approximately 150 detailed Folisolic soil descriptions with chemical analyses. Most of the soils described were located on a 1:1,900,800 map, which was included. During this time, C. Tarnocai also discussed his ideas on a new proposal and it was decided that T. Lord, H. Luttmerding, and R. Trowbridge would help develop it for presentation in 1984 to the NSCWG.

During the 1984 field season, C. Tarnocai organized another field trip to British Columbia to be directed by C. Fox. The objectives were to further describe and sample representative Folisols as defined by the latest (following section) classification proposals, and in addition, to sample for variability in the pedon, and spatial variability in the landscape. This work is detailed in a report by C. Fox presented at the 1984 NSCWG meetings.

Appended to this report is the final proposal for changes to the classification of Folisolic soils in Canada. It includes two options: one for the creation of a new soil order and one for the expansion of the Folisolic great group. The authors of the report, the chairman of the NSCWG, and members of the B.C. working group (inactive) maintain the recommendation for the creation of a Folisolic order.

In summary, during the period from 1979 to the present (1984), the B.C. working group has identified deficiencies in the present classification of Folisols. It has now tabled three reports (with proposals for modification) to the ECSS via the NSCWG, and has forwarded various other reports that are

directly related to Folisolic soils. It has contributed detailed soil descriptions, with analyses and locations, and members have assisted in the 1983 and 1984 field trips sponsored by the LRRI. The NSCWG should now have sufficient documentation of the problem, suggested modifications, Canada-wide reviews, data base, and analyses in order to make recommendations to the ECSS for revisions to the present classification.

In order to assist the committee, the following section of this report contains a new proposal for modifications to the Canadian System of Soil Classification. Alternative I defines a new soil order; Alternative II expands the existing Folisol great group.

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PROPOSAL FOR FOLISOLIC SOIL CLASSIFICATION IN CANADA

ALTERNATIVE I

FOLISOLIC ORDER

Soils of the Folisolic order are composed of upland (folic) organic materials, generally of forest origin, which are thicker than 40 cm, or at least 10 cm thick if over bedrock or fragmental material. Deep Folisols (greater than 40 cm of folic material) occur frequently in cool, moist, and humid forest ecosystems, particularly on the west coast of Canada. They also develop in the cold, northern regions where soil temperatures are extremely cold. Shallow Folisols are found throughout Canada and often occur on upper slope shedding positions over bedrock and on, or incorporated in, fragmental or skeletal material.

Folic organic material forms under contrasting ecosystems when compared to peat organic material. The processes of upland and wetland development are associated with different types of vegetative sequences and composition related to environmental and climatic characteristics of the landscape. Directly related are the decomposition processes and products. The products of upland ecosystem development are folic materials, those of wetland development are peat materials.

Folisolic soils are well to imperfectly drained although they may become saturated after rainfall or snowmelt. Folisolic soils contain 17% or more organic carbon (approximately 30% organic matter) by weight in the diagnostic horizons and meet the following specifications.

For folic materials, not usually saturated with water (freely-drained), to qualify as Folisols they must have:

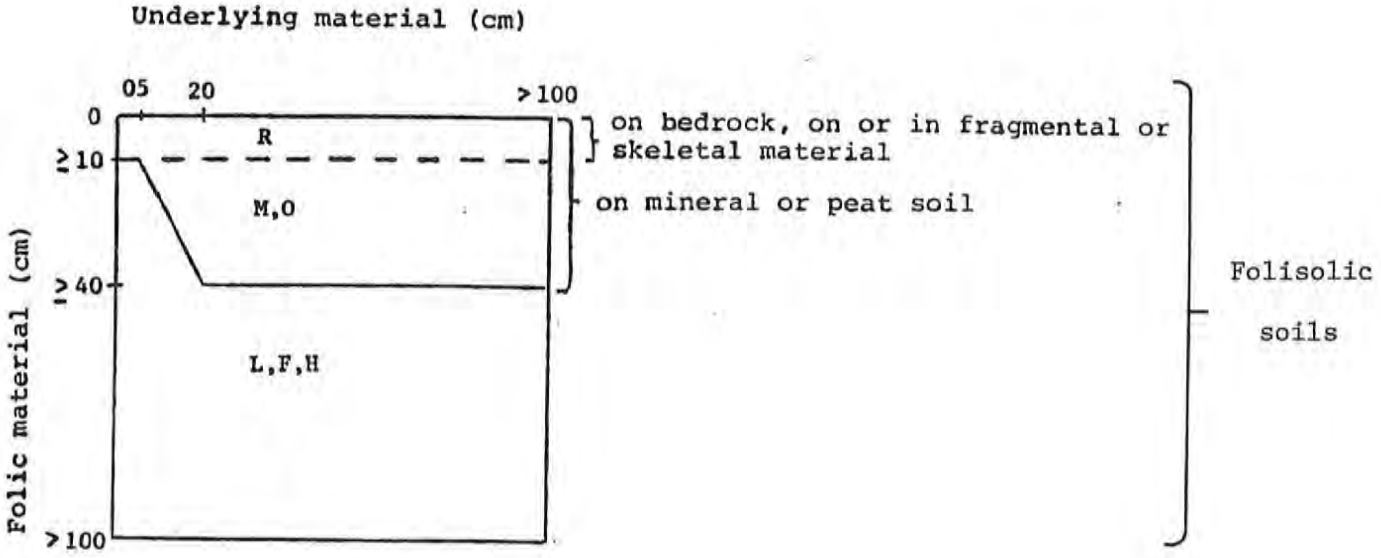
1. folic material greater than 40 cm deep; or
2. folic material greater than 10 cm deep, if directly overlying a lithic contact or fragmental material, or occupying voids in fragmental or skeletal material; or
3. folic material more than twice the thickness of a mineral or peat soil layer if the mineral layer is less than 20 cm thick.

Many soils have L, F, and H horizons composed of folic material at the surface. The distinction between Folisolic soils and soils of other orders is based on:

1. the total thickness of the folic material, which is at least 40 cm if underlain by 20 cm or more of mineral or peat material;
2. the relative thickness of the folic material if underlying mineral or peat material is less than 20 cm thick;
3. at least 10 cm thick if over lithic or fragmental and skeletal material;
4. the depth to permafrost; folic materials having permafrost at depths of 1 m or less are classified as Cryosolic soils.

The Folisolic order is divided into two great groups, based on the degree of decomposition of the folic material as distinguished by the diagnostic F and H soil horizons. The L horizon, if present, is considered to be parent material.

Figure 1. Depth relationships involved in Folisolic soil classification.



FOLISOLIC ORDER

HEMIC	HUMIC
F horizon(s) dominant in folic horizons	H horizon(s) dominant in folic horizons

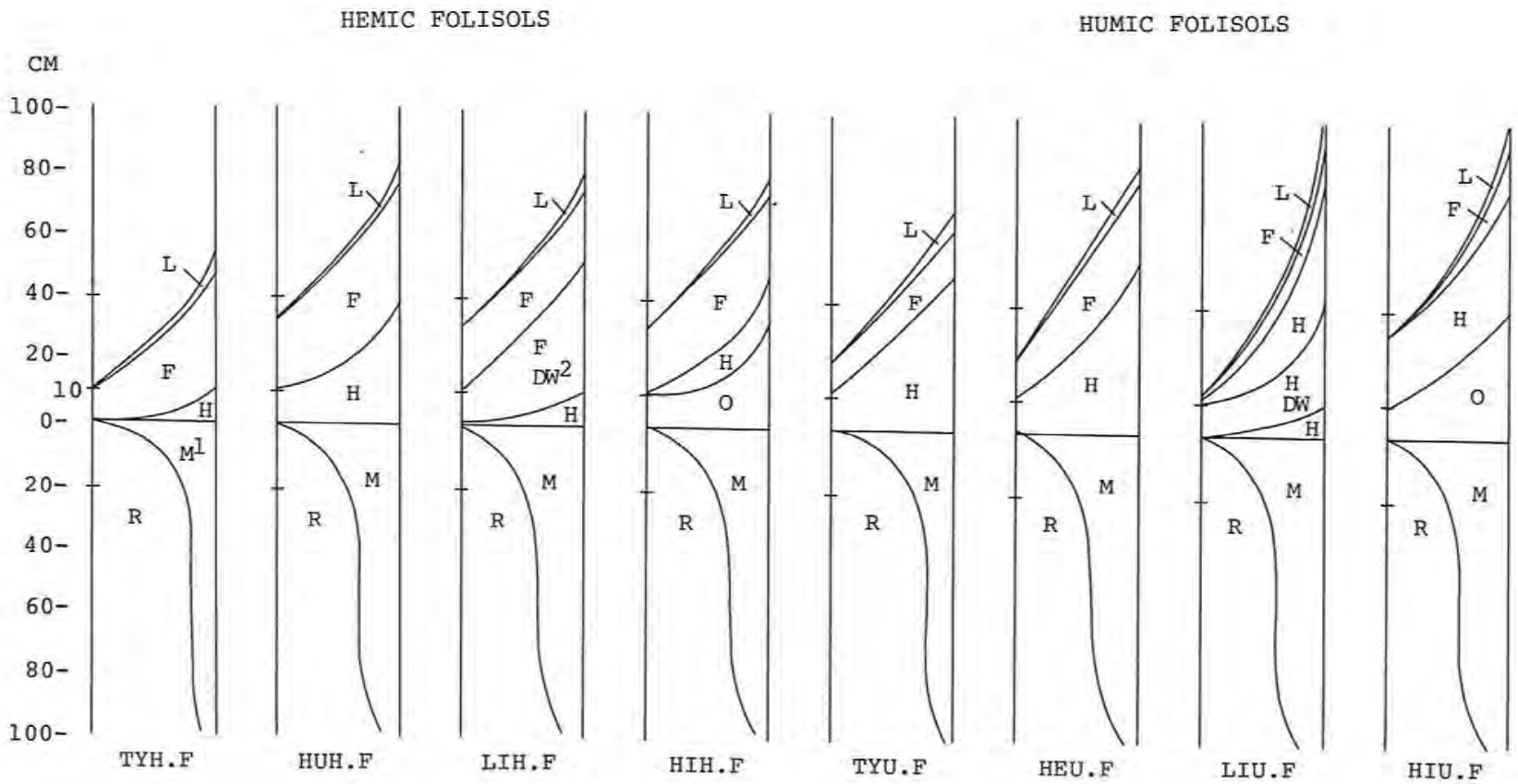


Figure 2. Diagramatic horizon pattern of subgroups of the folisolic order.

[1]M = mineral soil
[2]DW = decaying wood

Note: horizons may be broken and irregular; in addition, roots, channels, voids, and turbated features are common.

HEMIC FOLISOLS

Soils of this great group are composed largely of the moderately decomposed F horizon(s) in the control section and may have subdominant H and O horizons. They commonly have lithic or fragmental layers, but they meet the requirements for the Folisolic order. The F horizon is partially decomposed folic material generally derived from mosses, leaves, twigs, reproductive structures, and woody materials containing numerous live and dead roots.

The folic material may be comminuted by, and contain excrement of, soil fauna and/or permeated by fungal hyphae. It is common to find varying amounts of charcoal in Hemic Folisols, particularly at the folic-mineral or bedrock interface. In F horizons that are suitable for, and contain, large populations of micro- and meso-fauna, the F horizon is often loose and friable. F horizons may also be compact and appear felty (due to fungal hyphae). Intergrades of these characteristics may also occur. Layers or pockets of decaying wood in an intermediate state of decomposition may be designated as F horizons and some soil pedons have significant amounts of this type of folic material (see Lignic subgroup). The horizons are generally brownish-yellow to brownish-red in colour. Macromorphological decomposition is very apparent even though some or much of the folic material may be identified as to its origin. Roots are generally abundant and horizontally oriented, particularly in forest ecosystems. The folic material may serve as the major source of plant nutrients and water reserve, as well the substrate for most soil biological activity. Hemic Folisols usually occur on upper slope shedding positions and are often shallow to bedrock or fragmental material.

Hemic Folisols are divided into four subgroups, based on the presence and amounts of F, H, and O horizons and decaying woody materials in those horizons.

Typic Hemic Folisol

Common horizon sequence: (L), F, H, (M^1, R)

Soils of this subgroup are dominated by the F horizon(s). The soils may have subdominant H or O horizons but each in total will be less than 10 cm thick in the control section. These soils are often shallow to bedrock or fragmental material, or the folic material may occupy voids in fragmental material. There may be a thin layer of mineral soil separating the folic horizons from bedrock or the fragmental material.

Humic Hemic Folisol

Common horizon sequence: (L), F, H, (M^1, R)

Soils of this subgroup are dominated by the F horizon(s) but they have a significant (greater than 10 cm) H horizon. The H horizon will be thicker than an O horizon, if present. The H horizon may be the result of the advanced stages of humification of the horizon sequence. At times it may be associated with natural disruptive events such as fire, that initially promote advanced decomposition and humification before ecosystem processes recover to a steady state.

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[1] M = mineral layer

Lignic Hemic Folisol

Common horizon sequence: (L), F, H (M[1], R)

Soils of this subgroup are dominated by the F horizon(s) composed primarily of moderately decomposed woody materials; or the soil may have, in addition to typical folic F horizons, a significant (greater than 10 cm) F horizon composed primarily of decomposed woody materials. The large amount of decaying wood that makes up these F horizons is generally the result of forest blowdown. This occurs as a continual process in uneven aged forests or at periodic intervals due to major storm events that create even aged stands. Lignic Folisols have also been described in second growth forests as a result of logging residues. The soil may have H or O horizons of similar woody nature but those horizons will be less significant in the control section than the combined F horizons.

Histic Hemic Folisol

Common horizon sequence: (L) F, H, O, (M[1], R)

Soils of this subgroup are dominated by F horizons and underlain by a significant (greater than 10 cm) O horizon. Saturation or high water tables resulting from drainage impediment by mineral horizon cementation or localized bedrock configuration may initially produce peatland development. Subsequent peat development becomes deep enough to produce surface conditions suitable for forest encroachment and subsequent folisolic development.

HUMIC FOLISOLS

Soils of this great group are composed largely of the well decomposed H horizon(s) in the control section and may have subdominant F and O horizons. Lithic, fragmental, or mineral and peat layers may be common in the control section but the soils meet the requirements for the Folisolic order. Mineral genetic development is common under the folic material and it may be appropriate for phase criteria (e.g. podzolic phase) in any Folisolic great group.

The H horizon is well decomposed folic material. The origin of the material is not recognizable microscopically, or only in small amounts as in the case of recent root or some unrubbed residues. The folic material may be permeated by fungal hyphae, comminuted by, and contain excrement of, soil fauna, and near the mineral interface may contain significant amounts of mineral grains. Microbiotic activity is generally considered to be high. H horizons may be granular, blocklike, or massive. Generally the colours are reddish-brown to dark grey or nearly black. The soil may be gritty to greasy in texture and have higher bulk densities than F horizons. Layers or pockets of decaying wood, in an advanced state of decomposition, may be designated as H horizons, and some pedons have significant amounts of this type of folic material (see Lignic subgroup). Fragments of charcoal may be found in the folic profile. Rooting channels, voids, and disruptive features are common in Humic Folisols.

Humic Folisols occur most frequently in cool, moist, humid forest ecosystems. Although they occur in many landscape positions, they commonly develop on lower slopes and in valley bottoms. Humic Folisols are divided into four subgroups, based on the presence and amounts of F, H, and O horizons and decaying woody materials in those horizons.

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[1] M = mineral layer

Typic Humic Folisol

Common horizon sequence: (L), F, H (M^1, R)

Soils of this subgroup are dominated by the H horizon(s). They may have subdominant F or O horizons but each in total will be less than 10 cm thick in the control section. These soils occur frequently over bedrock or unconsolidated mineral material.

Hemic Humic Folisol

Common horizon sequence: (L), F, H (M^1, R)

Soils of this subgroup are dominated by the H horizon(s) but they have a significant (greater than 10 cm) F horizon. The F horizon will be thicker than an O horizon if both are present. The F horizon is at the surface of the pedon, or directly beneath a layer of mixed recent litter and surface vegetation. It may be friable and loose, but more often it will be matted, slightly compact, and contain various amounts of visible fungal hyphae.

Lignic Humic Folisol

Common horizon sequence: (L), F, H (M^1, R)

Soils of this subgroup are dominated by the H horizon(s) composed primarily of well decomposed woody materials; or the soil may, in addition to typical folic H horizons, have a significant (greater than 10 cm) H horizon composed primarily of well decomposed woody materials. The soil may have F or O horizons of similar woody nature but those horizons will be less significant in the control section than the combined H horizons. The large amount of decaying wood that makes up these H horizons is generally the result of forest blowdown (see Lignic Hemic Folisol).

Histic Humic Folisol

Common horizon sequence: (L), F, H, O (M^1, R)

Soils of this subgroup are dominated by the H horizon(s) and underlain by a significant (greater than 10 cm) O horizon derived from peat materials. The Histic Humic Folisol development is often associated with a peatland whose surface properties have become conducive to forest encroachment and Folisolic development.

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[1] M = mineral layer

ALTERNATIVE II

FOLISOL GREAT GROUP

Soils of the Folisol great group are composed of upland (folic) organic materials, generally of forest origin, which are thicker than 40 cm, or at least 10 cm thick if over bedrock or fragmental material. Deep Folisols (greater than 40 cm of folic material) occur frequently in cool, moist, and humid forest ecosystems, particularly on the west coast of Canada. They also develop in the cold, northern regions where soil temperatures are extremely cold. Shallow Folisols are found throughout Canada and often occur on upper slope shedding positions over bedrock and on, or incorporated in, fragmental or skeletal material.

Folic organic material forms under contrasting ecosystems when compared to peat organic material. The processes of upland and wetland development are associated with different types of vegetative sequences and composition related to environmental and climatic characteristics of the landscape. Directly related are the decomposition processes and products. The products of upland ecosystem development are folic materials, those of wetland development are peat materials.

Folisolic soils are well to imperfectly drained although they may become saturated after rainfall or snowmelt. Folisolic soils contain 17% or more organic carbon (approximately 30% organic matter) by weight in the diagnostic horizons and meet the following specifications.

For folic materials, not usually saturated with water (freely-drained), to qualify as Folisols they must have:

1. folic material greater than 40 cm deep; or
2. folic material greater than 10 cm deep, if directly overlying a lithic contact or fragmental material, or occupying voids in fragmental or skeletal material; or
3. folic material more than twice the thickness of a mineral soil layer if the mineral layer is less than 20 cm thick.

Many soils have L, F, and H horizons composed of folic material at the surface. The distinction between Folisolic soils and soils of other great groups is based on:

1. the total thickness of the folic material, which is at least 40 cm if underlain by 20 cm or more of mineral or peat material;
2. the relative thickness of the folic material if underlying mineral or peat material is less than 20 cm thick;
3. at least 10 cm thick if over lithic or fragmental and skeletal material;
4. the depth to permafrost; folic materials having permafrost at depths or 1 m or less are classified as Cryosolic soils.

The Folisolic great group is divided into four subgroups, based on the degree of decomposition of the folic material as distinguished by the diagnostic F and H soil horizons. Layers or pockets of decaying wood may be designated as F horizons and some soil pedons have significant amounts of this type of folic material (see Lignic Folisol). Mineral genetic development is common under the folic material and it may be appropriate for phase criteria (e.g. podzolic phase) in any Folisolic subgroup. The L horizon, if present, is considered to be parent material.

Hemic Folisol

Common horizon sequence: L, F, H, (M[1], R)

Soils of this subgroup are composed largely of the moderately decomposed F horizon(s) in the control section and may have subdominant H and O horizons each less than 10 cm thick. They commonly have lithic or fragmental layers, but they meet the requirements for the Folisolic great group. The F horizon is partially decomposed folic material generally derived from mosses, leaves, twigs, reproductive structures, and woody materials containing numerous live and dead roots.

The folic material may be comminuted by, and contain excrement of, soil fauna and/or permeated by fungal hyphae. It is common to find varying amounts of charcoal in Hemic Folisols, particularly at the folic-mineral or bedrock interface. In F horizons that are suitable for, and contain, large populations of micro- and meso-fauna, the F horizon is often loose and friable. F horizons may also be compact and appear felty (due to fungal hyphae). Intergrades of these characteristics may also occur. The horizons are generally brownish-yellow to brownish-red in colour. Macromorphological decomposition is very apparent even though some or much of the folic material may be identified as to its origin. Roots are generally abundant and horizontally oriented, particularly in forest ecosystems. The folic material may serve as the major source of plant nutrients and water reserve, as well the substrate for most soil biological activity. Hemic Folisols usually occur on upper slope shedding positions and are often shallow to bedrock or fragmental material, or the folic material may occupy voids in fragmental material. There may be a thin layer of mineral soil separating the folic horizon from bedrock or the fragmental material.

Humic Folisol

Common horizon sequence: L, F, H, (M[1], R)

Soils of this subgroup are composed largely of the well decomposed H horizon(s) in the control section and may have subdominant F and O horizons. Lithic, fragmental, or mineral and peat layers may be common in the control section but the soils meet the requirements for the Folisolic great group.

The H horizon is well decomposed folic material. The origin of the material is not recognizable microscopically, or only in small amounts as in the case of recent root or some unrubbed residues. The folic material may be permeated by fungal hyphae, comminuted by, and contain excrement of, soil fauna, and near the mineral interface may contain significant amounts of mineral grains. Microbiotic activity is generally considered to be high. H horizons may be granular, blocklike, or massive. Generally the colours are reddish-brown to dark grey or nearly black. The soil may be gritty to greasy in texture and have higher bulk densities than F horizons. Layers or pockets of decaying wood, in an advanced state of decomposition, may be designated as H horizons, and some pedons have significant amounts of this type of folic material (see Lignic Folisol). Fragments of charcoal may be found in the folic profile. Rooting channels, voids, and disruptive features are common in Humic Folisols.

Humic Folisols occur most frequently in cool, moist, humid forest ecosystems. Although they occur in many landscape positions, they commonly develop on lower slopes and in valley bottoms.

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[1] M = mineral layer

Lignic Folisol

Common horizon sequence: (L), F, H (M^1, R)

Soils of this subgroup are dominated by the F and H horizon(s) composed primarily of moderately to well decomposed woody materials; or the soil may have, in addition to typical folic horizons, a significant (greater than 10 cm) F or H horizon composed primarily of decomposed woody materials. The large amount of decaying wood that makes up these F horizons is generally the result of forest blowdown. This occurs as a continual process in uneven aged forests or at periodic intervals due to major storm events that create even aged stands. Lignic Folisols have also been described in second growth forests as a result of logging residues. The soil may have H or O horizons of similar woody nature but those horizons will be less significant in the control section than the combined F horizons.

Histic Folisol

Common horizon sequence: L, F, H, O, (M, R)

Soils of this subgroup are dominated by the F or H horizons and underlain by a significant (greater than 10 cm) O horizon. Saturation or high water tables resulting from drainage impediment by mineral horizon cementation or localized bedrock configuration may initially produce peatland development. Subsequent peat development becomes deep enough to produce surface conditions suitable for forest encroachment and subsequent folisolic development.

NOTE: The concept of expanding the Folisol great group could be formulated differently. For example, two great groups, Hemic and Humic, could each be divided into the following subgroups: Typic, Humic Hemic or Hemic Humic (depending on the great group), Lignic, and Histic.

[1] M = mineral layer

Soil Profiles and Analyses

Site No.: 83-01-F3
Location: Port Alice Lat: 50° 34' 5", Long: 127° 18' 5"
Soil classification: I. Lignic Humic Folisol, II. Lignic Folisol

Morphological Description

Horizon	Depth cm	Colour	Structure	Consistence	Hor. boundary	Roots	Botanical Composition
L	0-2		-	-	-	-	Twigs, barks, needles, cones
Fq	2-9	5YR 3/2	matted	-	abrupt	-	Fungi (40), plant parts (20), rootlets (20), amorphous (20)
Hr	9-13	2.5YR 2.5/2	weak, granular	-	wavy, clear	plentiful, medium-coarse, horizontal	-
Hwl	13-27	2.5YR 3/6	ligneous	friable	clear, wavy	few, medium, horizontal	Wood
Hdl	27-43	2.5YR 2.5/2	granular	-	gradual, wavy	few, fine-medium, horizontal	-
Hw2	43-59	2.5YR 2.5/3	ligneous, breaks to granular	friable	clear	very few, fine, horizontal	Wood
Hd2	59-71	2.5YR 2.5/1	massive to coarse, granular	friable	gradual, broken	-	Rootlets, plant fragments (20) amorphous (80)
Ho	71-76	5YR 2.5/1	massive	very friable	gradual, smooth	few, medium, horizontal	Rootlets (3), amorphous (97)
Ae	76-79	5YR 5/3	silt loam	friable	clear, discontinuous	-	-
Bfl	79-83	5YR 4/6	weak, blocky (silt loam)	-	gradual, wavy	-	Fungal hyphae
Bf2	83+	7.5YR 5/7	single grain (silt loam)	-	-	few, medium, horizontal	Fungal hyphae

Note: Definitions of lower case suffixes relating to organic horizons are to be found in these proceedings in C. Fox's paper "Characteristics of the Folisolic Soils of British Columbia".

Site No.: 83-01-F3

Chemical Analysis

Horizon	pH	C %	N %	Sodium Pyrophosphate		Exchangeable Cations me/100g				Ash %
				Fe %	Al %	Ca	Mg	K	Al	
L	4.2	50.1	0.91	0.01	0.02	28.2	5.3	2.2	0.4	4.24
Fq	3.2	45.7	1.16	0.07	0.11	18.0	6.6	1.7	2.6	8.30
Hr	2.7	50.1	1.30	0.01	0.07	19.7	9.5	0.6	2.4	2.44
Hw1	2.5	45.4	0.70	0.01	0.01	6.7	4.8	0.4	0.6	0.71
Hd1	2.4	52.1	0.57	0.01	0.02	18.5	5.8	0.4	1.7	1.50
Hw2	2.4	52.4	0.37	0.01	0.02	13.5	4.0	0.4	1.2	1.03
Hd2	2.6	49.8	0.88	0.04	0.19	23.1	6.2	0.4	6.4	3.70
Ho	-	33.3	0.43	1.07	0.90	5.1	1.5	0.5	20.7	32.40
Ae	3.2	9.6	0.09	1.29	0.34	3.3	0.9	0.3	10.0	82.16
Bf1	4.0	6.0	0	3.17	1.11	2.8	0.7	0.3	4.8	84.71
Bf2	5.6	2.3	0.32	0.10	0.43	2.8	0.9	0.3	-	91.34

Note: Definitions of lower case suffixes relating to organic horizons are to be found in these proceedings in C. Fox's paper "Characteristics of the Folisolic Soils of British Columbia".

Site No.: 83-01-F4
Location: Prince Rupert Hwy 16 near Rainbow Lake Lat: 54° 14' 5", Long: 130° 4' 5", Elev: 80 m
Soil classification: I. Histic Humic Folisol, II. Histic Folisol

Morphological Description

Horizon	Depth cm	Colour	Structure	Consistence	Hor. boundary	Roots	Botanical Composition
Fr	0- 3	5YR 2.5/2	fibrous	wet, loose	gradual, smooth	common, very fine-medium, horizontal	Needles (65), twigs (10), cedar cones (5), moss (10), stems (10)
Hr1	3-20	2.5YR 2.5/2	granular	wet, friable	gradual, wavy	abundant, very fine-coarse, horizontal	Wood (10), amorphous (75), rootlets (15)
Hr2	20-52	2.5YR 2.5/2	moderate, blocky	wet, non-sticky	-	plentiful, fine-coarse, horizontal	Wood (15), amorphous (75), rootlets (10)
Oh1	52-81	5YR 2.5/1	massive	wet, non-sticky	clear, smooth		Amorphous (70), sed. peat (20), other (10)
Oco	81-99	5YR 3/3	massive		gradual, wavy	few	Sed. peat (80), sedge (15), other (5)
Oh2	99-151	5YR 3/2	massive	non-sticky	clear, abrupt	very few	Sed. peat (50), sedge (30), moss (5), other (15)

Site No.: 83-01-F4

Chemical Analysis

Horizon	pH	C %	N %	Sodium Pyrophosphate Fe %	Sodium Pyrophosphate Al %	Exchangeable Cations me/100g Ca	Mg	K	Al	Ash %
Fr	4.5	44.9	1.00	0.02	0.04	53.6	5.1	2.0	0.4	8.03
Hr1	3.0	49.3	1.06	0.01	0.04	22.0	6.0	1.2	1.2	3.02
Hr2	2.8	48.9	1.06	0.06	0.10	4.8	9.4	0.8	2.6	3.22
Oh1	2.8	54.2	0.75	0.02	0.37	2.4	2.0	0.3	9.1	3.94
Oco	3.0	52.1	0.93	0.01	0.53	2.8	1.0	0.3	11.6	7.83
Oh2	3.5	45.1	1.24	0.01	1.35	2.9	0.8	0.3	11.1	17.99

Note: Definitions of lower case suffixes relating to organic horizons are to be found in these proceedings in C. Fox's paper "Characteristics of the Folisolic Soils of British Columbia".

Site No.: 83-01-F5
Location: Port Clements - near Golden Spruce Lat: 53° 38' 0", Long: 132° 12' 5", Elev: 12 m
Soil classification: I. Typic Humic Folisol, ~~II.~~ Humic Folisol

Morphological Description

Horizon	Depth cm	Colour	Structure	Consistence	Hor. boundary	Roots	Botanical Composition
Fr	0-5	5YR 2.5/1m	weak, non-compacted	loose	gradual, wavy	-	Hemlock needles (80), cone scales (5), twigs (10), cedar remains (5)
Hr1	5-30	5YR 2.5/2 m	granular	loose	clear, wavy	abundant, fine-coarse, horizontal	Amorphous (55), rootlets (20), bark (10), wood (15)
Hw	30-40	2.5YR 2.5/4 m	granular	loose	clear, wavy	few, fine, horizontal	Wood (95), other (5)
Hr2	40-50 50-72	5YR 2.5/1 m	weak, granular	loose	clear, wavy	abundant, fine, horizontal	Amorphous (75), other (25)
Hd	72-76	10YR 2/1 m	mod., granular	-	clear, smooth	abundant, fine, horizontal	Mineral (20), amorphous (80)
Ae	76-82	10YR 4/1 m	granular , weak-moderate	-	clear, smooth	abundant, fine-medium, horizontal	-
Bfcg	82-89	10YR 4/2 m mottles 10YR 5/6 m	blocky	cemented	clear, smooth	-	-
Bfg	89	10YR 5/1 mottles 10YR 5/8m	blocky, moderate	-	-	-	-

Note: Definitions of lower case suffixes relating to organic horizons are to be found in these proceedings in C. Fox's paper "Characteristics of the Folisolic Soils of British Columbia".

Site No.: 83-01-F5

Chemical Analysis

Horizon	pH	C %	N %	Sodium Pyrophosphate		Exchangeable Cations me/100g				Ash %
				Fe %	Al %	Ca	Mg	K	Al	
Fr	3.4	47.9	1.06	0.02	0.04	19.7	9.9	1.8	0.8	6.21
Hr1	2.6	49.2	0.81	0.01	0.03	15.2	8.0	0.9	1.7	2.16
Hw	2.7	50.9	0.21	0.01	0.00	12.2	9.9	0.5	0.4	0.88
Hr2	2.6	48.2	0.53	0.01	0.01	14.8	14.0	0.7	1.8	2.22
Hd	3.0	14.6	0.39	0.63	0.56	2.8	1.4	0.6	18.8	72.38
Bfcg	4.0	2.7	0.08	0.90	0.51	2.2	-	0.4	6.1	92.13
Bfg	4.1	1.0	0.02	0.26	0.28	2.3	-	0.4	3.5	96.58

Note: Definitions of lower case suffixes relating to organic horizons are to be found in these proceedings in C. Fox's paper "Characteristics of the Folisolic Soils of British Columbia".

Site No.: 83-01-F6
Location: Lake Takatia Lat: 52° 56' 0", Long: 132° 3' 5", Elev: 900 m
Soil classification: I. Hemic Humic Folisol, II. Humic Folisol

Morphological Description

Horizon	Depth cm	Colour	Structure	Consistence	Hor. boundary	Roots	Botanical Composition
Fr	0- 6	5YR 2.5/1.5m	matted-loose, fibrous	non-sticky	abrupt, irregular	abundant, very fine-medium, random	Rootlets (40), amorphous (35), twigs (20), plant remains (5)
Hr	6-23	5YR 2.5/1m	weak, fine, matted to weak, granular	non-sticky, friable	gradual, smooth	abundant, very fine - fine, horizontal	Amorphous (70), twigs (10), other (20)
Hd	23-48	10YR 2/1m	massive to mod., granular	slightly sticky, friable	clear, irregular	few, very fine, vertical	Amorphous (90), other (10)
R	48+	-	-	-	-	-	-

Site No.: 83-01-F6

Chemical Analysis

Horizon	pH	C %	N %	Sodium Pyrophosphate Fe %	Sodium Pyrophosphate Al %	Exchangeable Cations me/100g Ca	Mg	K	Al	Ash %
Fr	3.5	47.4	1.2	0.03	0.03	16.9	9.9	2.6	0.8	5.05
Hr	3.4	46.5	1.41	0.02	0.04	18.1	10.7	2.0	0.7	4.14
Hd	4.3	16.9	0.76	0.83	3.3	2.6	-	0.4	4.6	55.84

Note: Definitions of lower case suffixes relating to organic horizons are to be found in these proceedings in C. Fox's paper "Characteristics of the Folisolic Soils of British Columbia".

Site No: 83-01-F7
Location: Graham Island Lat: 53° 39' 5", Long: 132° 8' 0", Elev: 12 m
Soil classification: I. Typic Humic Folisol, II. Humic Folisol

Morphological Description

Horizon	Depth cm	Colour	Structure	Consistence	Hor. boundary	Roots	Botanical Composition
Fr	0-8	5YR 3/2m	matted to fibrous	loose (fibrous), non-sticky	gradual, smooth	abundant, fine, horizontal	Amorphous (20), hemlock needles (30), twigs (10), rootlets (40)
Hr1	8-20	5YR 2.5/2m	matted(moderate)	friable	gradual, smooth	abundant, very fine-medium, horizontal-vertical	Rootlets (10), amorphous (70), twigs(20)
Hr2	20-64	5YR 2.5/1.5m	weak, granular (fibered)	loose	gradual, smooth	abundant, very fine-coarse, vertical, horizontal	Rootlets (20), amorphous (60), twigs(20)
Hd	64-82	10YR 2/1m	massive	slightly sticky, firm	gradual, wavy	few, very fine to medium, horizontal	Amorphous (90), twigs (10)
Cg	82+	-	-	-	-	-	

Site No: 83-01-F7

Chemical Analysis

Horizon	pH	C %	N %	Sodium Pyrophosphate Fe %	Sodium Pyrophosphate Al %	Exchangeable Cations me/100g Ca	Mg	K	Al	Ash %
Fr	3.9	45.5	1.39	0.01	0.00	22.1	7.7	2.1	-	2.7
Hr1	2.9	49.3	1.26	0.00	0.00	7.1	10.7	1.7	0.6	1.21
Hr2	2.7	49.7	0.76	0.05	0.00	5.2	16.6	1.0	1.1	1.75
Hd	3.3	23.3	0.23	0.43	0.45	3.5	1.8	0.6	9.9	58.66
Cg	4.2	2.7	0.11	0.09	0.37	3.7	1.1	0.3	3.6	85.93

Note: Definitions of lower case suffixes relating to organic horizons are to be found in these proceedings in C. Fox's paper "Characteristics of the Folisolic Soils of British Columbia".

Site No.: 83-01-F11
Location: Pebble Beach between Sandspit & Alliford Bay Lat: 53° 13' 0",
Long: 131° 57' 5", Elev. 12 m
Soil classification: I. Typic Humic Folisol, II. Humic Folisol

Morphological Description

Horizon	Depth cm	Colour	Structure	Consistence	Hor. boundary	Roots	Botanical composition
Fr	0-5	5YR 2.5/1.5m	non-compact	-	abrupt, smooth	few, very fine, horizontal	Hemlock needles, cones, twigs, plant fragments (90), wood (5), amorphous (5)
Hd1	5- 23	2.5YR 2.5/2m	weak, compact	-	clear, wavy	abundant, fine, horizontal	Amorphous (90) wood(10)
Hd2	23- 28	5YR 2.5/1m	massive	-	diffuse, irregular	few, fine, random	Amorphous (85), charcoal (15)
Ho1	28- 40	5YR 2.5/1m	massive	-	clear, wavy	common, fine, horizontal	Amorphous (95), other (5)
Ho2	40-107	5YR 3/2.5m	mod. granular	-	clear, wavy	few, fine, horizontal	Amorphous (98), other (2)
Bm	107+	7YR 3.5/4m	single grain	-	-	-	-

Site No.: 83-01-F11

Chemical Analysis

Horizon	pH	C %	N %	Sodium Pyrophosphate		Exchangeable Cations me/100g				Ash %
				Fe %	Al %	Ca	Mg	K	Al	
Fr	3.4	47.9	1.27	0.02	0.04	18.6	6.5	1.7	1.1	5.39
Hd1	3.2	43.5	1.11	0.04	0.10	18.6	10.1	0.6	1.9	6.95
Hd2	3.4	33.7	0.97	0.38	0.40	21.7	10.5	0.5	9.9	39.40
Ho1	4.1	21.0	0.87	4.70	0.15	10.0	3.9	0.5	9.7	55.61
Ho2	5.0	17.4	0.70	3.31	0.25	13.5	5.3	0.3	1.2	51.78
Bm	4.9	4.0	0.23	0.47	1.01	5.6	1.5	0.3	1.1	32.13

Note: Definitions of lower case suffixes relating to organic horizons are to be found in these proceedings in C. Fox's paper "Characteristics of the Folisolic Soils of British Columbia".

Characteristics of the Folisolic Soils of British Columbia.

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Introduction

A Folisolic soil is defined in the Canadian System of Soil Classification (1978) as those soils having thick L, F and H horizons at least 10 cm thick overlying either rock or fragmental material, or a thin layer (<10cm) of unconsolidated mineral material overlying bedrock or fragmental material. The Folisolic soil is rarely saturated with water. Only the Typic Folisol is recognized (CSSC, 1978).

Problems in classification of Folisolic soils arose with observations of thick accumulations of organic materials overlying mineral soils and peat materials without either a lithic contact, or fragmental material or a thin layer of unconsolidated material above a lithic contact. As a result, the Working Group on Organic Horizons, Folisols and Humus Form Classification was formed in 1979 to put forward proposals for improvements to the definitions and classifications. R. Trowbridge has provided an outline of the progress of the Working Group to date.

Comments made by D. Moon in the Second Progress Report of the Working Group on Organic Horizons, Folisols and Humus Form Classifications (1981) stressed the need for supporting data and representative soil descriptions. Another major concern outlined by H. Luttmerding in the Second Progress Report was the reservation that the areal extent of the Folisolic soils would be insufficient to warrant establishing a separate soil order.

During the field season of 1983 (June and September) and 1984 (August) these two concerns were addressed. This report presents the following:

(a) a brief summary of the chemical and physical characteristics of folic material and Folisolic soils, with a proposal for describing folic materials in the field.
(b) a study carried out to investigate the spatial variability of folic material at sites designated as having Folisolic soils.

Characteristics of folic materials

In June and September 1983, twelve soils with thick folic materials (>40 cm) overlying mineral soil, and peat materials were described on Queen Charlotte Islands, Prince Rupert area and northern Vancouver Island (Fig. 1). The soils were characterized with reference to the following field survey forms: 1) CanSIS detail form, 2) the Canadian Wetland Registry and 3) proposals for describing folic materials as outlined in Klinka et al. (1981). The survey form that was used for describing the Folisolic soils is included in Appendix I.

Six main types of folic material were recognized; 1) ligneous (wood), 2) fungal material, 3) recognizable plant residues, 4) decomposed (amorphous) unrecognizable plant residues, 5) colloidal organic material, and 6) fecal

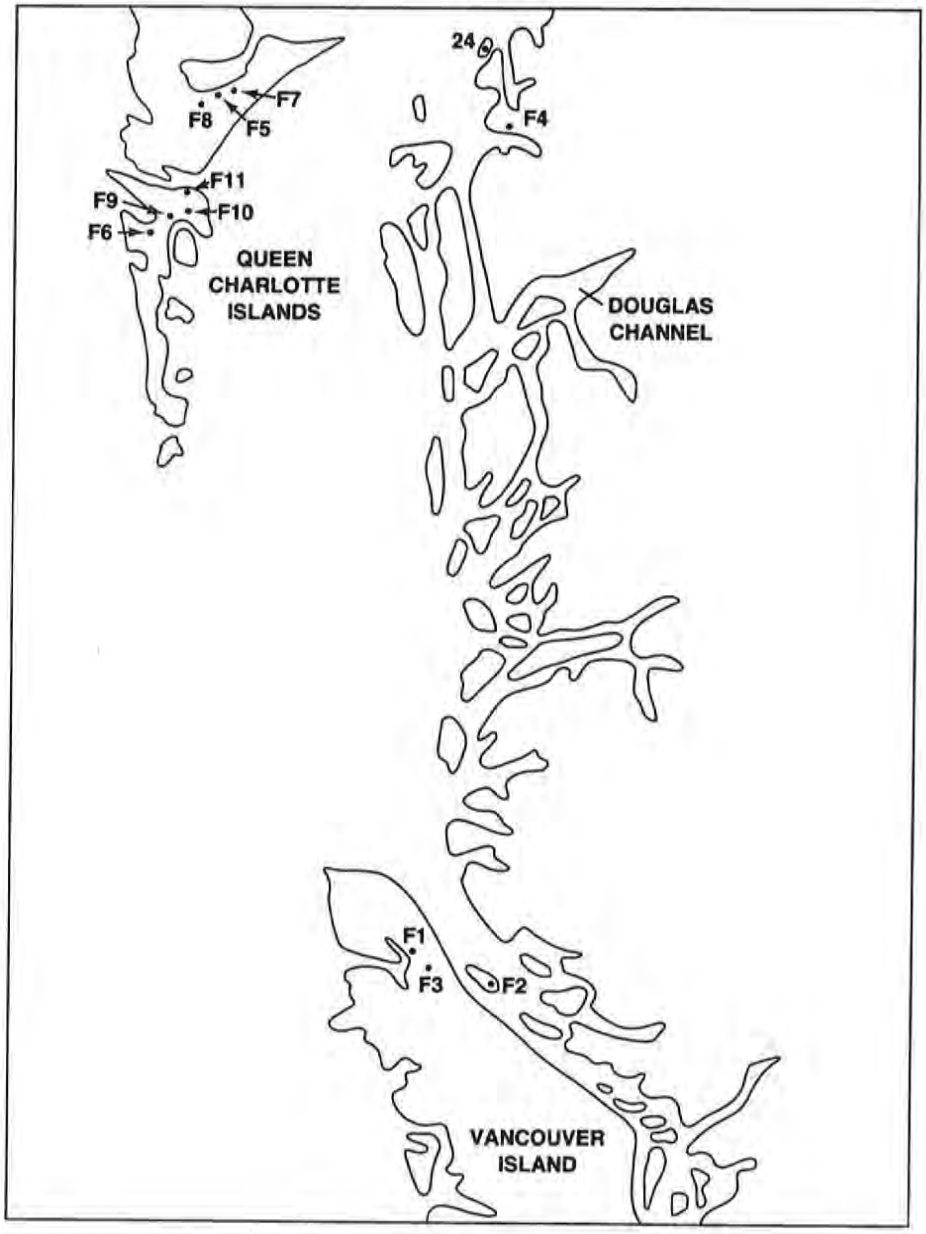

Fig. 1 Location of Folisolic Sites.

material. These folic materials were assigned (Table 1) lowercase suffixes w, q, r, d, o, and a respectively. The suffixes facilitate a more precise description of F and H horizons. The lowercase suffixes are modified from designations of humus form types recognized by Klinka et al. (1981).

By indicating whether the F and H material consists of ligneous, faunal material, amorphous, colloidal, plant residues or predominantly fungi, the folic materials can be better characterized and interpreted as to soil development. Each of these horizons have distinct morphologic features which contribute to the development of Folisolic soils. A summary of the chemical, physical and morphological properties of these folic materials from the twelve soils that were sampled in 1983 is shown in Tables 2 and 3.

The ligneous material (w) has colours ranging from red to dark reddish brown and dusky red. The wood material depending on the degree of decomposition will break readily to moderate to fine granular. Usually few to no roots are present in these horizons and the roots tend to be more prevalent in highly decomposed ligneous materials. Ligneous layers can be fairly thick (mean 20.6 cm), and frequently have very low pH values, low ash and low sodium pyrophosphate extractable Fe and Al. The pyrophosphate solubility index is very variable being a reflection of the degree of decomposition of the ligneous material.

The folic material designated as q is used to characterize those horizons which have abundant fungal hyphae present (greater than 20% by volume). Often the fungi can be seen as distinct mats and bands (basidiomycetes). These horizons are usually found immediately below the L horizon. In the lower part of the pedon, pockets of fungi in close association with root channels or decomposing wood are also observed. The q folic material tends to have higher exchangeable cations and % nitrogen suggesting increased nutrient availability. This is reflected in Fq horizons which tend to have abundant fine to coarse horizontal roots throughout the horizon.

The organic horizons designated as "d" are used with H horizons to characterize the decomposition and amorphous composition of the folic material. The structure of Hd horizons is massive but readily breaks to granular or blocky structure. In some pedons, Hdw horizons were recognized, such horizons were derived entirely from ligneous material but are extremely decomposed so that little evidence remains of the original wood structure. Organic d horizons tend to be black to reddish black and very dusky red to dark reddish brown. These horizons are characterized by plentiful to abundant roots frequently at the upper contact with Hr horizons.

The organic horizon "o" is located either beneath Hd horizons at the mineral contact, in pockets along root channels, or may be found forming a layer of accumulation above the bark material of a decaying log. The organic material is colloidal with over 95% composed of amorphous material of unknown origin. The colour is always black and the character of the material is very greasy. Frequently fine rootlets can be found and if located above an impermeable contact such as a rock, a root mat may often form. These horizons tend to have high sodium pyrophosphate extractable Fe and Al. This may be a result of these cations complexing with the colloidal organic material. Often in these pedons, the underlying mineral materials show evidence of mottles suggesting water table movement. This organic horizon is usually very thin

Table 1: Proposal for lowercase suffixes to characterize F and H horizons.

Lowercase suffixes and definition.

a An horizon composed predominantly (>60% by volume) of fecal material from soil fauna. The structure of the horizon is usually very fine to fine granular.

d An horizon composed predominantly of fine substances and unrecognizable organic materials (>75% by volume amorphous). Colours are usually 2.5 YR, 5 YR, 10 YR and 10R with values 2.5 to 3 and chromas 1 to 2.

w An horizon composed entirely of wood derived material (ligneous). Colours are usually 2.5 YR, 10R with values 2.5 to 4 and chromas 2 to 6.

o An horizon composed entirely of colloidal organic material. Colours are usually 5YR, 7.5 YR with values of 2 to 2.5 and chroma of 1.

q An horizon composed predominantly (>20% by volume) of fungi that may be present as thick fungal mats or bands. The fungi is highly visible throughout the horizon.

r An horizon composed of distinct recognizable plant residues (for example, leaf, stem and root fragments) with less than 75% by volume amorphous (unrecognizable) material. The residues are recognizable as to the type of plant part but may not necessarily be recognizable as to botanical species. Colours are usually 2.5 YR, 5 YR, 10 R hues with values of 2.5 to 3 and chromas 1 to 2.

Table 2: Some chemical and physical characteristics of folic materials.

Folic Material	Number of Observ.	Statistic	Horizon thickness (cm)	pH 1:2 .01M $CaCl_2$	% C	% N	% Pyrophosphate Sol. Index	% Ash	Exchangeable Cations 2N NaCl (me/100g)				Na Pyrophosphate Extractable %	
									Ca	Mg	K	Al	Fe	Al
w	8	X	20.6	2.70	48.7	0.54	44.57	1.16	8.58	7.10	0.45	1.40	0.012	0.03
		S.D.	10.4	0.19	3.9	0.23	50.6	0.56	3.27	3.29	0.07	0.99	0.004	0.03
q	5	X	5.4	3.50	45.2	1.14	11.46	8.78	24.22	5.48	2.10	2.58	0.096	0.09
		S.D.	2.9	0.60	1.3	0.22	4.81	3.08	14.80	0.87	0.61	2.67	0.100	0.07
d	10	X	15.3	2.83	45.4	0.92	47.13	12.18	15.60	7.81	0.54	4.45	0.097	0.15
		S.D.	9.0	0.32	8.8	0.32	21.30	18.90	7.28	2.50	0.12	3.09	0.150	0.14
o	3	X	28.0	-	23.9	0.66	77.00	46.59	9.50	3.56	0.43	10.5	3.020	0.43
		S.D.	27.7		6.8	0.18	38.30	10.10	3.44	1.56	0.09	7.98	1.490	0.33
Fr	6	X	5.3	3.51	47.4	1.08	7.20	5.02	18.25	7.46	2.10	0.81	0.020	0.03
		S.D.	1.4	0.23	1.4	0.26	1.57	2.31	2.17	1.89	0.32	0.56	0.008	0.02
Hr	12	X	23.0	2.85	48.9	0.94	19.40	4.50	11.29	11.09	1.05	1.63	0.020	0.035
		S.D.	12.5	0.24	2.1	.28	14.80	4.39	6.19	2.71	0.43	0.74	0.015	0.031
a	1	-	30.0	2.70	47.0	0.81	56.20	7.73	29.60	10.70	0.70	6.40	0.160	0.19

X - mean

S.D. - standard deviation

Table 3. Morphological characteristics of folic materials.

Folic Material (Horizons observed)	Colour (moist) Hue / Value / Chroma	Structure	Boundary	Roots	Generalized Composition (by volume %)
w (Fw, Hw)	2.5YR, 10R / 2.5 to 4.0 / 2 to 6 dark reddish brown, dark red, dusky red, red	- ligneous - breaks to moderate to fine granular	- abrupt; clear; wavy; smooth	- few to none - fine to medium horizontal	>90% ligneous <10% rootlets
q (Fq)	5YR; 10R / 2.5 to 3 / 1 to 2 dark reddish brown, black reddish black	- non-compact matted - loose, fibrous	- abrupt; clear; wavy; smooth	- abundant - fine to coarse horizontal	>20% fungi <25% amorphous >60% plant parts
d (Hd, Hdw)	2.5YR, 5YR, 10YR 10R / 2.5 to 3 / 1 to 2 very dusky red; dark reddish brown; black, reddish black	- massive - breaking to fine to coarse granular, blocky - greasy	- abrupt; clear; gradual; wavy	- plentiful to abundant - fine to very coarse horizontal	>75% amorphous <20% plant material (rootlets, residues)
o (Ho)	5YR, 7.5YR / 2 to 2.5 / 0 to 1 black	- massive - breaking to fine granular - very greasy	- abrupt; clear; wavy; smooth - often very discontinuous	- very few fine to medium - horizontal	>95% amorphous < 5% rootlets
r (Fr, Hr)	2.5YR, 5YR, 10R / 2.5 to 3 / 1 to 2 reddish black, very dusky red, dark reddish brown, black	- non-compact matted - weak granular, fibered - loose, fibrous	- gradual; clear; abrupt; smooth; wavy	- abundant to plentiful - very fine to coarse - horizontal	>25% plant residues (recognizable) <75% amorphous
a (Ha, Hra)	5YR / 2.5 / 1 to 2 black to dark reddish brown	- very fine to extremely fine granular - very soft, fluffy	- gradual; smooth	- plentiful - fine to coarse - horizontal	>60% amorphous (fecal pellets) <40% plant residues <10%fungi

(less than 5 cm), discontinuous,and in close contact with the underlying mineral material or lithic contact. In some cases, where the colloidal material has filled the interstices between stones, gravels or fragmental rocks, these horizons of colloidal organic material can attain great thicknesses (a soil sampled on Queen Charlotte Islands had Ho horizons a total of 80 cm thick).

Folic materials derived from predominantly recognizable plant residues were designated with an "r" to indicate residues. Both Fr and Hr material were observed. These were differentiated according to the degree of decomposition of the plant residues together with the amount of observable amorphous material: for Fr the amorphous content is assigned at less than 30% and for Hr the amorphous content may range from 30 to 75%. The distinguishing morphologic feature of these horizons is the amount of recognizable plant residues. The designation of F or H is used to differentiate the decomposition: If the plant residues can be almost entirely rubbed out with gentle pressure to result in amorphous material, the layer is referred to as Hr; if the plant residues cannot be rubbed out using gentle pressure, it is an Fr horizon. In Table 2, these horizons have been reported separately. The Fr horizons are usually directly beneath the L layer and tend to be thin. The Hr horizons tend to be thicker, more acid and have higher pyrophosphate solubility index than Fr horizons.

Folic material consisting almost entirely of fecal material was designated as an "a" organic horizon. It was observed as an Ha and Hra horizon. This material has very fine to extremely fine granular structure with a very soft fluffy character. The individual granular units compose the dominant proportion of the organic material and they can be viewed easily with a 10X hand lens. Numerous roots were observed in this horizon suggesting nutrient availability. Higher Ca and Mg exchangeable cations were noted in this layer (Table 2). The pyrophosphate solubility index was also high in comparison to other folic material (except for "o" material) suggesting that the reworking of the plant residues by soil fauna has increased the solubility of the organic material. Fungi can be found in association with the root and plant residue material but it is not a dominant feature of "a" folic materials.

Characteristics of Folisolic Soils

Folisolic soils were examined for chemical, physical and morphological characteristics from twelve sites sampled from coastal British Columbia. Some of the results are shown in Table 4 for selected pedons. The majority of the sites sampled in 1983 were on mineral material in the Coastal-Western Hemlock vegetation zone, for example, sites F1, F2, F3, and F8. In addition, Folisolic soils were examined from an Alpine site (F6) on Queen Charlotte Islands and two sites in the Prince Rupert area (F4 and 24) were located overlying peat material. The Alpine site, sites overlying peat material, and pedons from the Queen Charlotte Islands overlying mineral material tended to have greater occurrence of Hr horizons than soils observed on northern Vancouver Island. Folisolic soils with peat materials within the pedon seemed to be dominated by Hr horizons.

Table 4: Chemical and physical analyses of selected Folisol soils.

Site	Horizon	Depth (cm)	pH 1:2 .01 M $CaCl_2$	%C	%H	%N	% Pyrophosphate sol. Id.	% Ash	2N NaCl Exchangeable Cations (me/100 g) Ca	Mg	K	Al	Na Pyrophosphate Extractable Fe	Al	Total Elemental Analyses % Fe	% Al	% Mn	% Ca
F3	L	0-2	4.2	50.1	5.80	0.91	11.8	4.24	28.2	5.3	2.2	0.4	0.01	0.02	0.12	0.34	0.124	1.21
(Port Alice,	Fq	2-9	3.2	45.7	5.06	1.16	12.8	8.30	18.0	6.6	1.7	2.6	0.07	0.11	0.39	0.98	0.023	0.65
Northern	Hdl	9-13	2.7	50.1	5.01	1.30	15.2	2.44	19.7	9.5	0.6	2.4	0.01	0.07	0.06	0.30	0.001	0.45
Vancouver	Hwl	13-27	2.5	45.4	5.79	0.70	19.3	0.71	6.7	4.8	0.4	0.6	0.01	0.01	0.01	0.03	tr	0.14
Island)	Hd2	27-43	2.4	52.1	4.98	0.57	35.4	1.50	18.5	5.8	0.4	1.7	0.01	0.02	0.02	0.10	tr	0.39
	Hw2	43-59	2.4	52.7	4.80	0.39	165.7	1.03	13.5	4.0	0.4	1.2	0.01	0.02	0.02	0.07	tr	0.32
	Hd3	59-71	2.6	49.8	4.52	0.88	51.4	3.70	23.1	6.2	0.4	6.4	0.04	0.19	0.14	0.58	0.002	0.56
	Ho	71-76	-	33.3	3.69	0.43	122.8	32.40	5.1	1.5	0.5	20.7	1.07	0.90	1.77	4.60	0.014	0.77
	Ae	76-79	3.2	9.6	1.17	0.09	31.5	82.16	3.3	0.9	0.3	10.0	1.29	0.34	4.35	8.46	0.049	2.38
	Bfl	79-83	4.0	6.0	1.22	-	10.7	84.71	2.8	0.7	0.3	4.8	3.17	1.11	7.90	11.29	0.048	2.43
	Bf2	83+	5.6	2.3	1.00	0.32	3.0	91.34	2.8	0.9	0.3	-	0.10	0.43	6.90	13.83	0.053	2.79
F2	L	0-1	4.4	50.1	5.65	1.34	14.6	3.66	25.8	6.7	3.4	-	0.01	0.01	0.11	0.18	0.175	0.84
(Malcolm	Fq	1-3	3.5	47.5	5.12	1.54	10.9	5.08	20.9	5.4	3.3	0.6	0.03	0.03	0.16	0.35	0.043	0.53
Island	Fw	3-47	2.9	55.1	5.24	0.24	5.7	0.67	7.7	3.3	0.5	-	tr	-	0.01	0.02	0.001	0.12
	Ha	47-77	2.7	47.0	5.14	0.81	56.2	7.73	29.6	10.7	0.7	6.4	0.16	0.19	0.29	0.95	0.003	0.41
	Hd	77-113	2.6	48.8	5.10	0.79	50.1	3.60	20.0	10.1	0.6	2.9	0.02	0.08	0.10	0.41	0.001	0.38
	Ho	113-115	not sampled															
	Ae	115-118	3.0	10.4	1.18	0.26	47.9	96.23	4.0	1.1	0.4	6.4	0.44	0.21	2.06	9.03	0.044	2.12
	Bfg	118+	not sampled															
F1	L	0-1	3.5	49.0	5.73	1.01	11.0	5.02	22.0	4.2	2.5	1.8	0.02	0.06	0.21	0.45	tr	0.61
(Coal	Fq	1-8	2.9	43.8	4.72	0.92	19.9	14.48	14.6	4.1	1.7	7.7	0.30	0.22	0.70	1.54	0.012	0.59
Harbour	Hw	8-35	2.6	42.5	6.15	0.27	10.1	0.56	3.9	5.6	0.4	0.4	0.01	0.00	0.01	0.03	tr	0.09
Northern	Hd	35-56	2.5	51.2	5.48	1.12	70.3	4.00	3.5	7.4	0.5	5.2	0.03	0.14	0.08	0.43	0.001	0.09
Vancouver	Ae	56-65	2.9	5.6	1.26	0.27	25.0	86.48	2.9	1.2	0.4	25.1	0.37	0.40	1.40	10.43	0.005	0.14
Island)	Bhf	65-70	3.4	10.6	1.73	0.43	34.3	74.65	2.9	1.0	0.4	26.3	0.37	0.91	4.78	10.04	0.018	0.17
	Bfl	70-74	4.1	5.6	1.50	0.25	9.9	82.20	2.8	0.7	0.3	8.8	2.77	1.48	5.65	13.11	0.041	0.19
	Bf2	74-89	4.1	3.8	1.17	0.22	8.2	88.67	3.1	0.6	0.4	5.5	1.62	1.17	4.30	13.15	0.046	0.22
	Bhf	89-94	-	11.3	1.73	0.41	39.8	76.72	3.0	1.2	0.5	23.4	2.69	1.06	3.39	11.34	0.016	0.21
	R	94+																
F8	Fr	0-4	3.2	45.8	5.18	0.58	5.6	9.36	15.7	5.6	2.4	1.8	0.03	0.05	0.30	0.71	0.026	0.47
(Graham Is.	Hrl	4-18	2.7	49.8	5.65	0.69	13.6	6.44	6.2	10.8	1.3	1.6	0.01	0.02	0.05	0.12	0.001	0.10
Q.C.I.)	Hr2	18-53	2.9	52.5	5.95	0.50	61.0	3.24	2.6	14.0	0.5	2.5	0.03	0.07	0.11	0.20	tr	0.03
	Ahe	53-70	3.6	12.5	1.72	0.25	47.9	75.97	2.5	0.8	0.3	13.5	3.57	0.96	4.86	4.36	0.024	0.35
	Bfcg	70+	4.7	7.0	2.21	0.10	10.1	76.69	2.2	-	0.4	1.5	0.62	1.35	4.51	12.56	0.022	0.53
F7	Fr	0-8	3.9	45.5	6.03	1.39	6.0	2.70	22.1	7.7	2.1	0.0	0.01	0.00	0.04	0.10	0.066	0.51
(Graham Is.	Hrl	8-20	2.9	49.3	5.39	1.26	6.1	1.21	7.1	10.7	1.7	0.6	0.00	0.00	0.03	0.07	0.003	0.15
Q.C.I.)	Hr2	20-69	2.7	49.7	5.55	0.76	11.8	1.75	5.2	16.6	1.0	1.1	0.05	0.00	0.04	0.10	0.002	0.10
	Hd	69-82	3.3	23.3	2.89	0.23	72.7	58.66	3.5	1.8	0.6	9.9	0.43	0.45	0.97	5.01	0.016	0.60
	Cg	82+	4.2	2.7	0.51	0.11	10.7	85.93	3.7	1.1	0.3	3.6	0.09	0.37	2.19	9.91	0.039	1.98
F4	Fr	0-3	4.5	44.9	5.34	1.00	7.2	0.03	53.6	5.1	2.0	0.4	0.02	0.04	0.29	0.71	0.015	1.76
Prince	Hrl	3-20	3.0	49.3	5.62	1.06	9.2	3.02	22.0	6.0	1.2	1.2	0.01	0.04	0.06	0.17	0.001	0.57
Rupert	Hr2	20-52	2.8	48.9	6.22	1.06	32.1	3.22	4.8	9.4	0.8	2.6	0.06	0.10	0.13	0.38	0.001	0.13
British	Ohl	52-81	2.8	54.2	6.43	0.75	169.5	3.94	2.4	2.0	0.3	9.1	0.02	0.37	0.04	0.93	tr	0.05
Columbia	Oco	81-99	3.0	52.1	5.95	0.93	60.6	7.83	2.8	1.0	0.3	11.6	0.01	0.53	0.02	1.20	tr	0.06
	Oh2	99-151	3.5	45.5	5.21	1.39	65.2	17.99	2.9	0.8	0.3	11.1	0.01	1.35	0.10	3.85	0.003	0.34
	R	151+																
24	Hr	0-45	2.6	50.6	5.51	0.89	8.3	1.85	7.7	12.2	1.2	0.9	0.01	0.00	0.05	0.11	0.002	0.16
(Finlayson	Oh	45-59	-	53.1	5.86	0.76	29.4	2.81	4.7	8.9	1.1	2.2	0.02	0.05	0.11	0.25	0.002	0.10
Is.)	R	59+																
F6	Fr	0-6	3.5	47.4	5.69	1.21	8.2	5.05	16.9	9.9	2.6	0.8	0.03	0.03	0.26	0.40	0.018	0.44
(Moresby Is,	Hr	6-23	3.4	46.5	5.90	1.41	8.0	4.14	18.1	10.7	2.0	0.7	0.02	0.04	0.18	0.27	0.005	0.45
Q.C.I.)	Hd	23-48	4.3	16.9	3.00	0.76	58.0	55.84	2.6	-	0.4	4.6	0.83	3.30	5.64	8.23	0.076	2.69
	R	48+																

tr - trace

Folisolic soils tend to have very acid pH especially in the H horizons. The folic materials have high per cent carbon ranging between 40 to 55% except for Ho materials which tend to be less than 40% carbon. The Ho and occasionally Hd horizons because of their location near the mineral contact have a higher % ash content. The pyrophosphate solubility index is high for Hd and some Hw, Ha horizons, reflecting advanced decomposition of the organic material. Exchangeable cations are higher in the surface horizons suggesting nutrient availability. It is here that the majority of roots are located in the pedon. Roots tend to be located frequently at the Hr-Hd interface with few to no roots in the underlying mineral material or peat materials. The data for sodium pyrophosphate extractable Fe and Al show increases in the Hd and Ho horizons that are located in the lower portion of the Folisolic pedon. The main characteristic of the folic materials at this position in the pedon is the increased amorphous content and in the case of Ho horizons colloidal organic material. The increase in Fe and Al is also reflected in the total Fe and Al analyses.

Folic materials can attain thick accumulations especially when w organic horizons form part of the pedon, for example, site F2 (115 cm) and F3 (76 cm). Folisolic soils which are formed primarily by the accumulation of plant residues tend to have profile depths of folic materials less than 55 cm.

Various soil development stages were observed in the underlying mineral material such as Regosols, Brunisols, Gleysols and Podzols. Radiocarbon dating at the interface of the folic material with the mineral material indicated that considerable time has elapsed from the initial stages of organic accumulation. For example, Folisolic soils overlying mineral material sampled from Queen Charlotte Islands (Fig. 1) had the following radiocarbon dates: Site F9 at 50 cm was 1270 ± 80 B.P.; Site F8 at 58 cm was 1170 ± 60 B.P. and Site F5 at 70 cm was 420 ± 80 B.P. The radiocarbon dating was determined from samples of wood material (usually bark) that still remained at the folic material - mineral interface. Radiocarbon dates were also obtained for the Folisolic soils overlying peat materials as follows: Prince Rupert site F4 (at 52 cm) indicated accumulation of folic material began approximately 1930 ± 350 B.P. and at site 24 (41 cm) folic accumulation started 980 ± 70 B.P. These radiocarbon dates would seem to suggest that underlying soil formation may have been already in place. All the sites sampled in 1983 were virgin sites. The sites were virtually untouched except for the occasional removal of the mature red cedar trees by logging possibly in the 1800's. The variability of the folic materials is a direct reflection of the source of organic materials such as wind throw and/or the gradual accumulation of plant residues. At present it is the folic materials that influence the soil properties.

Spatial Variability of Folisolic Soils

A field survey was carried out August 10-21, 1984 on Northern Vancouver Island to determine the spatial variability of folic materials at sites that were characterized (June, 1983) as being Folisolic soils; that is, having more than 40 cm of accumulated organic materials. Table 4 presents the chemical

and physical analyses of the Folisolic soils sampled in 1983 from the three selected sites - Coal Harbour, F1; Malcolm Island, F2; and Port Alice Turnoff, F3. A grid sampling survey was used with a defined distance of 25 metres between each sampling point at Coal Harbour and Port Alice and 15 metres at Malcolm Island. At each sampling point, five replicates were taken using the Macaulay auger in the following sequence: A centre point and 4 replicates at a distance of 2.5 metres from the centre point and at every 90 degrees. In addition to the grid survey, a representative soil profile was described and two transects of 7 metres were completed using the Macaulay auger to determine the thickness of the various horizons and the depth of the organic material at every 50 cm on the transect.

The results of the grid sampling are presented in Tables 5 to 7. The depth of folic material is shown for each replicate at each stop on the grid sampling survey. A depth average was calculated for those soils having more than 40 cm folic material (Folisol) and those soils with less than 40 cm of folic materials. A ratio was calculated as the number of times out of the five replicates that the soil can be designated as Folisolic. This ratio was defined as a potential for sampling a Folisolic soil at that particular point on the transect. This ratio was recalculated as a percent and then plotted (Figs 2, 4, 6). For each site, a sketch of the topography along each transect is also shown in Figs. 2, 4 and 6.

At the Coal Harbour site, the overall results of the grid survey (Table 5) showed that the average depth of Folisolic soils was 57 cm and the depth of those soils not classified as Folisolic soils (as defined by 40 cm depth) was 21 cm. Over the area of the grid, 25% of the soils were Folisolic. This low percentage of areal occurrence was a direct result of the topographic relationship. The Folisolic soils tended to be located (Fig. 2) at the base of a steep hill along a terrace following the stream (T1-01, T2-01, T3-01, T4-02). If this portion of the grid is considered, 75% of the soils are Folisolic with an average depth of 81 cm. The depths (averages 11 to 18 cm) on the slope and crest of the hill (T3-03, T2-02,03, T1-02,03) tended to be shallow due to the steepness (slopes 27 to 38%) and the possibility of removal of organic residues by fire as evidence from charcoal layers found at these sites. Where the accumulation of folic materials was not greater than 40 cm (for example, at stops 04 and 05 on all transects), an occasional Folisolic soil was described. The Folisolic soil was always in association with substantial ligneous material: a decomposed stump or log on the surface; whereas, the other replicates with less than 40 cm of folic material were usually a result of direct accumulation of plant residues.

At the Coal Harbour site, the greatest potential for Folisolic soils occurred where ligneous materials predominated throughout the accumulated folic materials (Fig. 3). The cross-section of the transect using depth data obtained at every 50 cm showed folic materials ranged from 9 cm to 126 cm on the transect west from the pit and from 50 to 151 cm on the transect east along the baseline from T2-01 towards T3-01. Abundant ligneous material in the form of decomposed logs (Hw, Hdw, Fw, horizons) dominates the folic material resulting in horizons that are highly variable as to thickness and extent. Included in the cross-section are significant areas of void space. This void space may be the result of the following: 1) the complete

Table 5: Coal Harbour Site - Depth of folic material observed with grid survey sampling of 25 metre spacing.

TRAN-SECT	STOP	REPLICATES: Folic material depth (cm) 1	2	3	4	5	Depth Average >40	<40	Ratio >40:<40
1	01	50	46	29	50	120	67	29	4 : 1
1	02	12	10	1	16	16	-	11	0 : 5
1	03	6	5	30	5	24	-	14	0 : 5
1	04	9	39	42	9	20	42	19	1 : 4
1	05	15	30	8	30	18	-	20	0 : 5
2	01	85	43	127	155	90	100	-	5 : 0
2	02	2	16	30	16	5	-	14	0 : 5
2	03	20	10	20	30	19	-	20	0 : 5
2	04	15	29	16	17	48	48	19	1 : 4
2	05	10	20	26	42	16	42	14	1 : 4
3	01	70	118	92	33	20	93	27	3 : 2
3	02	33	38	41	20	29	41	30	1 : 4
3	03	10	37	18	16	7	-	18	0 : 5
3	04	28	44	10	34	26	44	25	1 : 4
3	05	5	28	13	20	5	-	14	0 : 5
4	01	38	8	20	59	2	59	17	1 : 4
4	02	38	75	35	30	79	67	33	3 : 2
4	03	18	54	33	45	35	50	29	2 : 3
4	04	34	10	44	20	27	44	23	1 : 4
4	05	11	19	44	17	31	44	20	1 : 4
							57	21	25% 75%

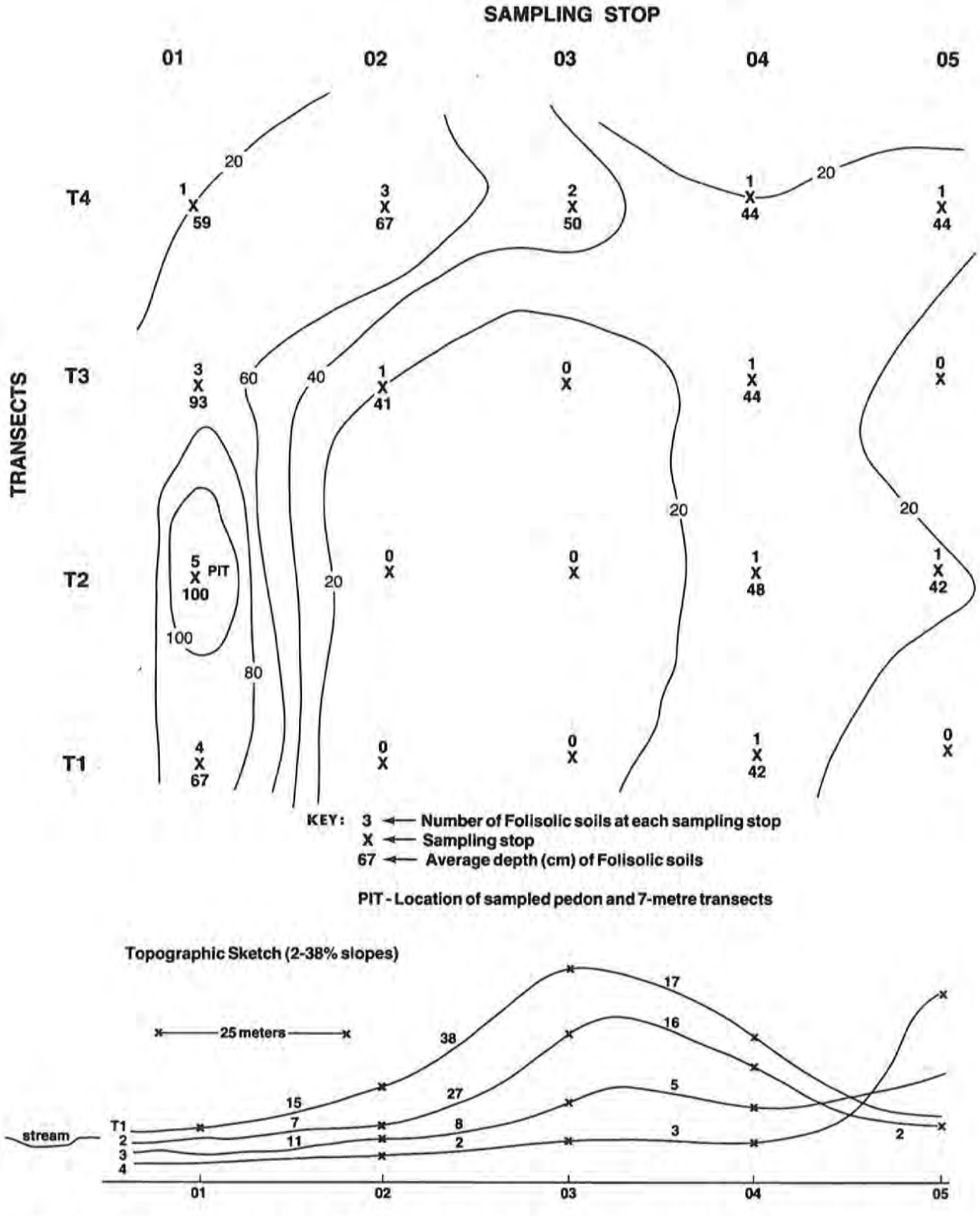

Fig. 2 Diagrammatic sketch of topography and grid survey at Coal Harbour Site. (Contours indicate the potential (%) of sampling a Folisolic soil)

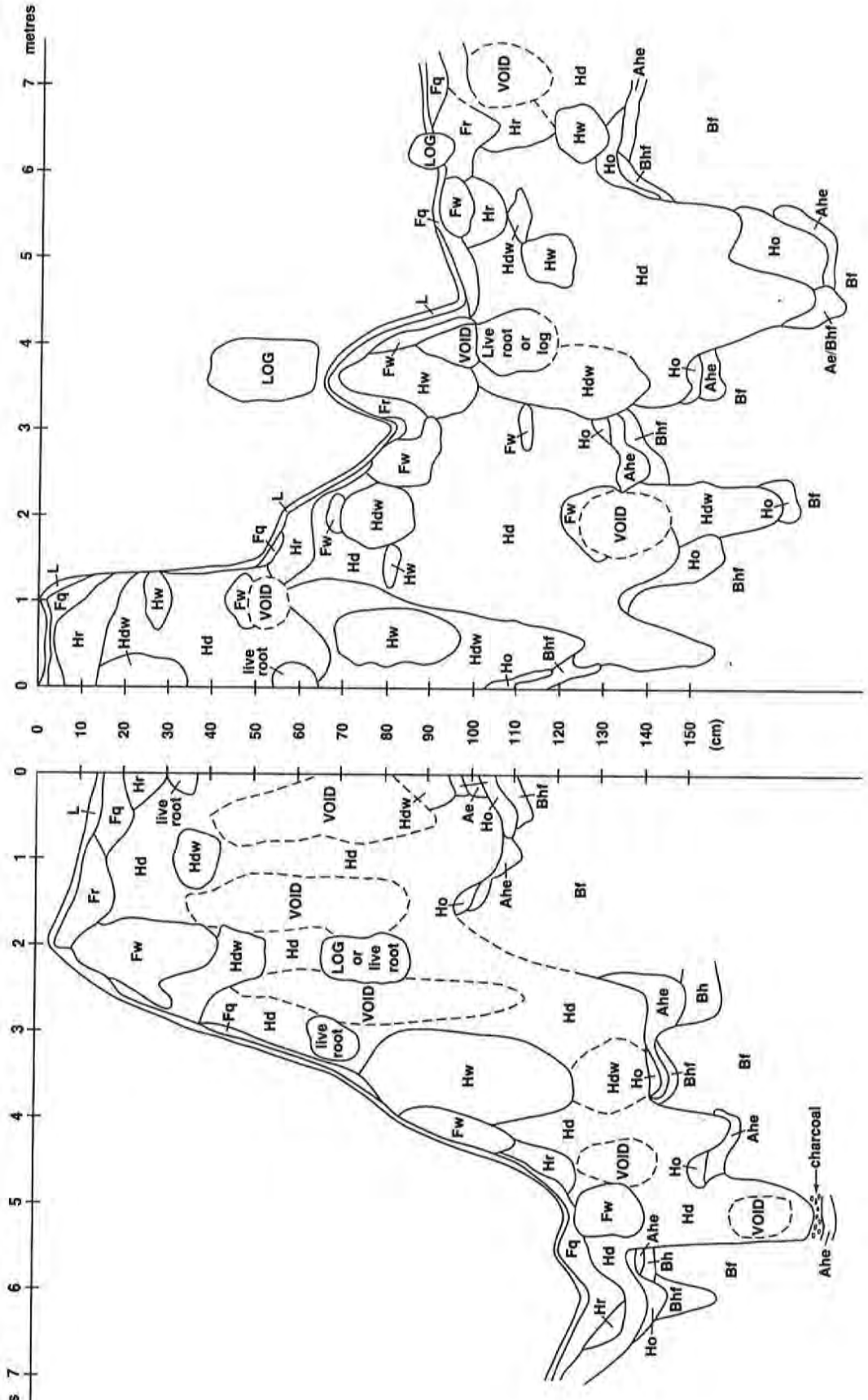

Fig. 3 COAL HARBOUR - SITE 84F1 - Cross-sections of the 7-metre transects.

decomposition of the interior of fallen logs 2) the spaces formed by the initial positioning of windthrown logs and stumps, or 3) the growth of live roots.

At the Port Alice turnoff site, soil F3 (Table 4), the grid survey included topography with slopes of 6 to 15% leading down to a lake (Fig. 4). Of the total number of soils sampled in the grid survey, Folisolic soils were distributed over 63% of the area (Table 6). The average depth of the Folisolic soils was 65 cm while those soils not classified as Folisolic had average depths of 27 cm of folic materials. The grid survey also revealed that the Folisolic soils dominated in areas where 1) mature red cedars remained and had not been logged and 2) the red cedars were logged in the past (1800's) and large stumps remained. The present vegetation was primarily hemlock with amabilis fir with an understory of small hemlock trees and Vaccinium growing frequently on decomposing logs.

For the most part, the 7-metre transects (Fig. 5) indicated the Folisolic soils were in close association with ligneous materials from previous windthrow. The thickness of the folic material is related to both the amount of ligneous material present and the topographic configuration of the underlying mineral material which may be disturbed into hummocky relief by the windthrow of the trees. The depth of folic materials ranged from 27 to 79 cm south of the pit and from 49 to 107 cm north of the pit.

The Folisolic site on Malcolm Island had level topography with slopes 0 to 1% (Fig. 6). The Folisolic soils were located most often near the creek as well as in association with large Sitka spruce trees. The grid survey (Table 7) established that Folisolic soils were located in 60% of the area and these soils had an average depth of 64 cm of folic materials. For replicates not classified as Folisolic, the folic materials averaged 28 cm thick.

The 7-metre transect (Fig. 7) showed that the thickness of the folic materials was directly related to the presence of ligneous materials (Hw, Fw, Hdw). At the pit site, a logged red cedar stump showing considerable decomposition was within 2 metres of the pit. The ligneous horizons in the first 1.5 metres of the transect can be directly associated with the former root structure of this logged tree. This relationship with decaying surface wood material is also shown at the 3 to 4 metre and 6.5 to 7 metre locations on the transect south of the pit and at 5 to 6 metres on the transect north of the pit where thick horizons of Hw, Hdw, Fw were observed. The depressions between the stumps are composed predominantly of Fr and Hr horizons indicating that the accumulation of plant residues is the main soil forming process. Overall, the folic material ranged from 16 to 109 cm on the transect north of the pit and from 10 to 76 cm on the transect south of the pit.

The question of areal distribution of depth of Folisolic soils in British Columbia was examined with reference to sampling site data obtained from the British Columbia Forest Service (R. Trowbridge) and the 1983 sampling sites. Sites reported as having greater than 40 cm of folic material over mineral or lithic materials were plotted (Fig. 8) showing the depth of L, F, and H horizons. The sites were grouped arbitrarily according to location; that is, Queen Charlotte Islands, Vancouver Island, the mainland north of Douglas

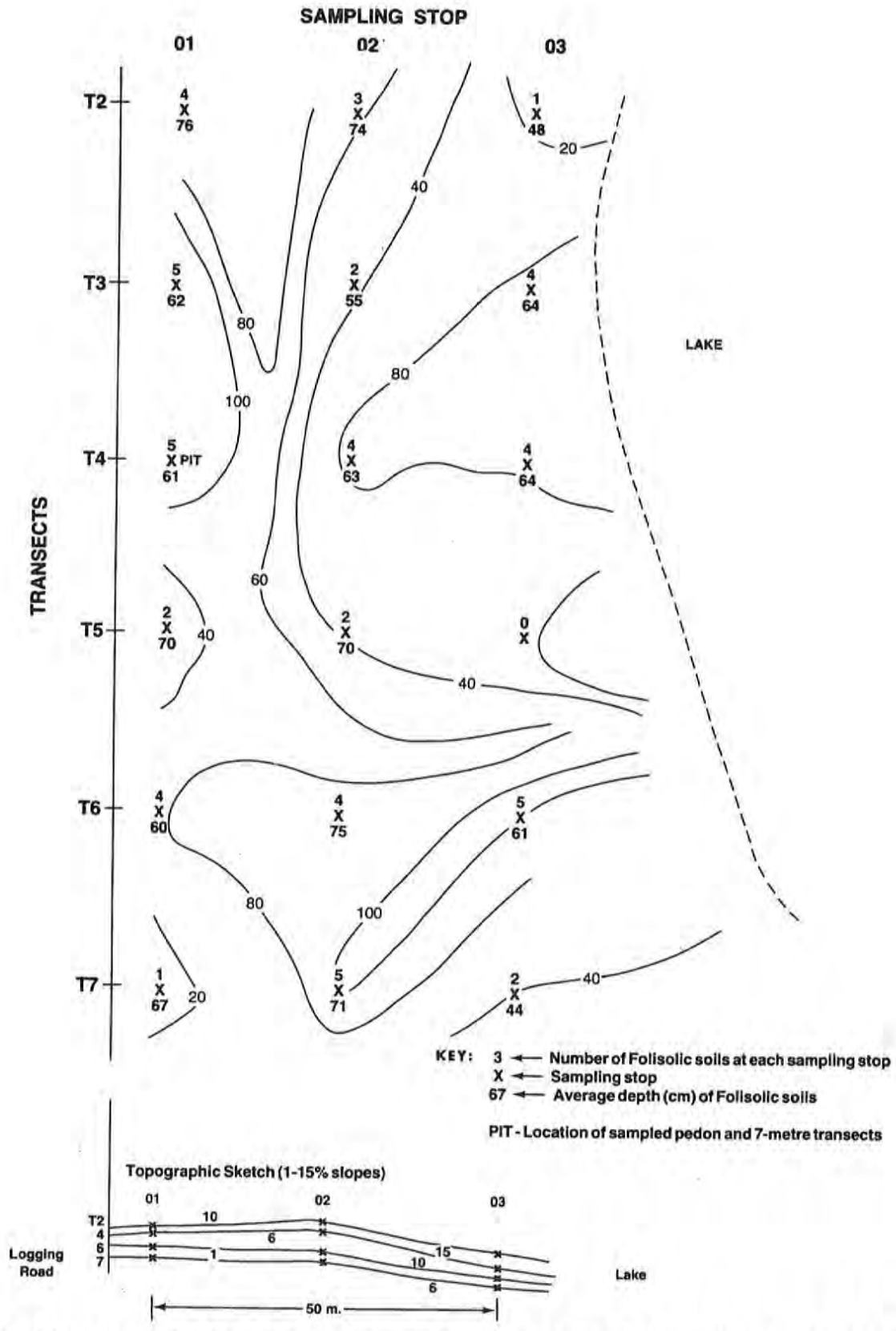

Fig. 4 Diagrammatic sketch of topography and grid survey at Port Alice Turn-off Site. (Contours indicate the potential (%) of sampling a Folisolic soil)

Table 6: Port Alice Turnoff Site: Depth of folic material observed with grid survey sampling of 25 metre spacing.

TRAN-SECT	STOP	REPLICATES: Folic material depth (cm) 1	2	3	4	5	Depth Average >40	<40	Ratio >40:<40
2	01	67	89	53	93	38	76	38	4 : 1
2	02	55	73	94	32	20	74	26	3 : 2
2	03	33	48	27	19	23	48	26	1 : 4
3	01	46	87	50	53	73	62	-	5 : 0
3	02	39	69	30	34	41	55	34	2 : 3
3	03	91	40	52	16	71	64	16	4 : 1
4	01	69	60	27	72	55	64	27	4 : 1
4	02	49	91	56	36	56	63	36	4 : 1
4	03	80	70	50	57	48	61	-	5 : 0
5	01	20	35	17	50	89	70	24	2 : 3
5	02	27	38	36	65	87	76	34	2 : 3
5	03	30	35	30	22	0	-	23	0 : 5
6	01	48	54	70	12	69	60	12	4 : 1
6	02	55	51	93	37	100	75	37	4 : 1
6	03	69	59	52	104	62	69	-	5 : 0
7	01	28	11	3	36	67	67	20	1 : 4
7	02	58	120	70	44	60	71	-	5 : 0
7	03	47	18	48	37	15	44	28	2 : 3
							65	27	63% 37%

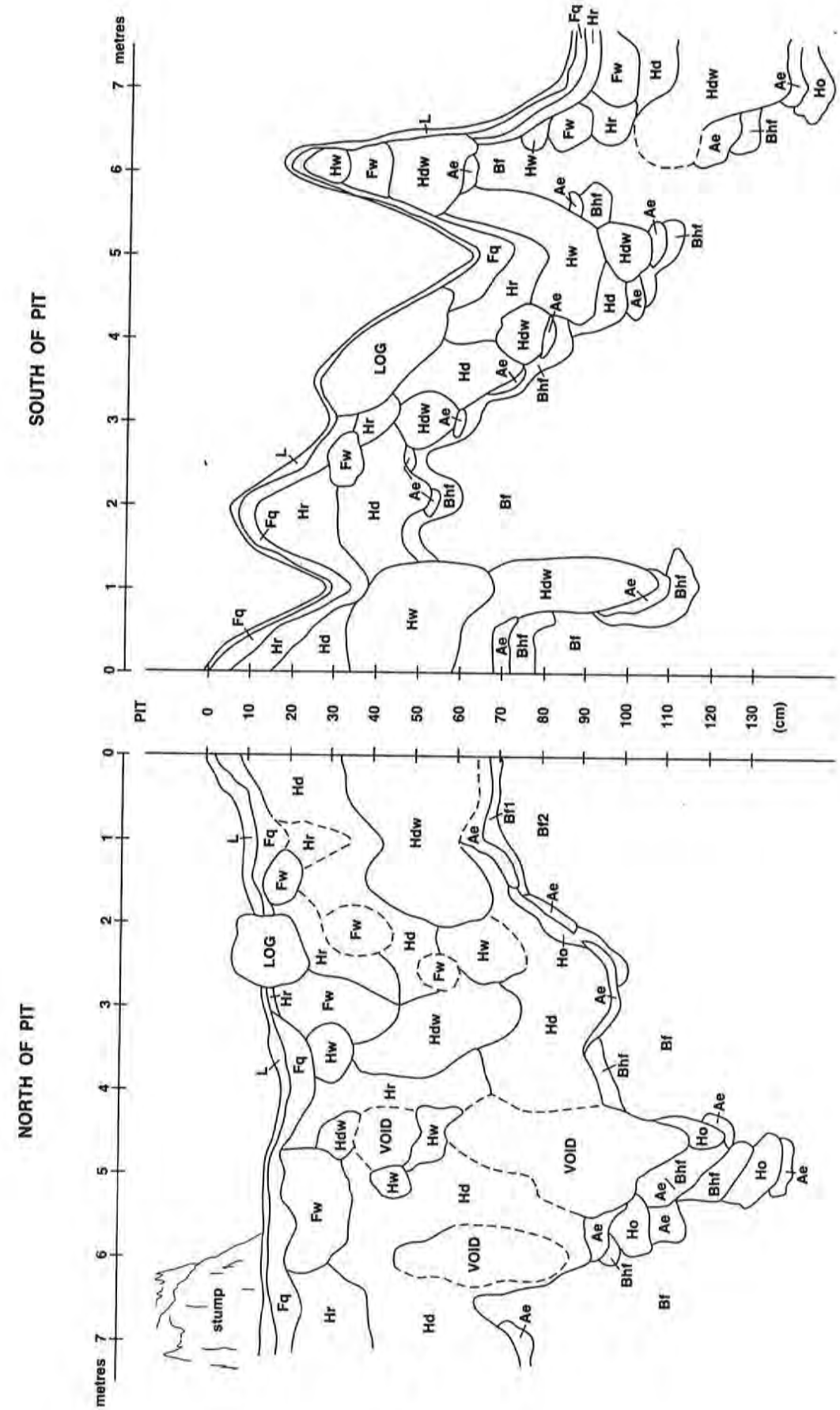

Fig. 5 PORT ALICE TURNOFF - SITE 84F3 - Cross-sections of the 7-metre transects

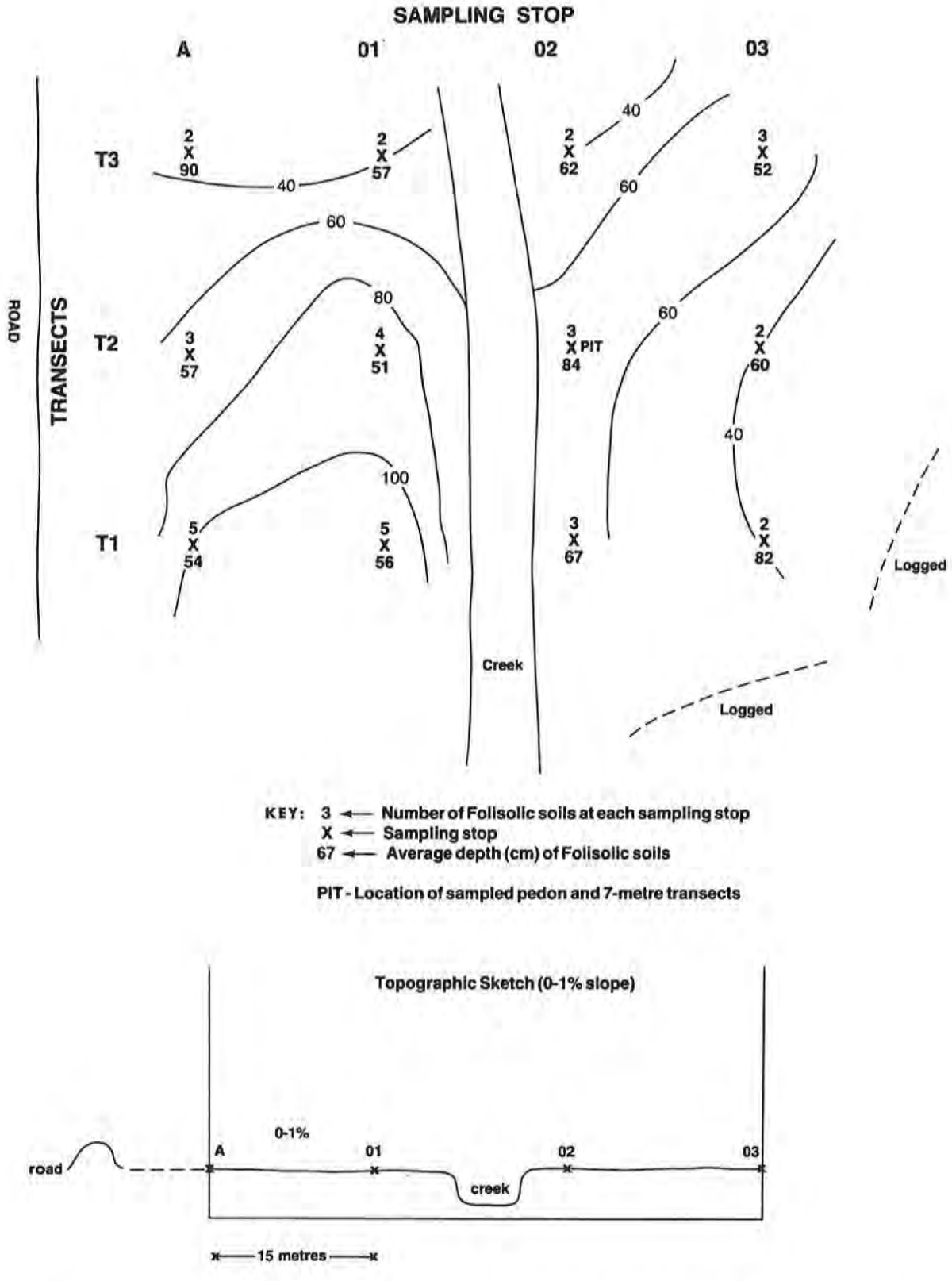

Fig. 6 Diagrammatic sketch of topography and grid survey at Malcolm Island. (Contours indicate the potential (%) of sampling a Folisolic soil)

Table 7: Malcolm Island Site - Depth of Folic material observed with grid survey sampling of 15 metre spacing.

TRAN-SECT	STOP	REPLICATES: Folic material depth (cm) 1	2	3	4	5	Depth Average >40	<40	Ratio >40:<40
1	A	56	60	49	60	45	54	-	5 : 0
1	01	66	64	61	43	45	56	-	5 : 0
1	02	51	35	34	64	91	67	35	3 : 2
1	03	44	35	20	120	17	82	24	2 : 3
2	A	75	33	47	-	50	57	33	3 : 2
2	01	52	30	47	53	52	51	30	4 : 1
2	02	62	52	-	26	140	84	26	3 : 2
2	03	78	27	24	12	42	60	21	2 : 3
3	A	81	35	35	25	98	90	32	2 : 3
3	01	17	42	24	15	71	57	19	2 : 3
3	02	39	32	57	29	67	62	33	2 : 3
3	03	26	32	43	48	65	52	29	3 : 2
							64	28	60%:40%

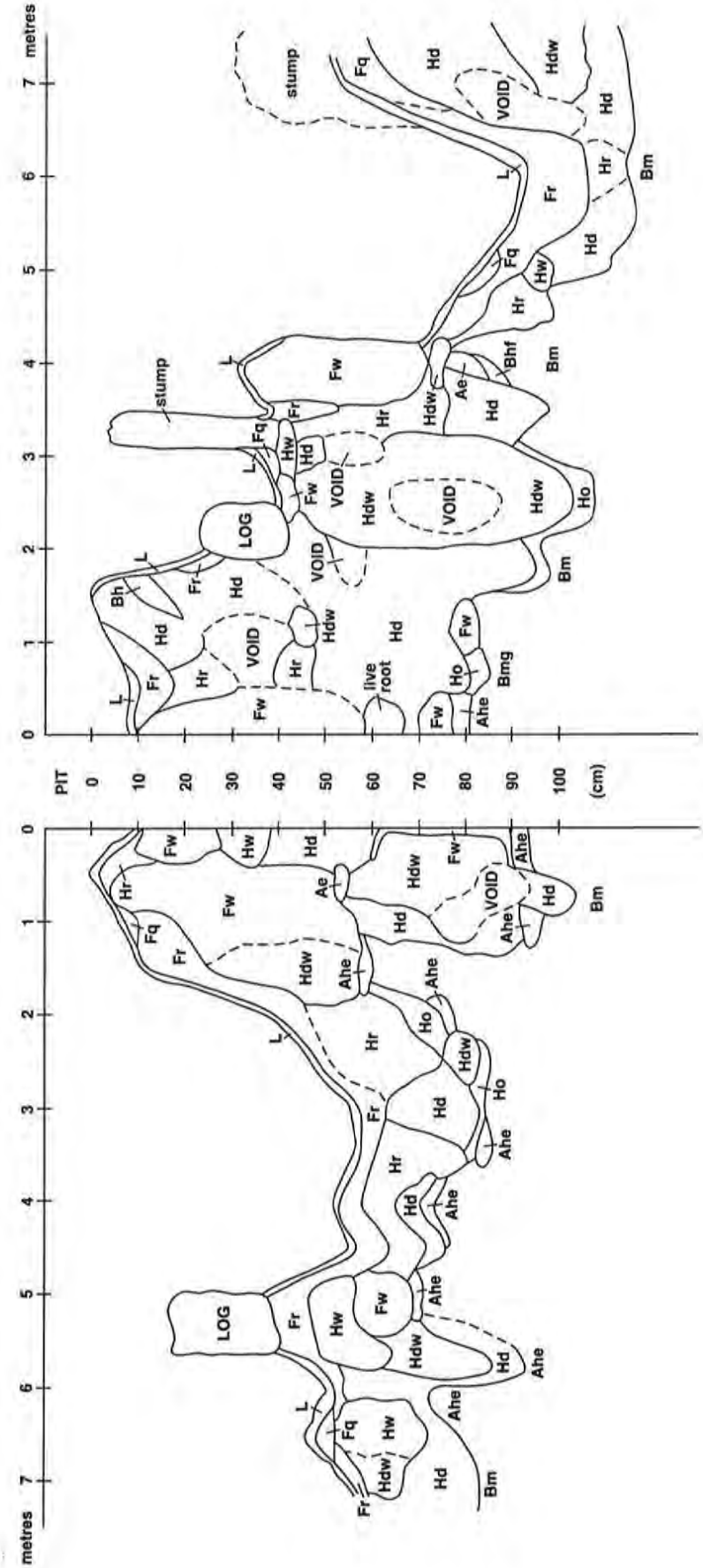

Fig. 7 MALCOLM ISLAND - SITE 84F2 - Cross-sections of the 7-metre transects

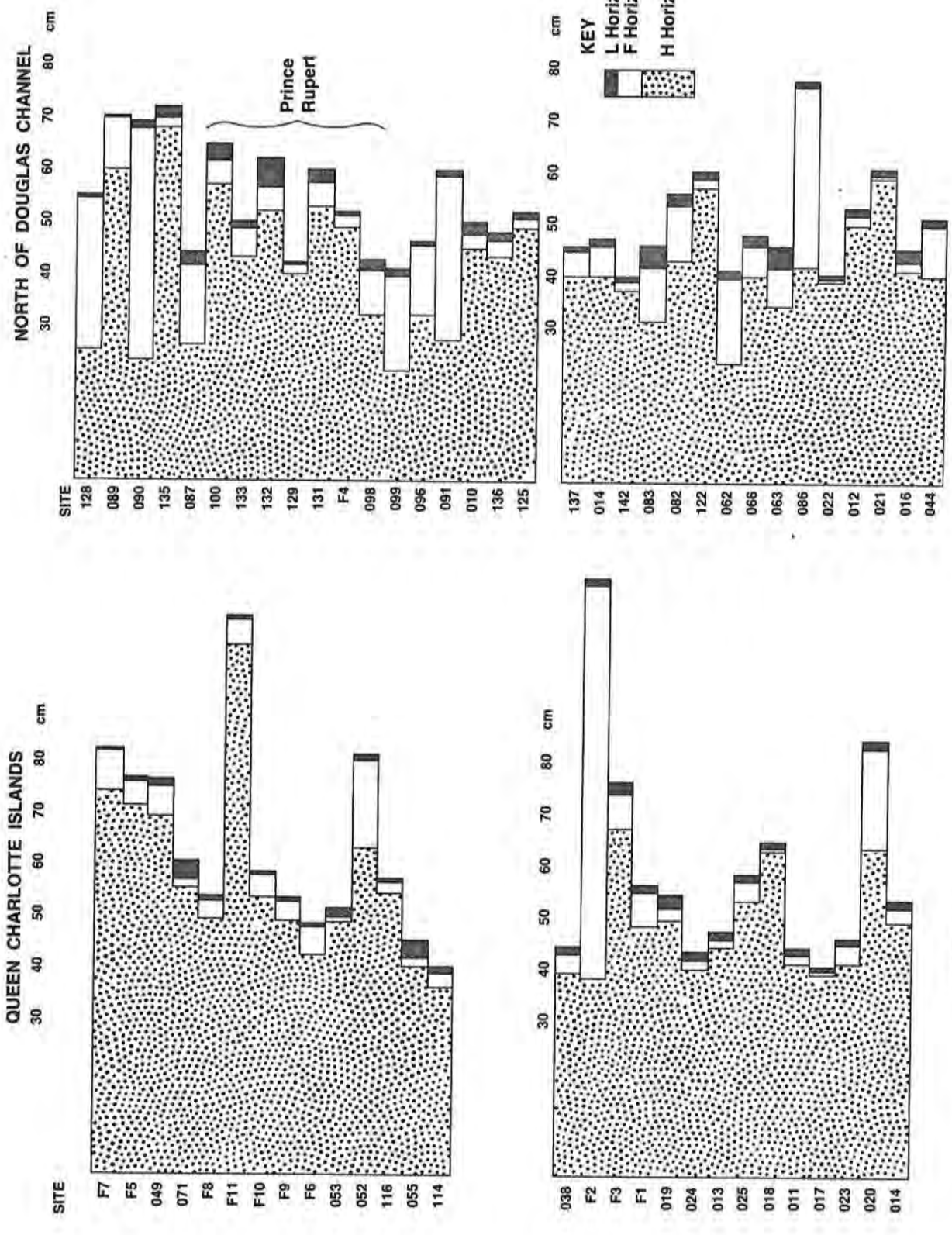

Fig. 8 Areal distribution of depth of folic materials from selected Folisolic soils in British Columbia.

Channel and the mainland south of Douglas Channel. The graphs show there is a tendency for increased F horizon material and less H horizon material on the mainland than on the Coastal Islands. This observation may be the result of a different environment on the mainland with less rainfall or possible increased incidence of fires. To determine the actual cause of this observation, more research is still required on the Folisolic soils both on the mainland and the Coastal Islands.

Summary

Folic materials sampled from coastal British Columbia were examined for chemical, physical and morphological characteristics. The spatial variability of folic materials at three Folisol sites on northern Vancouver Island were studied using a grid survey and transect method. The occurrence of Folisolic soils was related to the following: 1) the topographic relationship of the landscape 2) the amount of ligneous material present and 3) the amount of accumulated plant residues.

Acknowledgments

I would like to acknowledge C. Tarnocai for his valuable assistance with the location, sampling and description of the Folisolic sites; A. Eagle, D. Kroetsch for assistance with the grid survey sampling; R. Anderson, S. Bornais and K. Denholm for field assistance, and R. Trowbridge, T. Lord, and H. Luttmerding for field discussions on classification of Folisols.

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Appendix I:

Field survey form used to characterize Folisolic Soils.

FOLISOL FORM

PROV. YR. AREA ID. NO. (3 | 5 | 7 ... 11)

Transect ____
Stop ____

Location _____
Air Photo No. _____ Date _____

NTS map area				Latitude (N)			Longitude (W)			Military grid reference					Grid specifications						Elevation (m)
Primary quadrant	Alpha div.	Numeric div.	Direction	Deg.	Min.	Sec.	Deg.	Min.	Sec.	Zone	Alpha lat.	100,000 Meter	Easting	Northing	Distance between points in			Direction			
															X-Dir	Y-Dir	Units	Deg.	Min.	Sec.	
12	15	16	18	19	21	23	25	28	30	32	34	35	37	41	45	48	51	56	59	61	63 ... 68

Climate					Forest region	Wetland region	
Climate station	Relevance	Mean temp. °C for January	Mean temp. °C for July	Precipitation (mm)		Region	District
12	28	29	33	37	41	47	50

NOTES:

SITE POSITION SKETCH

VEGETATION TYPE:

SLOPE TYPE

**Simple
**Complex

Class	%Slope
1	0-0.5
2	0.5+ to 2
3	2+ to 5
4	6+ to 9
5	10+ to 15
6	16+ to 30
7	21+ to 45
8	46+ to 70
9	71+ to 100
10	>100

Slope ____ %

SAMPLE SITE POSITION ON SLOPE

Crest
Upper slope
Middle
Lower Slope
Toe
Depression

MICROTOPOGRAPHY

Level
Slightly mounded
Moderately mounded
Strongly mounded
Severely mounded
Extremely mounded
Ultra mounded

ASPECT

North
Northeast
East
Southeast
South
Southwest
West
Northwest
Level

SOIL Depth (cm)	TEMP °C
0	
5	
10	
20	
50	
100	

AIR TEMP. ____ °C

SITE - STOP

Surface Distrib.	% Cover
Vegetation Trees/Shrubs	
Wood (Dead) Windthrow	
Wood (Dead) Logged	
Soil	
Rock	
Water	

WATERTABLE

____ * Depth to Watertable (m)

KIND OF WATERTABLE

Apparent
Perched
Other

SEEPAGE

Present
Absent

SOIL SITE DRAINAGE CLASSES

Very rapidly drained
Rapidly drained
Well drained
Moderately well drained
Imperfectly drained
Poorly drained
Very poorly drained

SOIL PERVIOUSNESS CLASSES

Rapidly pervious
Moderately pervious
Slowly pervious

PARENT MATERIAL/LANDFORM

Type of Soil Sample

1. Bulk Chem/Phys.
2. Kubiena box
3. Bulk density
4. C14
5. Water
6. None

Transect ____ Stop ____

4 X 12 Y 14

Hor. No.	Lith dis.	Horizon designations: Master hor.	Suffixes	Modifier	Depth (cm): Upper limit	Lower limit
16	18	19	22	27	28	32
0 1						
0 2						
0 3						
0 4						
0 5						
0 6						
0 7						
0 8						
0 9						
1 0						
1 1						
1 2						

2 X 12 Y 14

Hor. No.	Lith dis.	Horizon designations: Master hor.	Suffixes	Modifier	Depth (cm): Upper limit	Lower limit
16	18	19	22	27	28	32
0 1						
0 2						
0 3						
0 4						
0 5						
0 6						
0 7						
0 8						
0 9						
1 0						
1 1						
1 2						

3 X 12 Y 14

Hor. No.	Lith dis.	Horizon designations: Master hor.	Suffixes	Modifier	Depth (cm): Upper limit	Lower limit
16	18	19	22	27	28	32
0 1						
0 2						
0 3						
0 4						
0 5						
0 6						
0 7						
0 8						
0 9						
1 0						
1 1						
1 2						

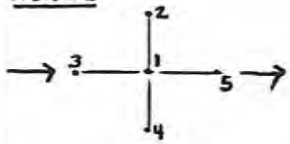
4 X 12 Y 14

Hor. No.	Lith dis.	Horizon designations: Master hor.	Suffixes	Modifier	Depth (cm): Upper limit	Lower limit
16	18	19	22	27	28	32
0 1						
0 2						
0 3						
0 4						
0 5						
0 6						
0 7						
0 8						
0 9						
1 0						
1 1						
1 2						

5 X 12 Y 14

Hor. No.	Lith dis.	Horizon designations: Master hor.	Suffixes	Modifier	Depth (cm): Upper limit	Lower limit
16	18	19	22	27	28	32
0 1						
0 2						
0 3						
0 4						
0 5						
0 6						
0 7						
0 8						
0 9						
1 0						
1 1						
1 2						

NOTES



MORPHOLOGY

AREA ID. NO. X Y

7	12	14

TRANSECT ____

STOP ____

Hor. No.	Horizon designations: Lith. dis.	Master hor.	Suffixes	Modifier	Depth (cm): Upper limit	Lower limit	Munsell colour: Aspect	Hue	Symbol	Value	Chroma	Hor. bound: Distinctness	Form	Consistence: Wet	Dry	Moist	Structure: Kind	Grade	Size	CHARACTER	pH (field)	Temperature °C	MOTTLES: Munsell colour: Aspect	Hue	Symbol	Value	Chroma	Abundance	Size	Contrast	Stones % Vol. est.	Rocks % Vol. est.	Limnic materials
16	18	19	22	27	28	32	36	37	40	42	44	20	21	22	23	24	18	19	25	26	48	52	36	37	40	42	44	31	32	33	72	74	76
01																																	
02																																	
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07																																	
08																																	
09																																	
10																																	
11																																	
12																																	

STRUCTURE
KIND

A-Fibered
B-Matted-Compact
C-Matted-Non-compact
D-Massive
E-Granular
F-Layered
G-Single grain
H-Columnlike-Erect
I-Columnlike-Recumbent
J-Blocky-Angular
K-Blocky-Subangular
L-Prismatic

GRADE

1-Weak<20%
2-Moderate 20-60%
3-Strong >60%

SIZE

1-Fine <5mm
2-Medium 5-20mm
3-Coarse >20mm

HORIZON BOUNDARY
DISTINCTNESS

1-Diffuse
2-Gradual
3-Clear
4-Abrupt

FORM

1-Smooth
2-Wavy
3-Irregular
4-Broken

COLOUR ASPECT

M-Moist
D-Dry
F-Frozen

LIMNIC MATERIALS

1-Yes
2-No

CONSISTENCE
WET

1-Nonsticky
2-Slightly sticky
3-Sticky
4-Very Sticky

MOIST

1-Loose
2-Very friable
3-Friable
4-Firm
5-Very Firm
6-Pliable
7-Resilient
8-Tenacious

DRY

1-Loose
2-Soft
3-Slightly hard
4-Hard
5-Very Hard
6-Extremely hard
7-Rigid

CHARACTER

A. Mushy
B. Mucky
C. Greasy
D. Gritty
E. Leafy
F. Mossy
G. Acerose
H. Felty
I. Fibrous
J. Ligneous
K. Crusty

NOTES

COMPOSITION

TRANSECT ____ STOP ____

AREA ID. NO. X Y (7 | 12 | 14)

Hor. No.	Horizon designations: Lith. dis.	Master hor.	Suffixes	Modifier	Root: Penetration depth (cm)	Root: Abundance	Root: Size	Root: Orientation	Texture	von Post	Rubbed fiber %	Sphagnum	Sedge	Moss	Sed. peat	Amorphous	Seeds	Cones	Needles	Plant Parts	Rootlets	FUNGI	FUNGI: Dist.	FECAL	FECAL: Dist.	Wood: Diameter (cm)	Wood: Hardness	Wood: Abund.	Wood: Dist.	Charcoal	Charcoal: Dist.	Charcoal: Size	MINERAL	MINERAL: Dir.	FAUNA	Other
16	18	19	22	27	28	31	32	33	34	46	50	54	56	58	66	68	70	54	56	58	60	62	64	74	76	74	76			72	74		66	68		64
0 1																																				
0 2																																				
0 3																																				
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0 7																																				
0 8																																				
0 9																																				
1 0																																				
1 1																																				
1 2																																				

CHARCOAL/FAUNA FUNGI/FECAL PELLETS

ABUNDANCE

0 None
1 Few
2 Common
3 Abundant

DISTRIBUTION

R Random
C Clustered
B Banded
D Isolated

ROOT DESCRIPTION

ABUNDANCE

1-Very few
2-Few
3-Plentiful
4-Abundant

SIZE (mm)

1-Micro
2-Very fine
3-Fine
4-Medium
5-Coarse

ORIENTATION

1-Vertical
2-Horizontal
3-Oblique
4-Random

TEXTURE

A-Sand
B-Loamy Sand
C-Sandy Loam
D-Loam
E-Silt Loam
F-Silt
G-Sandy Clay Loam
H-Clay Loam
I-Silty Clay Loam
J-Sandy Clay
K-Silty Clay
L-Clay
M-Heavy Clay
N-Fibric
O-Mesic
P-Humic

WOOD HARDNESS

1-Hard
2-Soft
3-Very Soft

CHARCOAL SIZE	DIAMETER mm	LENGTH
1. Very Fine	<2	<5
2. Fine	2-10	5-20
3. Medium	11-50	21-100
4. Coarse	51-250	101-500
5. Very Coarse	>250	>500

NOTES

Hor. No.	Composition – other: Description	Value (%)

DIAGRAMMATIC SKETCH OF PROFILE (to scale)

PROPOSALS FOR IMPROVING THE CRITERIA FOR THE PODZOLIC ORDER

J.A. McKeague

A number of problems have arisen since Publ. 1646 emerged in 1978 both on the criteria for Podzolic soils and on their application. The problems listed have been pointed out by pedologists from B.C. to Nfld.; probably others will be added at this workshop. The material that follows is a listing of perceived problems and of proposals to be considered for solution of each of them.

1. Classification of Podzolic soils in which the only Bhf horizon that occurs underlies the Bf horizon. Such soils are found in B.C. (Luttmerding and others); commonly the Bhf horizon overlies a duric horizon or very dense till. We think of typical Ferro-Humic Podzols as having a Bhf-Bf sequence from top to bottom of the podzolic B. If the pedon to be classified has a horizon sequence as follows: FH, Ae, Bf (40 cm), Bhf (15 cm), BCc, Ccj, how should it be classified? Publication 1646 could be interpreted in either of two ways: a) the soil has a Bhf horizon so it belongs with Ferro-Humic Podzols, or
   b) in Ferro-Humic Podzols the dark Bhf horizon underlies the Ae usually and the color becomes lighter with depth (p. 98); thus, the pedon does not fit Ferro-Humic Podzol.

   Tentative solution - A Bhf at least 10 cm thick anywhere within the podzolic B is diagnostic of Ferro-Humic Podzol. Slight modification of the chapter on Podzolic soils would be required.

2. There is no consistency in the acidity requirements for Podzolic and Brunisolic Soils. For example, Herb Luttmerding pointed out that: Ae 0-2 cm. Bf 2-12 , BC 12-14, Ck 14- , is classified as Humo-Ferric Podzol, but that Ae 0-2 cm, Bm 2-12 cm, BC 12-17 cm, Ck 17- , is classified as Eutric Brunisol. Should we insist that a Podzolic Soil must be acid to a depth of 25 cm (mixed 0-25 cm has a pH less than 5.5)?

   Tentative solution - No, a podzolic B is an adequate requirement. The system is not based at a high level on acidity (except for Brunisolic soils).

3. If the horizon sequence of a pedon is L-H, Ae, Bf? BC, C and the Bf? is 30 cm thick, must all of the horizon be sampled to determine whether it meets the requirements of a podzolic B?

   Tentative solution (in use, I think) - To determine whether the soil meets Podzolic criteria, it is necessary to sample only the 10 cm of B horizon that is most strongly expressed. If it all looks the same, it is desirable to take 3 samples (top middle and bottom 10 cm). Determination of pyro. Al and Fe takes only a few minutes per sample. Of course, the sampling must be done honestly: mark off the Bf1, Bf2 and Bf3 on the profile and take an average sample of each over approximately 50 cm of the profile. If any one of the three subhorizons meets the requirements of a podzolic B, it's a podzolic soil. For other purposes, of course, it may be desirable to sample the entire B horizon in a single sample.

4. What is the appropriate horizon designation for a lower B subhorizon of a Podzolic Soil that readily meets the chemical criteria but not the color criteria of a podzolic B? Such horizon have colors such as 2.5Y5/4 but they may contain more than 2% organic C and more than 1% pyro (Fe + Al).

   Tentative solution - Such horizons should be designated Bf. In fact, I would like to waive the color criteria whenever possible as diagnostic criteria and use color locally as an indicator.

5. What is the appropriate designation for a horizon similar to that mentioned in '4' except that it does not meet the chemical criteria of a podzolic B? Is it Bfj, Bm or BC?

   Tentative solution - BC because a horizon directly underlying a podzolic B is expected to contain some of the accumulation products of the podzolic B; it is transitional between Bf and C. Bfj should be reserved for B horizons that do not quite meet podzolic B criteria and that occur directly below an eluvial horizon. Do we need Bfj at all?

6. How do we classify shallow soils on calcareous gravels that have podzolic B horizons? Some of these B horizons are black and Ca-organic coatings occur on gravel fragments. Is a new class required for the soils on beach ridges of the James and Hudson Bay Lowlands that Dick Protz has described and analyzed?

   Tentative solution - Only at the family and series levels. These are interesting variants among the juvenile Podzolic soils but they fit reasonably comfortably within present system.

7. Do we want to classify well-drained Podzolic soils with brownish B horizons as Humic Podzol? Les Evans has data for such soils from N. Ontario. For some reason these soils have very low Fep values (0.05%). Commonly organic C/Fep exceeds 20. Presumably, weatherable Fe minerals are in short supply.

   Tentative solution - No, such soils should be Humo-Ferric Podzols. Perhaps we could restrict Bh horizons to chromas less than 2.

8. Are the present colore criteria for podzolic B horizons adequate? Les Evans has suggested color criteria that are more closely related to the chemical criteria for soils of N. Ontario.

   Tentative solution - As stated in '4' I would prefer to waive color as a diagnostic criterion when possible but to use it regionally, as Les has, as a field clue to podzolic B horizons. Different color limits will apply in different areas.

9. How do we want to classify cultivated soils having Ap horizons that meet the chemical but not the morphological criteria of a podzolic B? Wang et. al. (CJSS 64:229-239) studied an area of Podzolic Soils in N.B. used for potato production and noted the above problem.

Tentative solution - As proposed by the authors, waive the color criteria.

10. Are the current chemical criteria of a podzolic B adequate? This question has arisen for a number of reasons:

    a) Perhaps most fundamental, pyrophosphate does not extract effectively amorphous inorganic products accumulated in podzolic B horizons. Farmer and other have shown that Al, and to a degree, Fe, may move as a soluble complex with Si and be deposited in B horizons of soils. Evidence of imogolite (a finely crystalline Al_2Si mineral) and an Al_2Si allophane has been found in the B, especially lower B, horizons of many Podzolic soils in many countries.

    b) Pyrophosphate is known to peptize finely divided particles of a wide range of compositions including silicate clay minerals, ferrihydrite and goethite.

    c) Pyrophosphate extractable Al and Fe are known to be strongly method dependent.

    d) The criteria result in exclusion of some soils with striking color profiles from the Podzolic order.

Tentative solution - Stay with it using exactly the procedure specified in the CSSC Manual until a better procedure emerges. We have tried oxalate, hydroxylamine-hydrochloride, Na tetraborate, EDTA, etc. The ideal juice remains to be found; it probably always will, but something better than pyrophosphate may be found.

Internationally, much work is in progress on podzol or Spodosol classification criteria and on podzol genesis. Within a few years, it is probable that modified concepts and criteria will emerge.

DEFINITION OF SOIL SURFACE AND CONTRASTING HORIZONS

Charles Tarnocai

SOIL SURFACE

The soil surface is defined in the *Manual for Describing Soils in the Field* (Expert Committee on Soil Survey 1983, p. 63) as follows:

> The top of the mineral soil is considered to be zero depth both for organic litter (less than 40 cm thick) and for mineral soils; zero depth for organic soils (more than 40 cm thick) is the top of the organic material. Organic layers (except those that are buried) are listed in descending order of depth; mineral horizons and layers in organic soils are listed in ascending order of depth.

This definition is used to indicate the depth of soil horizons in the description of pedons.

Problems relating to this definition

For measuring soil temperatures and water tables and for determining the rooting depth and depth of the restrictive layer and permafrost table, the top or surface of the soil (even if the surface is formed by an organic horizon) is considered to be the soil surface. Correlation of the data relating to soil temperature, ground water depth and permafrost table with the depths given in the pedon descriptions constantly creates problems.

Recently, in relation to the computerized soil data forms, this convention has been questioned. Firstly, it created a logical problem between the depth indicated for the mineral and organic soils. In addition to this, information recorded in the monitoring file (soil temperature, ground water depth, etc.) could not be correlated with the soil description file in the case of the mineral soils.

Suggested solutions

Possible alternative solutions to this problem are as follows:

1. The top of the soil, composed of either mineral or organic horizons, is considered to be the soil surface. Soil horizons are then listed in descending order, starting from this surface. The new definition is then as follows:

   > The top of the mineral or organic soil or the organic surface horizon of the mineral soil is considered to be zero depth. All depths are listed in descending order from the zero depth.

   In soil descriptions, however, both the horizon thicknesses and the depth are recorded. These depths can then be correlated with other soil depth data. The horizon thicknesses provide a record for those horizons which are subject to compaction.

   For example:

Horizon	Depth (cm)	Thickness (cm)
L	0-3	3
F	3-8	5
Ae	8-16	8
Bt	16-26	10
BC	26-50	24
Ck	50-65	15

2. Soil surface is defined as in the *Manual for Describing Soils in the Field* (Expert Committee on Soil Survey 1983, page 63) but in soil descriptions the horizon thicknesses are also given.

   For example:

Horizon	Depth (cm)	Thickness (cm)
L	8-5	3
F	5-0	5
Ae	0-8	8
Bt	8-18	10
BC	18-38	20
Ck	38-54	16

CONTRASTING HORIZONS OR LAYERS

Roman numerals are prefixed to the master horizon or layer designation (O, L, F, H, A, B, C, R) to indicate lithologic discontinuities either within or below the solum. The first, or uppermost, material is not numbered, for the Roman numeral I is understood; the second contrasting material is numbered II, and others encountered are numbered III, IV, and so on, consecutively with depth. Thus, for example, a sequence from the surface downwards might be Ah, Bm_1, $IIBm_2$, IICca, $IICk_1$, $IIICk_2$.

Lithologic discontinuity is due to the mode of deposition or to strongly contrasting texture (differing by two textural classes) or to mineralogical composition that indicates a difference in the material from which the horizons have formed. These contrasting materials have resulted from geologic rather than from pedogenic processes.

A change in the clay content associated with a Bt horizon (textural B) does not indicate a difference in parent material. Appearance of gravel, or a change in the ratios between the various sand separates, will normally suggest a difference in parent materials. A different Roman numeral would not normally be used for a buried soil in a thick aeolian deposit. The difference between the properties of the buried soil and the overlying material are presumably the result of pedo-genesis. A stone line usually indicates a need for another Roman numeral. The material above the stone line is presumed to be transported. If the transport was by wind or water, one must suspect that during the movement there was some sorting of the material according to size.

INTERNATIONAL SOIL CLASSIFICATION

J.A. McKeague

This report provides some information on two projects aimed at bringing about an increased degree of unanimity in soil classification at an international level. The projects are the International Reference Base for Soil Classification (IRB) and classification work sponsored by Soil Management Support Services (SMSS) under the Soil Conservation Service of U.S.D.A.

INTERNATIONAL REFERENCE BASE, IRB

I am not certain of the origin of this project; it probably developed, in part, as a result of work on the FAO-Unesco soil map of the world project. The legend developed for that map was considered by some as the nucleus of an international system of soil classification. Undoubtedly people such as Rudy Dudal of FAO were strong promoters of an international system.

IRB-1 The first concrete step that I know of was a meeting (IRB-1) held in Sofia, Bulgaria in May 1980. Undoubtedly much discussion and political activity preceded the meeting sponsored by FAO-Unesco in cooperation with ISSS and the UN Environment Program (UNEP). The decision to work on an "International reference base for soil classification" rather than an international soil classification system was probably "politically" motivated. The U.S.A., France and probably other countries already had "international systems". The stated aim of the IRB was to provide a base to which all other systems could be referred. Thus, to consider together Russian and Canadian soil information, translation of both classifications into IRB would be the first step. It was thought that the idea of getting rid of national systems and using a unique international system of soil classification would be threatening to some national soils groups.

The first meeting included representatives of only the following: FAO, ISSS, Belgium, Bulgaria, France, USA, USSR. Incidentally, meetings were held in Sofia because that was a mechanism by which the UN organizations could use available soft currency. Bulgarian contributions to the UN must be used within Bulgaria. The main conclusion of the meetings was that an international reference base (possibly 3 categories) should be prepared as a project of FAO, Unesco, UNEP and ISSS. It was pointed out that other comprehensive systems such as Soil Taxonomy are the property of the nation that developed them; hence, decisions about modifications rest with the pedologists of one nation.

IRB-2 The second IRB meeting was held in Sofia in June, 1981. UNEP funding made it possible to add representatives from Brazil, Canada, China, Romania, Sudan, Yugoslavia (to countries represented at the first meeting). The group worked through 26 proposed major soil groups (orders), cut them to 15 and developed tentative definitions and criteria. It was decided that a 4-category system would be developed and that temperature and moisture regimes would be used mainly in category 4. Though there was some evidence of a power struggle between the ISSS and UN organizations, and also between UNEP and FAO, the international spirit was excellent.

IRB-3 The third IRB meeting was held in Sofia in October 1983; representatives from Australia and England were included with most of those from IRB-2. It was clear that not much technical progress was made between IRB-2 and -3. On the other hand, the ISSS seemed to have gained control of the project which was supported at the 1982 ISSS meeting in Delhi. Funding remained a problem but it seemed probable that UNEP would be able to help. For the first time, IRB began to get organized with an executive, a steering committee and convenors for sub-committees of some of the 16 major soil groups proposed. It was hoped that a full-time classification specialist would be hired to work on the project but funding was not definite. The hope of most of the participants was to develop an international system that would ultimately replace all national systems.

IRB in 1984. There has been some correspondence and tentative outlines of the classification to level 4 have been completed by approximately 3 of the sub-committee chairmen. Input is sought from all who are interested. Some of the subcommittee convenors will be asking specifically for Canadian input. It is hoped that IRB will have a tentative system for ISSS' 86.

Dr. E. Schlichting, Stuttgart-Hohenheim, Germany is chairman of IRB, Dick Arnold of SCS is head of the steering committee, and Dr. Sombroek of ISSS is deeply involved though I do not know his official role. The major soil groups and convenors of working committees to develop their classification are listed.

1. Weakly developed soils - de Bakker, Netherlands
2. Swelling/shrinking soils - Bhattacharjee, India
3. Groundwater-influenced soils - Ciric, Yugoslavia
4. Saline-alkali soils - USSR
5. Calcic/gypsic soils - Boyadgiev, FAO, Rome
6. Mollic soils - Guthrie, U.S.A.
7. Umbric and shallow soils - ?
8. Sialic soils (Alfisols etc) - Hollis, England
9. Fersialic soils (Ultisols etc) - Santanna, Ghana
10. Ferrallic soils (Oxisols etc) - Isbell, Australia
11. Andic soils - Alvorado, Costa Rica
12. Surface water soils - Blume, Germany
13. Podzolized soils - McKeague, Canada
14. Histic soils - Farnham, U.S.A.
15. Pergelic soils - ? U.S.S.R.
16. Anthropogenic soils - Li., China

I will inform members of the classification working group and others interested of developments in IRB. Suggestions are welcome.

SOIL MANAGEMENT SUPPORT SERVICES, SMSS

This organization began in 1979 with an agreement between the U.S. Agency for International Development (AID) and the Soil Conservation Service (SCS). It provides a mechanism for the SCS to provide technical assistance to developing countries in soil survey, classification and land management. The stated goals (see Soil Taxonomy News No. #4) are:

1. To make Soil Taxonomy appropriate for soils of intertropical areas.

2. To assist staff in developing countries to use the system.

3. To assist in solving other problems related to the assessment and wise use of land resources in developing countries. Overall, the goal is better technology transfer due to the rigorous use of a well-defined system of classification.

A number of international committees have been established aimed at improving the classification of certain orders or potential orders:

ICOMOX - Oxisols
ICOMERT - Vertisols
INCOMOD - Spodosols
ICOMLAC - Soils with low activity clays
ICOMAND - Andisols
ICOMAG - Soils with aquic water regimes

These committees have organized field tours and workshops in several countries. Soils have been sampled and analyzed; a considerable amount of data is available. It is highly desirable that IRB subcommittees interact with the ICOM's. Such interaction may result in a modified Soil Taxonomy that is similar to IRB. In the case of the podzolic soil group of IRB, we are working with Ted Miller, chairman of ICOMOD.

Several years ago Charles Tarnocai met with the late Guy Smith and U.S. leaders in soil taxonomy and made the case for Cryosolic soils as an order in Soil Taxonomy. No ICOMOCRY has been established to date but Cryosolic soils are included as a class at the top level of IRB.

CLASSIFICATION OF CLAY SOILS

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D.F. Acton

Introduction

Several years ago we began a closer examination of the morphology of clay soils in Saskatchewan. As we proceeded, especially when we had good exposure of these soils to depth, we noticed features heretofore unnoticed or ignored. It also appeared as though there was insufficient recognition of these soils in the Canadian System of Soil Classification. As a consequence, Dr. A.R. Mermut, who had joined our staff at this time began an examination of these soils. He was joined a year or two later by a graduate student, G.S. Dasog, who had experience mapping clay soils in India. Both of these gentlemen are reporting on specific aspects of these studies at the ASA meetings in Las Vegas so it has fallen on me to report to this body. This past September Dr. L.P. Wilding from Texas A & M University accepted an invitation to visit the University of Saskatchewan, present a lecture and participate in discussions on the genesis and classification of clay soils. We were very pleased that C. Wang found time in his schedule to participate. The contribution of both of these scientists was much appreciated.

My report will present an overview of the properties and distribution of clay soils in Saskatchewan, refer to several theories that have been proposed for their genesis, and allude to some of the problems we have in their classification. I will only proceed toward a solution by making some recommendations for further study.

Nature and Distribution of Clay Soils in Saskatchewan

Clay soils in Saskatchewan are associated with glacial lake basins. They occur extensively throughout all zones, from the associated Brown soils of the short-grass prairie, through the Black soils of the aspen-grove and into the Gray soils of the mixed-wood and soft-wooded region of the low and mid boreal. As indicated in Fig. 1, we have examined and sampled soils throughout these zones. In addition to characterizing general chemical and physical properties, we are looking closely at their micromorphology, mineralogy and doing some work in swelling pressures and other properties related to geotechnical interpretations. In addition, we have been monitoring cracking phenomena in the field. An offshoot of our studies has been work initiated by Grevers and de Jong, examining the relationship of structure to rooting of various species of forage crops after an extended rotation.

Field Morphology

Clay soils in the grassland region of the province, where there is a 50% probability of a moisture deficit in excess of 400 mm, have a non-descript, massive morphology, at first glance. The Ap horizon is only slightly darker than underlying layers. It may or may not be calcareous but there is usually lime carbonate at 15 cm, although one often encounters soils with a lime-free layer to 30 or 40 cm scattered sporadically

CLAY SOILS IN SASKATCHEWAN

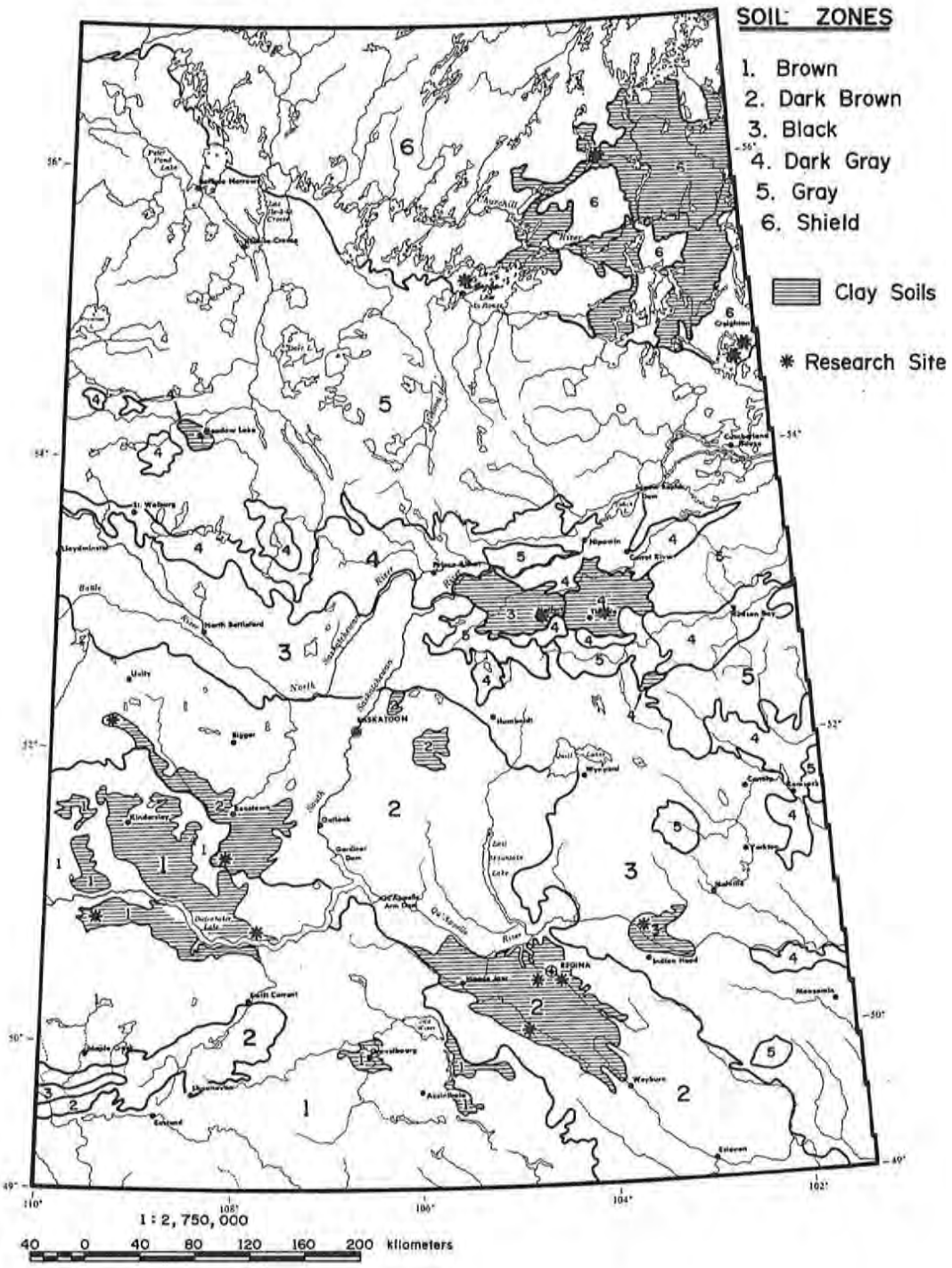


Figure 1. Distribution of clay soils and location of investigation sites in Saskatchewan.

throughout the landscape. When these soils are adequately exposed and carefully examined, especially if they are relatively dry, one can readily see "tonguing" of the A horizon extending 40 - 60 cm or more into the subsoils. These layers are usually lime-free and have a weak, cyclic pattern. The subsoils have a very coarse prismatic structure in the upper part. Starting at 50 or 60 cm you can see shear planes at angles approaching 60° to the horizontal. These shear planes are grooved or fluted, in other words, represent classical slickensides. They are most pronounced at depths of 60 - 100 cm, become more indistinct below this and disappear at approxiately 150 cm. It is possible to find organic matter that has fallen along cracks and roots that extend to this same depth.

The thickness of the material affected by pedoturbation varies. On gentle slopes it varies from 100 to 150 cm. It may be somewhat thicker in depressional areas (and may contain an apparent buried surface) and thinner on steeper, eroded slopes. The subsoil material below the zone of cracking and slickensides is usually varved or laminated. Salts, especially gypsum, are often present in the lower part of the slickensides zone and just below it.

Under more humid environmental conditions such as occur associated with Black soils formed under grasslands the same morphology prevails, however, surface colors are darker and higher in organic matter, reflecting the zonal differences. Under mixed, wooded boreal environments associated with Dark Gray soils there is some weak indication of leaching of salts and carbonates and even lessivage, although prominent slickensides are still present from 50 to 130 cm, at least when cultivated. Finally, under cooler boreal environments where moisture defi-cits are only ≈ 100 mm, there is obvious leaching and lessivation. However, under virgin conditions, there do not appear to be any slickensides, although vertical cracking is still readily apparent.

When salts are present in the parent material it is possible to have solonetzic soil formation and still have strong slidensides below.

Chemical and Physical Properties

Chemical and physical properties of soils from the Brown or Dark Brown, Black, Dark Gray and Gray zones are presented in Tables 1 and 2.

It should be noted that: 1) clay content usually exceeds 50%, 2) organic matter is highest at the surface, decreasing gradually to a depth of 60 - 80 cm in grasslands but only 35 - 45 cm in forest, 3) pH is slightly alkaline throughout in grassland but slightly acid near the surface and alkaline at depths under forest, 4) there is a slight increase in carbonates and a marked increase in soluble salts with depth in grassland soils, coinciding with the break in organic matter. Under forest, the carbonate removal is more marked.

Micromorphological Properties

Micromorphological analysis quite clearly indicates that: 1) Pedoturbation has completely destroyed the geological structure in the upper

50 cm and appreciably altered this structure thoughout the slickenside zone of grassland soils. Under forested conditions this alteration of geological structure is much less severe. 2) Mixing of granular material from the surface into subsurface layers is obvious in grassland soils. 3) A masepic microfabric, characteristic of vertisols and presumed to be formed by shear pressures is apparent in arid grassland soils, becoming stronger in subhumid grasslands and cultivated forest soils. These fabrics are not as common under virgin forest conditions. 4) Argillans may be observed in the upper part of the solum in association with lessivation or solodization.

Horizon Designations

The most basic classification problem in these soils relates to horizon designations, especially as it relates to the separation of the solum from the C horizon. Considering the development of prismatic structure, increase in organic matter, decrease in salts and carbonates the solum should extend to at least 60 - 80 cm and micromorphological considerations would suggest it extend to 100 - 120 cm with a transition from solum to C horizon beneath this. Considering everything that effervesces to be C horizon, as we have traditionally done in Saskatchewan appears to be a lack of appreciation of the degree of alteration of these materials by soil formation.

Accepting the above, it then becomes a question of whether this solum is A horizon or AC transition or whether part of it should be considered B horizon. One must weigh the "in situ accumulation of organic matter" (for it to be an A horizon) against the development of soil structure or by a change in color, to be a B horizon.

Color criteria are difficult to utilize, especially in the more arid grasslands in that the clay portion of the varves in the parent material are dark colored, typically 2.5Y 3/2M with lighter-colored siltier portions 2.5Y 5/3M. When this is mixed the color lightens only to about 2.5Y 3.5/2M. This means then, to meet the color criteria of an Ah horizon, the color should be 2.5Y 2.5/2 or darker. The Brown and Dark Brown soils fail to do this, so from a color standpoint are not Ah horizons. For the same reason, they do not have a Chernozemic A. The Black and Dark Gray soils have moist values of 2.5 or lower so they quality as Ah and Chernozemic A horizons color-wise. In that these horizons; especially those at or near the surface have 0.5% more organic carbon than the 1C they qualify as Ah horizons.

Accepting that the surface horizon is an Ah (perhaps a Chernozemic A) it then becomes a question of how deep the A horizon extends. Once again, color is of marginal value in resolving this question. Organic C values, however, suggest that the A horizon may not extend beyond 10 - 20 cm in some soils but may reach 60 or 80 cm in others.

Structure from the standpoint of an A or B horizon is perhaps even more difficult to assess than color. When these soils dry, it is possible to see good prismatic structure but when they are moist their structure is massive. Considering the fact that they do have prismatic structure, that organic carbon although elevated over the C is below or

barely meets the requirements of an Ah horizon and are not untypical of any B horizons, and the elevated chromas over the C horizon tend to support the contention of a B horizon. The prismatic structure weakens considerably below 50 cm but in this layer there is strong coarse angular blocky structure created by shearing. Microfabric analysis confirms that geologic structure is often disrupted and sometimes destroyed completely in this layer. As such, these layers meet the criteria of a Bm horizon requiring a change in structure from that of the original material although perhaps not for the reasons given (oxidation, hydrolysis, solution).

Finally, at a cursory glance at the definition of a U horizon one could argue that these soils qualify on the basis that these are horizons markedly disrupted by physical processes other than cryoturbation.

Classification

At the present time most clay soils in Saskatchewan are classified as one of the Rego subgroups of the Chernozemic Order, although some have also been classified in the orthic subgroup. It is indicated in C.S.S.C. that Rego and orthic subgroups may have grumic features and that "Grumic families of the Chernozemic, Solonetzic, and Regosolic Orders are known to occur." The closest there is to describing grumic in C.S.S.C. is "very fine textured soils with transitional A and B self-mulching horizons and a granular, mulched layer at the surface."

The first problem with the present system is the lack of description or definition of the properties of a grumic soil. Alluding to a granular surface helps but certainly "self-mulching" does nothing but imply genesis. Also, there is no mention of slickensides as a criteria for classification of these soils.

A second problem, in the eyes of some, is that processes associated with shrinking and swelling are sufficiently strong, at least in semi-arid regions, to subdue or mask "normal" soil development processes of the region. The logical extension of this argument is that these soils should be classified differently from the "normal" soils at a high categorical level. Only where environments for soil formation are more humid or where there are sufficient salts present initially do soils with a strong resemblance to Chernozemic, Solonetzic or Luvisolic soils prevail.

Recommendations

THAT A COMMITTEE with strategic representation from provinces with appreciable areas of clay soils be established to consider the classifications of clay soils, in general, and at least include consideration of the following recommendations:

1) THAT the use of the u lower case suffix be examined and clarified as necessary as it relates to grumic soils.

2) IF grumic horizons are to be designated with established lower case suffices such as h, m k, u, etc., that a diagnostic horizon be developed to facilitate their more precise classification.

3) THAT the appropriate level of consideration of grumic soils be closely examined. As it now stands, these soils are to be "recognized taxonomically at either the family or series level. They may be indicated also as phases of subgroups, great groups or orders". The resolution of this question must consider the fact that there are soils that meet the criteria of Solonetzic, Chernozemic and perhaps even Luvisolic, Regosolic or Gleysolic soils that have slickensides, perhaps as accessory features. (This was a revelation to Dr. Wilding.)

   There are also soils where slickensides per se are no stronger in terms of absolute measure than those mentioned above but which may play a relatively greater role in the formation of these soils. As such, it may be necessary to establish classes where pedoturbation features predomoniate and other classes where pedoturbation features are of secondary importance.

4) THIS committee develop a close working relationship with the ICOMERT to foster the development of an "international" soil taxonomy.

Table 1. Chemical and physical characteristics of representative Saskatchewan soils.

Sites and Horizons	Depth (cm)	Color (dry)#	Particle Size Distribution					Organic C	$CaCO_3$ Equiv.	pH paste	EC $dS.m^{-1}$	CEC	Extractable Cations		
			Sand	Silt	Clay	Fine Clay	CDB-Fe						Ca^{2+}	Mg^{2+}	Ca/Mg
			---%---					---$g.kg^{-1}$---					---$cmol(+).kg^{-1}$---		
Regina 1															
Apk	0- 20	2.5Y 5/2	1	24	75	51	7.9	16.2	41	7.7	1.0	49.5	36.2	12.9	2.8
Ak1	20- 40	2.5Y 5/2	2	23	76	34	7.9	12.3	59	7.9	0.4	49.6	32.9	18.5	1.8
Ak2	40- 62	2.5Y 5/2	1	13	85	49	7.8	9.8	74	8.0	0.5	43.9	28.5	20.5	1.4
Ak3	62- 88	2.5Y 5/2	2	27	71	44	7.6	8.0	67	8.0	0.7	37.5	25.7	18.1	1.4
Ask1	88-113	2.5Y 5/2	2	39	59	37	8.3	6.2	73	7.7	3.2	35.0	24.9	14.7	1.7
Ask2	113-135	2.5Y 5/2	1	23	75	50	10.2	6.7	66	7.7	4.2	36.3	26.4	15.1	1.8
ACsk	135-160	2.5Y 5/3	1	23	76	35	12.0	6.8	64	7.7	4.2	37.3	27.4	13.6	2.0
Csk	160-240	2.5Y 5/3	1	23	76	34	11.8	6.7	61	7.6	4.1	36.9	23.4	12.5	1.9
Leader															
Apk	0- 10		12.4	41.6	46.0	24.3	5.4	15.8	16	7.7	0.5	30.6	23.9	8.0	
Ahk1	10- 35		8.0	39.3	52.7	32.9	6.1	8.3	81	7.8	0.5	29.1	22.1	14.2	
Ahk2	35- 60		6.6	37.6	55.8	36.6	8.8	6.7	75	8.0	0.6	29.7	19.0	18.0	
Ahk3	60-100		2.3	30.6	67.1	32.0	10.2	6.6	60	8.0	1.4	35.1	19.6	19.8	
Acks	100-115		0.5	28.1	71.3	30.8	11.0	7.0	40	7.8	5.3	35.8	22.8	17.8	
Ck	115-150		0.1	32.6	67.4	28.9	11.7	6.6	42	7.7	5.3	33.1	21.4	17.0	

Munsell notation

Table 1, Cont'd.

Sites and Horizons	Depth (cm)	Color (dry)#	Particle Size Distribution				Organic C	$CaCO_3$ Equiv.	pH paste	EC $dS.m^{-1}$	CEC	Extractable Cations		
			Sand	Silt	Clay	Fine Clay						Ca^{2+}	Mg^{2+}	Ca/Mg
			%				$g.kg^{-1}$					$cmol(+).kg^{-1}$		
Indian Head														
Apk	0- 16	2.5Y 5/2	1.0	34.0	65	-	20.4	45	7.6	0.6	41.6	-	-	-
Ck1	16- 40	2.5Y 5/2	0.8	33.2	66	-	8.8	114	7.8	0.4	34.1	-	-	-
Ck2	40- 70	2.5Y 4.5/2	0.7	34.3	65	-	8.0	106	7.7	0.4	35.0	-	-	-
Ck3	70-100	2.5Y 5/2	0.2	30.8	69	-	7.5	86	7.7	1.0	34.7	-	-	-
Ck4	100-130	2.5Y 5/2	-	-	-	-	5.9	76	7.7	3.1	26.0	-	-	-
Csk5	130-175	2.5Y 5/2	0.5	29.5	70	-	4.2	114	7.5	3.5	23.6	-	-	-
Csk6	175-218	2.5Y 6/2	0.1	10.9	89	-	-	44	7.4	3.2	35.0	-	-	-
Melfort														
Ap	0- 17		7.1	43.3	49.6	28.7	50.7	4	5.5	0.4	41.1	18.6	12.4	
Bt1	17- 38		4.6	34.5	61.0	41.5	17.8	7	6.6	0.7	37.2	11.5	27.0	
Bt2	38- 65		3.3	31.1	65.6	41.2	10.9	16	7.5	2.5	35.8	13.7	26.4	
Cksa	65-105		1.9	19.1	79.0	47.1	7.9	48	7.6	7.0	33.4	16.4	26.0	
Cks	105-140		0.7	17.6	81.7	37.1	6.0	45	7.6	7.4	35.4	16.0	25.8	
Tisdale														
Ap	0- 10		7.7	36.0	56.3	33.5	54.0	7	5.8	0.5	45.6	28.3	10.4	
A1	10- 35		4.0	21.9	74.1	49.3	17.7	-	5.2	0.7	42.6	17.8	16.3	
A2	35- 80		5.6	25.4	69.0	46.4	15.2	2	6.5	0.7	38.8	19.1	19.5	
Ac	80-130		1.2	23.5	75.4	40.9	8.2	65	7.4	5.4	33.5	17.3	19.6	
Cks	130-165		0.0	21.6	78.3	36.5	9.1	51	7.4	5.6	34.0	16.4	20.1	

Munsell notation

Table 1, Cont'd.

Sites and Horizons	Depth (cm)	Color (dry)#	Particle Size Distribution				Organic C	$CaCO_3$ Equiv.	pH paste	EC $dS.m^{-1}$	CEC	Extractable Cations		
			Sand	Silt	Clay	Fine Clay						Ca^{2+}	Mg^{2+}	Ca/Mg
			%				$g.kg^{-1}$					$cmol(+).kg^{-1}$		
Nistum														
Lh	5- 0		-	-	-	-	434.2	9	-	-	91.9	-	-	
Ae	0- 15		13.5	22.7	63.8	23.0	15.5	7	4.8	0.3	31.2	4.4	11.7	
Bt	15- 45		3.6	16.7	79.7	35.4	8.6	7	5.3	0.4	38.2	6.1	24.4	
BC	45- 63		0.7	17.5	81.9	31.0	3.9	37	7.2	0.5	33.7	7.0	26.5	
Ck1	63-105		0.6	21.3	78.2	27.6	3.5	87	7.8	0.7	26.2	8.4	21.5	
Ck2	105-140		0.5	18.9	80.6	29.5	4.0	76	7.9	0.8	25.4	6.7	22.8	

Munsell notation

REPORT OF THE CanSIS-COMPUTER WORKING GROUP TO THE EXPERT COMMITTEE ON SOIL SURVEY

November 28, 1984

by K. Bruce MacDonald

(i) Review of the 1983 working group report

The report presented to the ECSS raised a number of questions which remain to be addressed.
-Is the current composition of the CanSIS working group correct and adequate? I would suggest that it requires more user input but that this will evolve over time.

-Within the national files what level of acuracy and reliability is acceptable and/or desirable? How is it to be achieved and maintained?

-What are national files and what purposes should they serve? The discussion of the CanSIS-computer working group identified such applications as the data base associated with the Generalized Soil Landscape Maps, Land Evaluation activities and Crop Modelling for national and broad regional assessments of crop potential.

-Is the current policy (that the data in CanSIS files is fully available and accessible) an acceptable one? How will it be handled when regional units develop and manage their own data bases?

-What are the appropriate schedules for data submission to the national files? What should be the frequency and timing of the updates to the on-line RAPID relations?

These questions remain with the group to be addressed in a gradual fashion over the next few years of operation.

(ii) Working group terms of reference

The name of the working group was changed to the CanSIS-Computer Working Group and the terms of reference were broadened to include local (regional) activities as well as the Ottawa based ones.

(iii) CanSIS (Ottawa) activities '83-'84

Activities of the CanSIS project in Ottawa are reported to all unit heads through the notes of the CanSIS subsystem meetings. These notes are our planning guide and should serve to indicate directions and progress. Comments are welcome at any time.

As local edp applications develop there will be a continuing

series of problems in communications and access to procedures of mutual interest. In an attempt to formalize communication, the Working Group representative from each unit has been asked to summarize computerized applications developed in his unit. It was the concensus of the working group that these summaries be compiled as a Compendium of Applications which would be distributed to all units and updated twice yearly.

Loceus Consultants have reviewed the projects related to data handling in LRRI and the Lands Directorate. Thier report has been submitted recommending areas for common planning and development and emphasizing the importance of providing regional capability.

Development and testing continues on the Collins and Moon Stand-alone Digitizing Work Station for Ottawa with plans to implement similar stations in Winnipeg and Saskatoon in the '84-'85 fiscal year.

Development activities on the mainframe cartographic system were designed to increase the allowable number of map symbols (this has been achieved) and to increase the dimensions of maps which can be input (this has not been done and will not likely be developed).

Last year the conversion of the data in Detail II to RAPID relations including a monitoring relation was reported. Development has proceeded to generate some 12 report modules for output from this format. This is leading to prototype new versions of the profile report. These new profile reports will be available both in paper form and machine readable format.

The Soil Names file has been revised to include English and French reports. Current schedules call for a 'roll-over' of data every 2 years. In my opinion it is questionable whether this is frequent enough to make this file useful.

The General CanSIS User's Manual is in printing in English and French.

A draft edp policy for LRRI has been prepared.

Training on an intensive 1-2 week program has been provided on request.

Microcomputer procedures to manage data collected under

contract in Nova Scotia have been developed and tested.

Next year's activities include completion of the testing of the Stand-alone Digitizing Work Stations and full implementation of the stations which have been purchased. An evaluation will be carried out of the mainframe cartographic software with a view to updating it or transferring the data to other commercially supported cartographic packages. The Land Potential Data Base will be reviewed and updated.

Charles Tarnocai has been appointed to the Institute edp committee to act as liaison for the soil survey personnel and to compile and coordinate edp related equipment needs.

(iv) Workshop activities

The workshop reviewed computer-based applications across Canada. It is apparent that within one year 4 groups operating independently have developed significant micro-based data handling capability specifically tailored to soil survey applications:
Dave Moon -Hand held and field/office micros

Jeff Grueul/Mike Schweiger -Lab analysis functions, daily file management, family particle size calculations

Louise Boardman/Bruce MacDonald - Nova Scotia contract project

Michel Nolin - Manipulation of Soil Series and Polygon Data

A committee led by D. E. Moon supported by Louise Boardman Jeff Grueul and Bruce MacDonald is developing benchmark standards for DBMS's for regional general purpose micros. A list of mandatory and desirable properties have been compiled and 4 possible packages rated. The recommendations will go the the LRRI edp committee.

(v) Actions and recommendations of the working group

Concensus of the CanSIS-Computer working group that standardization of general purpose micro applications is a desirable goal to avoid duplication of effort, to allow ready communication of data and procedures and personnel and facilitate support.

Recommended to ECSS that the role of members of the

CanSIS-Computer working group be recognized as being broader than simply the ECSS activities. That it include a STRONG LIAISON component both between regions and nationally and that this role be recognized in the work plans of the group members.

Recommended to ECSS that the developing role of edp correlation be recognized and supported. This function includes a normal correlation and standardization function but in addition it encompasses a strong technical support activity.

Recommended to ECSS that the full implementation of computer plans may require (i) intensive support for implementation and development of (micro) computer capability for personnel outside the units (ii) ongoing support from processing, digitizing and data maintenance once the system is in place. The first requirement can possibly be met by existing key personnel in active regions if travel funds are available and ad hoc modifications to work plans are possible. The second requires designation at the unit level of appropriste personnel for the level of computer activity. Charles Tarnocai has made a preliminary assessment of this requirement.

Future plans call for the implementation of additional stand-alone digitizing work stations in the units. Implied in this plan and other plans involving computerized procedures is the requirement in the region to accomodate the overheads in terms of space, dollars, personnel (not only in py but also in terms of levels of expertise).

(vi) Future working group activities

The working group will prepare section 702 of the Handbook. It will include in part the guidelines and standard procedures for information transfer, identify and describe concepts and broad guidelines of computerized data handling, describe existing capabilities, and include developing areas of concern.

The CanSIS Ottawa personnel with assistance from correlation and regional staff will review and critically evaluate the existing files of CanSIS to develop a clear statement of specification for data to be input, format, and content. This assessment will be presented to the working group with specific recommendations to modify or restructure the Soil Data (Detail) file and consider the utility of a soil property and/or polygon file.

SOME CURRENT APPLICATIONS OF MICROCOMPUTERS TO SOIL SURVEY

D. E. Moon
(Land Resource Research Institute, Agriculture Canada)

This report will address the work done while I was on secondment to the Land Evaluation group in Ottawa. The tasks which were completed include:

1) an evaluation of microcomputer hardware and software specifications for hand-held microcomputers to be used for field data collection, specifications for portable microcomputers to be used in a field office, and specifications for a desk top general purpose microcomputer,

2) an evaluation of data management needs and requirements for soil survey, an evaluation of a number of existing commercial packages, and the recommendation of a package for general use, and

3) the development of procedures for the application of microcomputers to the problem of routine soil survey data management and evaluation during the course of a survey.

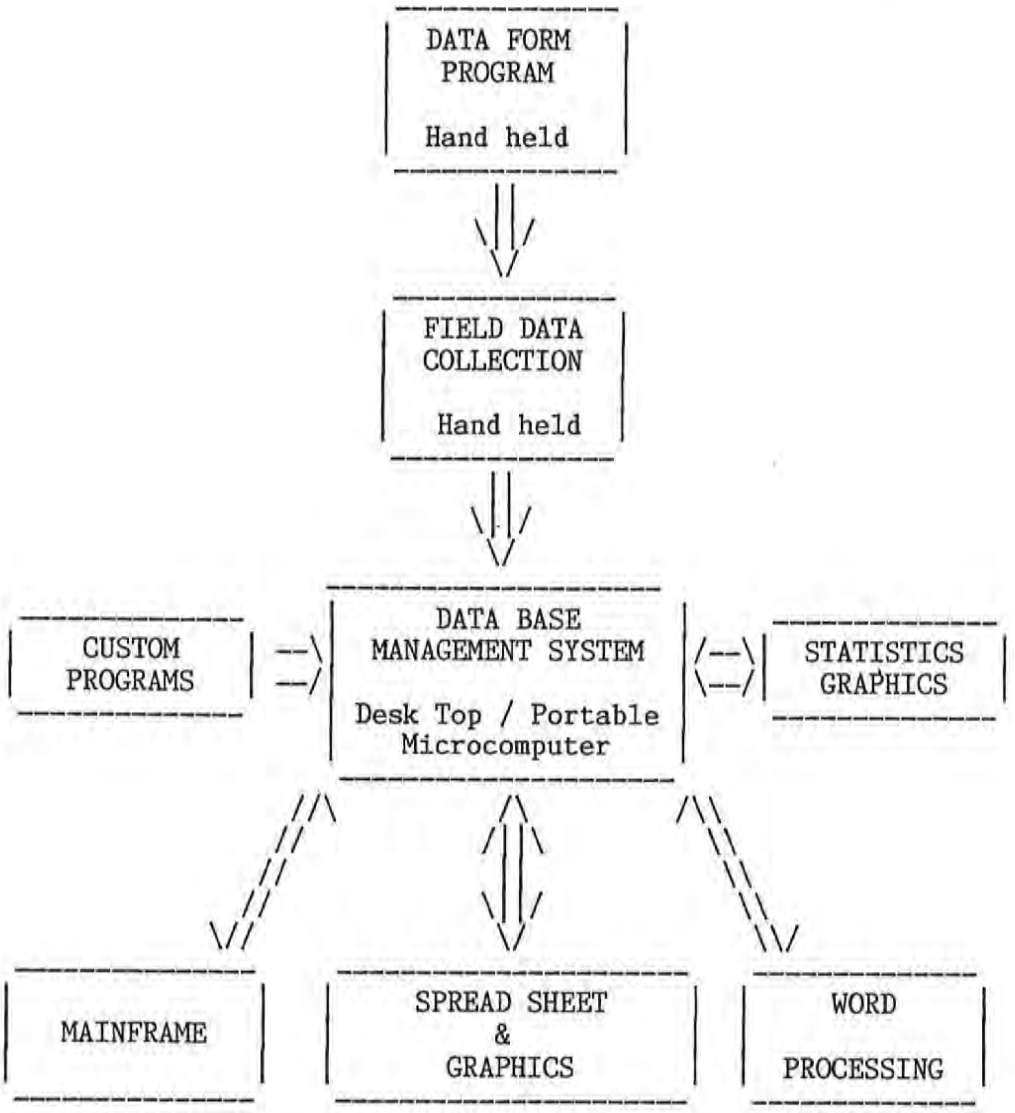
This report will address only the last task. Task 2 was discussed during the CanSIS meetings and the report is presented elsewhere in these proceedings. Task 1 resulted in a report titled "An Evaluation of Microcomputers for Applications in Soil Survey" which is available on request.

The availability of handheld, portable, and desktop microcomputers has made possible immediate access to soil survey data. This means that a surveyor can use data, as he collects it, to help in the definition of soil classes, map units, sampling strategies, and sampling intensities. To take advantage of this capability, procedures have been developed to make soil survey field data immediately available for computer assisted analysis by recording data on a hand held computer in the field. Data is transferred directly to a transportable desktop microcomputer supporting a commercial data-base management package. The data base management system is linked to a number of other commercial software packages to provide graphics, statistically defined confidence limits, and numbers of samples necessary to meet specified confidence limits. In addition, the microcomputer can exchange data with other microcomputers or mainframe systems either directly or via a telecommunications network. Figure 1 presents the components of the package as a flow diagram. Details on the procedures are presented below.

Field Data Collection

There are two major advantages to collecting data in machine readable form. The first, immediate access to data, has already been mentioned, the second is the reduction of data transcription errors. Significant as these

Figure 1. The components of a field oriented data base management and evaluation package for soil survey.



errors may be, the recording of incorrect data in the field cannot be rectified once the surveyor has left the field. Because of this it was considered essential to allow for the editing and correction of data before leaving the site of data collection. This requirement has influenced both the design of the data collection program and the choice of a field computer.

The choice of a field computer presented a problem. At the present time I know of no system which will fully answer all of our needs. Some of

the features which were considered essential are:

1) multiple line display - The review and editing of data is based in large part on pattern recognition, that is the expectation that specific ranges of values or features will occur in specific places on a form. To take advantage of this fact requires more than a single line of display on the field data collection machine. I felt that a 40 character by 8 line display would provide the minimum display size necessary.

2) a minimum of 28 Kilobytes of storage - The computer must have the capacity to both store the program used to collect and check the data and store enough data to allow for at least a day's worth of data collection before transferring the data to magnetic tape or another computer.

3) a full feature keyboard - much of the soils data collected is descriptive. The probability of entry errors when using non-connotative numeric symbols is high and the probability of catching errors when editing non-connotative symbols is low. For this reason I felt that easy entry of both numeric and character data was essential.

4) field durability - the computer must be able to stand up to the rigours of field work. Ideally it should be water proof, shock proof, and abuse proof.

5) office application - the field season is a relatively short period for most of us and it would be nice if the field computer could also function as a highly portable individual work station in the office.

Since at the time this project was undertaken I could not find a machine which would meet all of these requirements I chose to develop applications on the machine which came closest to meeting what I felt were the most important features. The Radio Shack met all of the minimum requirements with the exception of field durability and was priced at approximately 1/5 that of the available field durable models. None of the field durable models I looked at met the requirements for full feature keyboards or display size. If treated with the same degree of respect as a good camera and used in a protective case, the Radio Shack will, I believe, provide a viable interim solution.

At the time of writing this report a prototype of the data collection program has been field tested on the Radio Shack Model 100. The results indicated some problems associated with both the software and the hardware. The software problems were primarily associated with having to enter the data in a fixed sequence when the data is not necessarily found in that sequence when sampling with an auger. This problem has been resolved. Field data entry is done using either, multiple page screen forms in which data can be entered in any order or, in response to a specific sequence of prompts for data. The program checks for null entries, appropriate data type, field length (it rejects fields which are too long and pads fields which are shorter than the maximum allowed if

fixed format storage is required), and for upper and lower case consistency. Errors in these checks result in a beep and the issuing of a message identifying the nature of the error followed by a prompt identifying the data field to be re-entered. On completion of data entry when following prompts, or at any time when using screen form entry, the data can be reviewed and changed if necessary using the screen forms.

The data may be stored on cassette tape or it can be transferred to a microcomputer, a minicomputer, or a mainframe computer. Data transfer to another computer can be done with either a direct serial connector or by telephone and storage to magnetic tape can be done in the field. The problem of field durability is yet to be resolved. While the Model 100 can be used effectively in good weather, it will require the design of a protective case to be confidently used under adverse weather conditions.

Data Form Program

It is was obvious, from the array of daily data forms currently being used in Canada, that some method of quickly writing a program to run a hand held microcomputer as a field data collection device was essential. It needed to be flexible enough to handle varying sizes and types of data. In an attempt to meet this need a program, which writes programs to run the Radio Shack Model 100 as a field data collection device has been written.

This program writer currently runs on any Microsoft BasicA system but I expect to have it running on the Radio Shack Model 100 by this field season. It is largely self explanatory and prompts the user for the information required to produce a variety of specific data forms. It prompts for information on each data field, the size of field, the data type (eg. numeric or alpha numeric), and instructions in the form of directions or specific prompts to be issued during data collection. It automatically replicates fields for horizon data and allows for data entry as sequential prompts or as screen forms in which data can be entered in any order. In addition it writes the code necessary to display user defined screen forms and it allows the user to specify the format in which the data is to be stored prior to uploading to a larger system.

Field Office Applications

Applications of portable microcomputers to use in the field office have also been developed. The data is loaded directly into a data base management system (DBMS). The Aladin (A.D.I. America) DBMS was selected because of its ease of use for ad hoc retrievals and because it allows the incorporation of sophisticated custom programs as executable utilities within the DBMS structure. All operations are performed using a series of menus and user defined screen forms (an example of the form associated with the map delineation file for the Power River resource inventory is presented in Figure 2). The last line of the display shows the functions that the DBMS will perform if the corresponding numbered key on the keyboard is pressed. These functions change as different procedures are followed but they show the user what options are available at any given time. Some of the features of the DBMS are presented below.

Figure 2: Screen form for the map delineation file on the Power River inventory. Quineex has been entered at position S1 to select delineations in which the dominant soil is Quineex.

```
POWER.MAP Delineations  (CON:,CON:)  (---)                    Data.View
==============================================================================
                                    MAP UNIT:
                                    _____
 POLYGON: __                                                  HECTARES: ...
 LINKAGE: _____                                                  ACRES: ...

                1  DOMINANT:          2  SUBDOMINANT:        3  MINOR:
 VEGETATION:   V1: ____________       V2: ____________       V3: ____________
 SOIL:         S1:>Quineex            S2: ________           S3: ________

 SURFACE FEATURES: _______    VERIFICATION: ..........     MANAGMNT AREA: ..

                              INTERPRETATIONS:

 PRODUCTIVITY:   SLIDE HAZARD:   FLOOD HAZARD:   DEBRIS FLOW:   ROAD SEDIMENT:
 _______         .........       ........        ........       ........

            REGEN.LIMTNS:       UNGULATE USE:    RANGE:
            ........            ...........      ....
==============================================================================

1CANCEL2_____3PRINT 4CALC  5_____        6JUMP  7_____8SORT  9FINISH 0FIELD
```

Figure 3: Screen form for the map delineation file on the Power River inventory after selection for the Quineex soil. The entry " 1 : 29 ->S1: Quineex " indicates that this is the first of 29 delineations which have Quineex dominant.

```
POWER.MAP Delineations  (CON:,CON:)  (---)                    Data.View
==============================================================================
                                    MAP UNIT:
                                    Sp/MTF
 POLYGON: 601                                                 HECTARES:   2
 LINKAGE: S01707                                                 ACRES:   5

                1  DOMINANT:          2  SUBDOMINANT:        3  MINOR:
 VEGETATION:   V1: Tiarella           V2:                    V3:
 SOIL:         S1: Quineex            S2: Klaskish           S3:

 SURFACE FEATURES: Channeled   VERIFICATION: Ground        MANAGMNT AREA: 1B

                              INTERPRETATIONS:

 PRODUCTIVITY:   SLIDE HAZARD:   FLOOD HAZARD:   DEBRIS FLOW:   ROAD SEDIMENT:
 Good            None            None            Low            High

            REGEN.LIMTNS:       UNGULATE USE:    RANGE:
            Moderate            Critical         E(W)
==============================================================================
    1 : 29  ->S1: Quineex
1CANCEL2_____3PRINT 4CALC  5_____        6JUMP  7      8SORT  9FINISH 0FIELD
```

Up to 32 files can be addressed at one time and data fields or records are selected by pointing to the field desired and typing the value on which records are to be retrieved. For example, retrieving delineations in which the Quineex soil is dominant requires typing the name Quineex into the field labelled S1 (Figure 2). The first record fitting the requirement is displayed along with the total number of delineations in which Quineex is dominant (Figure 3). Successive records are viewed alphabetically by repeatedly pressing the enter key. Plot data for the Quineex soil is viewed by placing the cursor on the letter "Q" in the name Quineex and pressing the numbered key corresponding to the label JUMP. All of the files currently available are displayed and pressing the number corresponding to the plot data file causes the first Quineex plot in that file to be listed.

Reports are defined by following a series of on screen menus and pointing on the screen form to the fields required. The report is generated by pressing the numbered key corresponding to the label GENERATE. Multiple files can be addressed in constructing the report simply by using the JUMP key to move between files. Sophisticated reports with field headings, column headings, and page headers and footers are also possible. As with most data base management packages calculations, selection criteria, and reports can be saved for future use without having to redefine them. Table 1 shows a report which gets information from two files and amalgamates it, with field headings, into one report.

The Aladin package offers a number of built in features such as univariate statistics, contingency tables, regression, counts, and summations and offers the ability to define different groupings or classes to be used as the basis for calculating the statistics. For statistical procedures not available within the DBMS and for more sophisticated graphics than the DBMS offers, the export of data to statistical programs or graphics programs which also run on the micro computer is straight foreward.

The Lotus 123 (Lotus Development Corp.) integrated software package has been used to demonstrate a custom designed procedure to analyse data for the Power River inventory. It combines fully menu driven graphical display of frequency distributions for the entire data set or for selected soils and the calculation of univariate statistics (Figure 4 is a plotted output of the screen display for a graph of slope frequencies). While the examples used are for a specific inventory the application of the procedures to most inventories is easily accomplished.

While I have not presented all of the procedures developed or adapted to soil survey, I hope that I have demonstrated some of the potential applications that microcomputers have to soil survey. They can dramatically streamline surveys which, during the course of the survey, make use of the data collected to define map units, soils, sampling requirements, and legends. I am neither suggesting that everyone use the specific hardware or software that I have chosen, nor that the approaches to data management and manipulation I am using will be universally applicable. Many of the problems I have had to solve are common to a large number of land resource inventories. If this work, or anyone else's, is

Table 1: Section of a report which combines data from two files to provide data on delineation properties and the soil properties found in the delineations

A09 He/SCS 6 Ha MA: FEATURES: CHECK: Ground

	VEGETATION	SOIL	SLOPE	DTI	DRD	DMOT	TEX-S	HUMUS	DEPTH	EXP-MIN
DOM:	Tsuga	Aanimi	10-35 %	80	200	80	g L	FH-MOR	15	0
SUB:	Thuja	Power	50-80 %	120	120	120	vg SL	FH-Mor	15	20
MIN:										

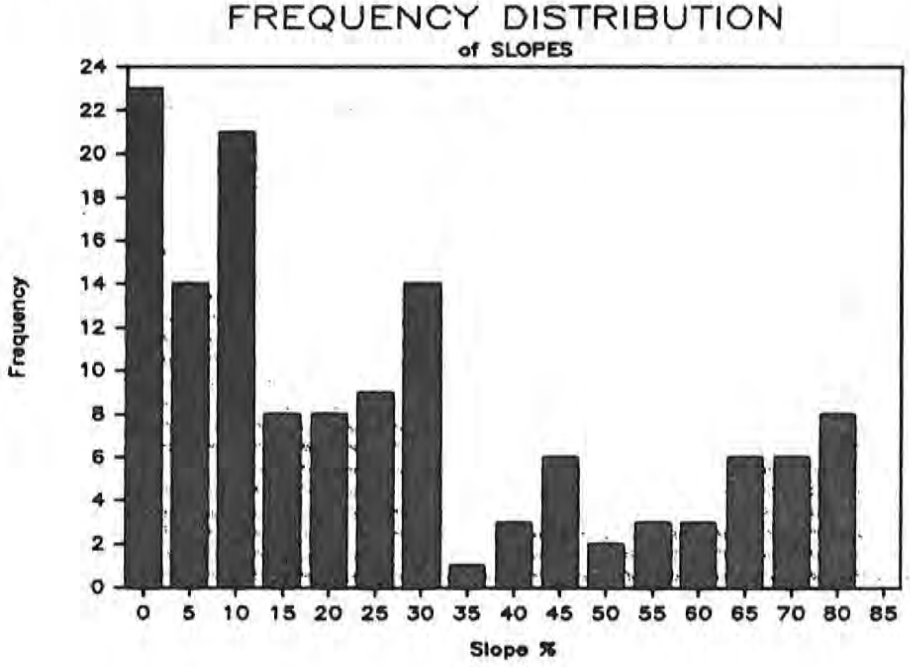
SITE CLASS	REGEN LIMITNS	UNGULATE RANGE	HAZARDS SLIDE	FLOOD	DEBRIS	SEDIMENT
Medium	Moderate	N-Cr	Low	None	Low	High

A12 He/MMB 5 Ha MA: FEATURES: CHECK: Ground

	VEGETATION	SOIL	SLOPE	DTI	DRD	DMOT	TEX-S	HUMUS	DEPTH	EXP-MIN
DOM:	Tsuga	Cuttle	10-50 %	30	40	30	g L	H-Mor	12	0
SUB:	Thuja	Kayumin	20-50 %	80	90	80	vg SL	FH-Mor	15	0
MIN:		Bunsby	0-50 %	5	5	5	g L	FH-Mor	20	0

SITE CLASS	REGEN LIMITNS	UNGULATE RANGE	HAZARDS SLIDE	FLOOD	DEBRIS	SEDIMENT
Poor	Slight	N-Cr	Low	None	Low	Low

Figure 4: A plot of the frequency distribution of slopes measured for the Power River inventory detailed plot data.



applicable to your problem you may find that taking advantage it can save you a lot of needless effort. I have not addressed other kinds of survey projects, office applications, or lab applications but the Ontario Institute of Pedology has demonstrated the value of microcomputers in the management of lab data and I would refer you to them for further information.

I will leave you with a note of caution. Microcomputers are a tool like any other. They can dramatically increase your personal productivity but they require that you learn to use them. You will not learn to do so in a day, you will find them frustrating at first, and you will quickly find that they cannot think for you. You can, in a few days, learn enough to begin using them without a loss in productivity. From that point continued use leads to greater skill and therefore greater productivity. If you rely on data technicians and resident experts to do all of your computer work for you, you will find that the microcomputer provides no more benefit to you than you had from the mainframe. If they become as much a tool as a shovel and auger, we will have unprecedented power to use the data we collect in a timely and effective manner.

SWIG UPDATE - 1984

Progress Report to ECSS for the "Soil Water Investigation Group" (SWIG)

R.G. Eilers

A brief meeting of SWIG members was held Monday evening, Nov. 26, to discuss three main items:

A. Testing and Evaluation of Proposed Water Regime Criteria
B. Integration of SWIG and Soil Taxonomy
C. SWIMM

A. The new criteria for describing soil water regimes is available in the Revised CanSIS Manual for Describing Soils in the Field. This criteria has remained relatively unchanged for the last couple of years. Some provinces have adopted it and are using it in their daily field surveys.

Please note that there were some typographical errors in the criteria as specified in the manual. The corrections are as follows: Please make the necessary changes in your manual.

Hydraulic Conductivity (cm/h) page 35

M - Medium	0.5-15
L2 - Very Slow	0.05-0.15
L1 - Extr. Slow	<0.05

Add: Depth to impeding layers page 37

As was suggested in last year's ECSS proceedings, the members felt that there was an important need to have more flexible classes for persistence of water tables. The second proposal (ECSS, '83) with a slight modification was agreed to and is included here for review and testing.

Persistence classes should be assigned according to a seasonal or annual duration of mean highest water table class. Seasonal is normally understood to refer to the growing season. However, the actual dates for growing seasons are somewhat dependant on crop and geography, i.e. the start and duration of the growing season will differ from the Maritimes to southern Ontario to the prairies and British Columbia. Thus, the date and duration of the growing season will be defined regionally. However, the persistence classes in terms of days should remain unchanged and be applied as follows:

First identify whether your rating pertains to seasonal (S) or annual (A) durations.

Next, select the appropriate number of days according to the following classes:

Symbol	Class	Days (duration of mean high water table within the identified depth class)
S -	Short	2-20
S1	2-10	
S2	10-20	
M -	Medium	20-60
M1	20-40	
M2	40-60	
P -	Prolonged	>60
P1	60-120	
P2	120-240	
P3	>240	

This method of designation provides for two levels of detail in a similar fashion as the depth to water table and the K Sat. classes.

Examples of persistence classes, therefore, would be:

SS - Seasonal	Short	= 2-20 days (in defined growing season)
AS2 - Annual	Short	= 10-20 days(not in growing season)
SM1 - Seasonal	Medium	= 20-40 days
AP2 - Annual	Prolonged	= 120-240 days

Persistence classes identify the number of days that the water table occurs above or within the indicated water table depth class, e.g. H2, SS1 means that the average annual least depth of water table occurs within 50 to 100 cm of ground level for only 2-10 days during the growing season.

B. Regarding the integration of SWIG and Soil Taxonomy - the meeting recommended that the chairmen of the SWIG, Soil Climate, and Soil Taxonomy Working Groups collectively assess the feasibility of such an integration and prepare a proposal as to how and where this integration could be accommodated. This proposal would be presented to all working group members for consideration and review.

C. Revision of SWIMM - It was unanimously agreed that this was a worthwhile project and should proceed as soon as possible.

Monitoring - It is apparent that we must look to a "high tech" approach to monitoring. Monitoring is time consuming. Staffing is becoming very scarce and the returns of data/man-hours spent are very small, as well, data for critical periods are seldom obtained because it is often physically not possible to be at the sites during these periods.

A brief review of some electronic monitoring equipment on the market indicates a very wide range of possibilities. As soil scientists and surveyors we can define the "what, when, why, and where" of monitoring, the "how" is much more difficult and dependent upon technology. I think it would be advantageous for us to develop a monitoring strategy by defining our data requirements. Then perhaps

a consultant should be hired to determine what type of monitoring equipment is available or what modifications to existing equipment might be required to meet our needs. It might even be feasible and cost effective to have some monitoring equipment tailor made to meet our requirements.

GENERAL COMMENT

It was encouraging to see the soil water characterization work being done in New Zealand as described by Steve Smith. It was particularly interesting to note the large number of parallelisms between the Canadian and New Zealand approach in terms of the components, criteria, and field methodologies. New Zealand has adopted a coordinated team approach involving pedologists, soil physists and hydrologists. Together they have embarked on a major program (SWAMP) involving field estimates and measurements to characterize soil water regimes throughout the country. As well as collecting high quality data from major grassland (rangeland) soils, the scientists are promoting and demonstrating their field techniques to other agencies and organizations which are involved in soil and water characterization, mapping and management activities. These activities parallel the objectives established for our SWIG program in Canada. "We must be on the right track".

REPORT OF MAPPING SYSTEM WORKING GROUP

K.W.G. VALENTINE

INTRODUCTION

The working group discussed six topics, some in conjunction with the CanSIS Computer and the Agronomic Interpretations Working Groups. They were:

1. Specifications for general and special purpose surveys.
2. Specifications of Survey Intensity Levels.
3. Survey Procedures for an intensity level 2 survey for agronomy.
4. Minimum Data Sets.
5. Information packaging.
6. Alberta provincial concerns and initiatives in soil mapping.

GENERAL AND SPECIAL PURPOSE SURVEYS.

The working group's job is to suggest soil survey procedures that are fast and cost effective. It appears easier to do this for special purpose surveys than for general purpose surveys. Therefore, the group first attempted to distinguish between a general and a special purpose survey to clarify for what type of survey it was recommending procedures. The distinction is expressed in Table 1.

SPECIFICATIONS FOR SURVEY INTENSITY LEVELS

Specifications for five levels of intensity for soil surveys in Canada were suggested by this Working Group in Table 2 of their 1981 Report. However, correspondence showed that some of them were either inappropriate or impossible

Table 1. The distinction between General and Special Purpose Surveys

General	Special
Do not know in advance most of uses to which survey will be put.	Know purpose of survey in advance.
Many clients will not be known.	Most clients will be known.
Information required about soil types and their attributes, followed by evaluations of those soils for some general types of land use.	Information required about the potential of specific pieces of land for particular type(s) of land use.
Requires collection of standard, or core, data set that may contain numerous properties.	Requires collection of only those properties applicable to evaluations; number of properties may be quite limited.
CanSIS was designed primarily for general purpose survey.	Data handling and storage can be done locally.
Compatability with other surveys is important.	Need not be compatible with other surveys.
Information is often published on small scale maps.	Information is more often published on large scale maps.
Map legends emphasize soil properties.	Legends emphasize evaluations.
Survey designed for long term efficiency, and long term relevance of information.	Survey designed for short term efficiency, and short term relevance of information.
Evaluations often use Capability Classifications.	Evaluations often use Suitability Classifications.

impossible to achieve under Canadian conditions. They obviously had to be revised, and the best way to do so was to ask surveyors how recent surveys had been done. This was done by a questionnaire. Thirty four people replied with information about 53 surveys. Revised specifications were then compiled and are presented in Table 2. One major change is the way surveys are allocated to an intensity level. Previously there was no unequivocal way of doing this. A particular survey would probably not fit exclusively into all the specifications for one intensity level. For instance, the figure for hectares per inspection might fall within the range specified for level 3 whereas the traverse spacing or number of delineations with at least one inspection might be within the ranges specified for levels 2 or 4.

Now an index is proposed using two measures of fieldwork that were answered by every respondent.

- the area represented by one inspection
- the percentage of delineations that had at least one inspeciton.

These two measures, expressing the density and distribution of inspections, are combined into the following index:

$$\frac{A/I}{D}$$

where A = Area of survey (in hectares or acres)

I= Number of inspections in survey

D= Percentage of delineations with at least one inspection

The following index ranges now define each survey intensity level:

Index Range (ha)	Index Range (acres)	Survey Intensity Level
0.04	0.10	1
0.04-0.39	0.10-0.99	2
0.40-3.99	1.0-9.99	3
4.00-39.9	10.0-9.9	4
40.0 and over	100.0 and over	5

Other changes from the specifications published in 1981 are:

-Percentage of delineations with at least one inspection are lower, and the ranges wider for each SIL.

-Proportion of total boundary length checked in the field is reduced, especially for intensive surveys.

-Traverses are spaced at closer intervals, and specifications for inspection spacing along traverses have been added.

-Rates of progress are slower at SIL 1 and 2, about the same at SIL 3, and faster at SIL 4 and 5

-There is now no distinction between definitive specifications for intensity level and characteristics associated with intensity level that has appeared in previous tables. The SIL index now defines intensity level and all other information is descriptive.

-Descriptive names have been given to each level. They can be used instead of the SIL number to describe a survey in our publications

A paper containing more discussion of the results has been submitted for publication to the Canadian Journal of Soil Science.

PROCEDURES FOR AN INTENSITY LEVEL 2 SURVEY FOR AGRICULTURE

In the past, the Working Group has discussed aspects of survey in isolation; intensity level separate from design, minimum data sets separate from methods of presentation. Some members felt it was time to discuss all aspects for one type of survey. An SIL 2 survey for agriculture seemed the most logical to deal with,because most of us have had some experience with such a survey.
Brief descriptions of three surveys were given as examples to start the discussion. Then the Working Group began to compile a list of topics that would be described in any specifications for such surveys. It was impossible, in the time allotted, to be very specific. Therefore, only the three examples are given on the following pages. Actual recommended specifications must wait for a subsequent Working Group Progress Report.

NOVA SCOTIA CONTRACT SURVEY: D. Holmstrom

Objectives:
- to discover and map relevant soil properties and their classes.
- to determine soil suitability for various crops; development of agricultural policy, and for general farm and land use planning.

Properties and Attributes (site data):
- major horizons: depth (cms), texture (12 classes), consistence (5 classes) and volume of coarse fragment (%).
- slope (%)
- stoniness (6 classes)
- drainage (6 classes)
- water transmissibility of sublayer (11 classes) and loose layer (3 classes).
- mode of deposition (15 classes)
- depth to pore discontinuity (cms) and layer type (8 classes)
- bedrock type (14 classes)
- Soil unit code and variant.

Design:
- pretype 1:10,000 black and white aerial photographs
- select 10 reconnaissance transects (10 sites per transect) which intercept the maximum number of delineations and run perpendicular to the landform.
- select 50 sites to confirm mapped delineations or delineations with no site verification.
- submit map sheet for correlation, approval and verification.
- select 10 delineation transects (10 sites per transect) which run within a map unit and run perpendicular to the landform.

Presentation:
- pamphlet design similar to CLI Soil Capability for Agriculture 1: 1,000,000 series. Maps would be presented at a 1:20,000 scale.

Client Liason:
- Ongoing. Initial contact has been made with county planners, agricultural representatives and provincial soil and crop extension personnel.

SIL2 SOIL SURVEY OF WESTBOURNE R.M., MANITOBA: M. LANGMAN

Purpose , Objectives: to provide requested soil information to the Municipal Planning Branch, Dept. of Municipal Affairs for planning and tax assessment.
- to map and classify soils (series, phases) in portions of Westbourne, R.M.
- from data, prepare interpretations for dryland agriculture capability, dryland irrigation suitability, selected engineering (10 uses) and recreational (5 uses) interpretations and soil hazards (erosion, salinity).

Survey Design: - initial planning included completion of 'Project Plan'
- project size determined by request of originator submitted to Soil Survey Advisory Board
- SIL determined by user requirements and survey staff assessment of level of soil information required to meet needs based on soil complexity, manpower, etc.
- legend developed from existing legend in SIL3 survey of area and from SIL2 legends in adjoining areas - publication legend is uncontrolled
- grid mapping method used (developed and tested in Manitoba in early 60's) 100-150 m inspection interval along pre-selected traverses spaced at 0.8 km
- additional inspections along road allowances (0.4 km interval) and sites selected for specific information (11.7 ha per inspec-inspection density)
- exact location of site to represent local soil landscape dominant nature

Properties: - (recorded at most observation sites)
- soil climate (2 subregions)
- drainage (3 drainage groups from 7 classes)
- dominant profile texture (7 textural groups from 23 classes)
- mode of deposition (7 classes)
- depth to contrasting layers (3 depth groups)
- buried horizons (yes , no)
- additional horizon features - a) color (O.M.%); b) depth, thickness; c) texture (23 classes); d) carbonates (yes, no, 3 classes C-hor); e) mottles; f) structure; g) concretions , nodules; h) salts (yes , no); i) clay films
- organic soils - a) degree of decomposition; b) thickness
- soil-landscape phases - a) erosion (5 wind and 6 water erosion classes); b) stoniness (6 classes); c) rockiness; d) slope (6 classes, aspect, position, length); e) salinity (4 classes)
- additional features - a) land use; b) man-made modifications; c) vegetation d) rooting depth; e) water table; f) landform
- Taxonomy - (4 orders - 9 subgroups - 41 series - phases)
-Location (NTS, Easting, Northing)

EAST COAST VANCOUVER ISLAND SOIL SURVEY: J. Jungen

Objective:
The mapping of soils and agriculture capability at a scale of 1:20,000 for regional and municipal planning, refining Agriculture Land Reserve boundaries, corridor development and resource planning, assessment and management.

Intensity Level and Scale
Level 2; Published scale is 1:20,000.

Method of Field Checking
- Traverses on foot or by vehicle where possible. Location of sites determined by surveyor (free survey).
- Approximately 9 - 15 ha per inspeciton
- Inspections usually 1 m depth
- One or more inspections per polygon

Main Parameters Recorded
- Aspect; Slope; Elevation; Terrain Classification; Soil Classification; Site position macro and meso; Site surface shape; Microtopography; Soil Temperature class; Perviousness; Flood Hazard; Depth to (i) water table, (ii) effective rooting, (iii) root restricting layer, (iv) bedrock; Brief Horizon description with depths; Coarse Fragment Description (sieved); Soil Texture: Cementation: Agriculture Capability for site; special comments on site.
Other items such as project identification, plot numbers, date, latitude-longitude, U.T.M. and photo numbers, etc. are also identified.

Sampling
1. Numerous 'grab' samples are taken for checks on texture, % C, pyro. Fe and Al, rubbed fibre, etc.
2. All named soils are sampled in detail at least once - more frequently for soils occupying a significant area.

Rate of Progress
Approximately 1050 ha/month/crew (1 pedologist and assistant)

Reliability
- estimated at 90%
- the coordinator checks some units and boundaries independently
- On site inspections by B.C. Land Commission staff while checking specific properties.
* Note this aspect is weak since we can never seem to find the time required to carry out an effective reliability check on our mapping.

Cost
$9, hectare (1984)

Computerization
1. BCSIS (British Columbia Soil Information System)
All soil site information is entered into this data bank.
2. CAPAMP (Computer Assisted Planning and Map Production)
a) Polygon File - All polygon related information is entered into this file.
b) Cartographic File - Modal soil parameter for each soil and soil phase are entered into this file.
3. Agriculture Capability File - Agriculture capability ratings including generalized present land use are in this file.
The polygon information is combined with cartographic data to produce derivative maps.
Algorithms have been written to produce the following derivatives and report summaries:
1. Soil Map
2. Agriculture Capability Map
3. Enhanced Agriculture Capability Map
4. Present Land Use.
5. Agricultural Soil Management Groups
6. Soil Drainage
7. Surface Soil Erosion Potential
8. Soil Sensitivity to Acidification
9. Irrigation Requirement
10. Soil Constraints for Septic Tank Effluent Absorption.

MINIMUM DATA SETS

This topic was discussed with the Agronomic Interpretations and CanSIS/Computer Working Groups. However, very little was definitely settled because we must rely on the Agronomic Interpretations Working Group to tell us what properties of soil and land are to be evaluated in assessing agricultural potential. These

will then form a minimum data set. However, a number of points came out of the discussion:

- There is general acceptance that for special purpose surveys the data collected can be limited to only those that are relevant to the assessments acquired.
- survey intensity must be considered.
- minimum data sets should ideally be based on models of soil-land use relationships.
- there is obviously no complete agreement yet on what is meant by a minimum data set. We must define what we mean by this term.
- some publications already constitute minimum data sets. Examples are the Land Capability for Agriculture and Septic Tank Constraints Manuals for British Columbia.

INFORMATION PACKAGING

The Working Group made recommendations for four publication categories which will vary according to the completeness of the information they contain, their presentation format, and the time they take to produce. The names of each category are those used by the Geological Survey of Canada for their publications.

1. "Open File"

   a. Maps - raw infomation with a key

   -Audience is technical or specialized

   -Time-immediate

   -Symbols-handwritten

   -Legend-typed

   -include disclaimer i.e. PRELIMINARY

   -Examples - Manitoba, Nova Scotia contract

   b. Site Information

   -copies of field sheets (circulated with discretion)

2. "Report"

   -technically complete and correct

   -Fairly basic document

   -technical or general

   -ready for wide circulation

   -Map-with or without report

   -final product, edited internally

   -like C.L.I. maps - with a 1500 word explanation - on map, or separate

   -with or without interpretations-depends on the objectives of the survey

   -report could be on work processor

   -suitable for special purpose survey, and possibly general purpose as well.

   Examples-Quebec-Richelieu

   B.C. -Pine Valley

   Ont. -N. Ont.-Open legend

3. Bulletin

-more complete than 2.

-complete discussion of project, landscape, physiography etc.

-mainly produced and edited locally

-General and technical

-Map and Report

-Map, printed, color or othophoto, formal legend

Report-reproduced from typing

-Full normal sections - area,, methods, M.U's, soil descriptions

-Interpretations

Examples-Manitoba-Roblin, Dauphin

-B.C. -Horsefly

4. "Memoir"

-long term - 'wide audience'

-complete

-technically sophisticated

-contents same - 3 and 4, format different

-Ottawa edit -RPS

-suitable for General Purpose survey.

SOIL SURVEY HANDBOOK

G.M. Coen

INTRODUCTION

The Soil Survey Handbook records old and suggests new procedures useful in undertaking soil surveys in Canada. It attempts to document those accepted practices which have not previously been written down. It also attempts to tie together the several published documents soil surveyors use to standardize their procedures. It is my belief that carefully conceived, well documented procedures can contribute significantly to quality and efficiency in conducting soil surveys. It is also my belief that if our procedures are properly recorded, novice soil surveyors should be able to obtain most of the answers to procedural questions from the literature with little need for apprenticeship.

ACCOMPLISHMENTS

1. Sections 100 to 400 have been reviewed and evaluated by several of the Editorial Lead Committee members. Editorial changes are underway and will be completed and ready for publication early in 1985.

2. Section 600 has been largely compiled. Alex McKeague is waiting for a couple of submissions before we submit Section 600 to the Editorial Lead Committee for review. Bob Smith and Julian Dumanski are compiling portions of 500 and 700 respectively.

COMMENTS

Not surprisingly, comments from the Editorial Lead Committee have pointed out some differences in approach to procedures that I must resolve. In general I have taken the position that our procedures should be developed to provide quality and efficient surveys. The comment was made to me that if we do not have the people to do the thing we need to do then we should not suggest that we should do them in the Handbook. For example, we do not now have the correlation staff either provincially or federally to undertake the procedures identified in the Handbook as necessary to undertake a cohesive mapping of soils in Canada. Should we take these references to correlation procedures out of the Handbook because we are unable to live up to them (creating a "credibility gap" with our peers) or should we leave the references in the Handbook and work toward obtaining the necessary personnel (this to avoid the inevitable "credibility gap" with our users)? My preference is for the second option.

Several people have wondered if we need the material included in Sections 100 and 200. However, at the 1982 ECSS meeting in Victoria I recorded strong support for the need to document the national and interprovincial relationships by which soil surveys are governed. I am inclined to reduce the volume of Exhibits, but leave the essentials of these two Sections as they are.

I have included detailed lists of tools that are used by soil surveyors. This tended to offend some of my colleagues because it was too obvious to need documentation. My rationale for including these lists relates to the statement I made in the introduction to the effect that novice soil surveyors should be able to obtain most of the information they need from the literature. I am inviting further comments from anyone with preferences one way or the other.

The final comment I would like to make is that I have included verbatum a listing of Miscellaneous Land Types published in 1973 Proceedings of the Ninth Meeting of the Canada Soil Survey Committee. I feel that it is important that we have standardized terminology for "Nonsoil features" to facilitate mapping correlation. However, the above material is obsolete (as pointed out in my editorial comment and elaborated by reviewers). I feel revisions to "Nonsoil features" are beyond the terms of reference of the Soil Survey Handbook Committee. I would recommend that a committee be established to update the 1973 report and publish it for distribution to the soil survey community.

RECOMMENDATIONS

1. That Sections 100 through 400 be printed as an interim document in a 3-ring binder format in sufficient copies to be distributed for testing to all members of soil survey units in Canada plus copies to be made available to interested individuals in universities and consulting firms.

2. That Section 600 be completed and evaluated by the Editorial Lead Committee and, if acceptable, be printed as an interim document as above.

3. That as segments of Sections 500 and 700 become completed they should be evaluated by the Editorial Lead Committee and if deemed appropriate printed as supplements to the above and distributed for testing.

ACKNOWLEDGEMENTS

Thanks to several members of the Editorial Lead Committee, and others who returned detailed comments on drafts of the Handbook. Without these responses it is difficult for me to evaluate the acceptability of the manuscript.

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REPORT ON THE AGRONOMIC INTERPRETATIONS WORKING GROUP.

B. van den Broek.

The Agronomic Interpretation Working Group met for the first time in Guelph (E.C.S.S. meeting 1984). On the agenda for this business meeting were the following items:

1. A discussion on the mandate.
2. Provincial reports regarding the "state of the art".
3. Drafting a workplan for the coming year.

THE MANDATE OF THE WORKING GROUP.

Agronomic interpretations can be defined as those kinds of interpretations that will benefit the field crop production as well as soil management. In comparison to other soil interpretation systems (i.e. forestry, engineering, etc.), relatively little has been done in terms of practical applications for specific soil and crop interpretations (other than the widely accepted C.L.I. interpretations itself). On the other hand, many of the provinces are now in the process of collecting information for their "second generation" soil maps, whereby more detailed information is being collected. With this level of detail, these new soil maps are extremely suitable for making specific crop and soil management interpretations (i.e. suitability ratings for general field crops, speciality crops, soil erosion and conservation, soil tillage recommendations, and others). The lack of general (nation-wide) guidelines for making these kinds of practical interpretations seems to be a major concern for many soil survey units across the country. Such guidelines could not only be beneficial for the units, but when it comes to the question of accepting the validity of these interpretations by the various users, these national guidelines may be very beneficial.

Some units have taken it upon themselves to modify and/or develop their own agronomic interpretations in order to satisfy the needs of local users. Very little consideration is thereby given to an exchange of ideas and information between the various units. In part this can be contributed to the very significant regional differences as far as their agricultural needs are concerned, but it can also be attributed to the lack of national co-ordination on this subject matter. Inevitably, this must then lead to a lot of duplication amongst the various units.

It can then be seen that the prime role of the Agronomic Interpretations Working Group should be that of a coordinating national committee responsible for (i) developing national guidelines, and (ii) to promote the exchange of ideas and information between the various units. To that extend, the working group set the following objectives as its mandate:

1. To modify and improve the 1964 C.L.I. - guidelines for agriculture that will bring the system in line as to what is required for the various S.I.L. levels of mapping. Special consideration will thereby be given to the significance of the C.L.I. system for the various commercial field crops.

2. To develop guidelines for the interpretation of soils information for agriculture (crop specific) as well as soil management, applicable at various

levels of mapping and to publish this information at the earliest feasible time.

3. To assess the feasibility of including an economic evaluation for soil management and land improvement recommendations and where possible to include these in the guidelines.

4. To determine the need for research projects in support of improved agronomic interpretations and to promote their undertaking by qualified scientists.

PROVINCIAL REPORTS.

Each of the provinces was requested to present a report on the "state of the art" of the agronomic interpretations in the respective provinces. The objective was to take inventory of what is known or done already. As could be expected, the reports illustrated quite clearly the variety of opinions and approaches that prevailed amongst the various units. After a lengthy debate, the following recommendations and conclusions were adopted:

1. C.L.I. - INTERPRETATIONS.
All provinces consider the C.L.I. interpretations as very valuable. Although most provinces are still using the existing guidelines concepts (drafted in 1964), locally some variations and/or improvements have been made. This clearly indicates that many units perceive the original guidelines as being incomplete and/or poorly defined especially at the subclass level). A general upgrade of the original guidelines would be welcomed by all units.

2. SPECIFIC RATINGS FOR HIGH-VALUE CROPS.
It was widely accepted that not all commercial crops are covered by the C.L.I. system, but there are varying opinions amongst the units as to what is and what is not covered by it. The need for special ratings for high-valued crops (and are not covered by the C.L.I. system) is perceived by some units as very desirable. In designing these special crop ratings it is necessary to take both the soil and the climate in consideration.

3. YIELD EVALUATION PROGRAMS.
One of the most desirable interpretation programs is a predictive model that will allow feasibility studies based on crop, soils, and climatic information. Some concern was expressed as to how attainable this kind of information will be.

4. LAND MANAGEMENT CLASSIFICATION SYSTEM.
The need for the development of a land management classification system was identified. This kind of information, based on soil and climatic factors, could then form the basis on which soil management recommendations could be made (i.e. soil tillage, tile drainage, soil fertility, etc.).

5. STANDARDIZED DATA BASE.
The need for a standardized data base for site specific information regarding soils and climatic information was recognized. Such a data bank should be designed in such a way that the information could be used at any desired scale (from the "farmgate" to the "reconnaissance surveys").

6. ORGANIC CAPABILITY RATINGS.
It was recognized that there is no need for an "Organaic Capability Rating". The work done by Leeshon and Hoffman can serve as a guideline.

The list of recommendations suggest that a tremendous task is awaiting the subcommittee. Although national guidelines regarding agronomic interpretations were welcomed by all units, it was made quite clear that there still is and always will be a regional preference as to what is needed. The subcommittee endorsed the idea of having broad national guidelines which then can be adopted by the individual units.

FUTURE PLANS FOR THE SUBCOMMITTEE

The long list of recommendations made in the previous section, suggest that the subcommittee will be operation for several years to come. To be able to bring the mandate of the subcommittee to a successful completion, it is necessary to break it into the following phases:

Phase 1.
This is considered the initial phase whereby each of the provincial units was requested to submit existing guidelines and/or manuals that deal with agronomic interpretations (regional concepts). The intention is to document all this information and evaluate it on its merits. This type of information will be complemented by an intensive literature search. It is anticipated that the first year of operations subcommittee's activities.

Phase 2.
Although at least one intermediate meeting will be held in the summer of 1985, it is anticipated that phase 1 can be closed off at the 1985 E.C.S.S. meeting. At that point in time a more detailed course of action will be discussed (i.e. where to put the priorities, etc.). Work on the development of the various guidelines will commence at that stage. It is anticipated that this will take at least a couple of years to complete.

Phase 3.
Phase 3 of the workload will consist of drafting, testing, and "fine-tuning" of the preliminary guidelines. Each unit will be requested to test out the guidelines and provide feedback to the subcommittee.

Phase 4.
The last phase will be the writing and publishing of the various guidelines for agronomic interpretations.

The subcommittee recognized the fact, that for many of the agronomic interpretations some interaction with the various other E.C.S.S. subcommittees will be required.

SOIL CLASSIFICATION

C. Tarnocai

INTRODUCTION

The meeting of the Soil Classification Working Group was held as a three-day workshop in conjunction with the Sixth Annual Meeting of the Expert Committee on Soil Survey (E.C.S.S.). The workshop had representation from all regions of Canada. Topics relating to soil classification on the agenda of this workshop were mainly those identified four years ago and finalized in 1981 (Tarnocai 1981).

These items were as follows:

1. Fine tuning the classification of the Gleysolic order.
2. Classification of Folisols.
3. Fine tuning the classification of the Podzolic order.
4. Revision of the definition of contrasting horizons and layers.

Most work relating to these classification topics has been completed and proposals were presented at the workshop for revision of the Canadian soil classification. In addition to the above-listed items, new classification problems were also presented for future work.

All of the papers presented at the workshop are to be found in the 1984 Soil Classification Workshop Proceedings. Excellent participation by the Working Group members and interested observers initiated in-depth and lively discussions, resulting in the formulation of the Working Group's recommendations to the E.C.S.S.

IMPROVED CRITERIA FOR THE GLEYSOLIC ORDER

The proposal concerning improved criteria for the Gleysolic order was prepared by A. McKeague and C. Wang with input from various regions. The proposal was presented by A. McKeague. In addition to this, British Columbia, the Yukon, Alberta, Saskatchewan, Manitoba, Ontario, Quebec and the Atlantic provinces presented the results of their testing of the criteria proposed by McKeague and Wang.

In the following section a summary of this proposal is given with the recommendations (in italics) for inclusion in the Canadian System of Soil Classification.

Rationale

The following concepts, which provide the foundation upon which the proposals for the Gleysolic order were built, are recommended by the Working Group for inclusion in the Canadian System of Soil Classification.

1. *The criteria for Gleysolic soil classification must be based on soil properties that indicate reduction during the genesis of the soil and not on the current soil water regime. Gleysolic soils are those in which the imprint of reduction or reduction-oxidation cycles is dominant over evidence of persistent oxidizing conditions. Many Gleysolic soils are poorly or very poorly drained, some are imperfectly drained, and others, in which drainage has been markedly improved, are now well drained.*

2. *In cases where two or more apparently "dominant soil forming processes" have left their mark on the soil, it is essential to decide an order of precedence. Hence, processes reflected by permafrost close to the surface, by the accumulation of organic material of specified thickness, and by podzolic processes giving rise to soils that meet the specifications of the Podzolic order take precedence over evidence of gleysolic processes. Specified evidence of gleysolic processes, on the other hand, take precedence over processes leading to the development of solonetzic B, chernozemic A, Bt, Bm or to weak evidence of soil genesis as in Regosolic soils.*

3. *Classification criteria are based on observable or measurable soil properties, not on vegetation, slope position or other non-soil properties that are commonly related to soil properties.*

4. *Criteria for the Gleysolic order should make sense from both practical and genetic points of view for soils of different horizon sequence, different parent material, and different soil climatic criteria.*

Specific Recommendations

The following specific changes were recommended for inclusion in the classification of the Gleysolic order.

1. The Gleyed Gray Luvisol - Luvic Gleysol split.
   Currently, a soil having a Bt horizon and low chromas accompanied by prominent mottling within 50 cm of the surface is a Luvic Gleysol. Some soils with brown chroma (approximately 3) and unmottled Bt horizons, however, have Aeg horizons with chroma of 1 and prominent reddish-brown mottles. According to the Canadian System of Soil Classification (Canada Soil Survey Committee 1978), these soils are Luvic Gleysols but they probably should be Gleyed Gray Luvisols (oxidation dominant).

It is recommended that, for soils with Ae horizons underlain by a Bt horizon or a relatively impermeable horizon of any kind, the low chroma and mottling criteria would have to be met by the horizon underlying the Ae. If the Ae extends to a depth greater than 50 cm, however, perhaps prominent mottling within 50 cm of the surface in the Ae should be diagnostic of a Gleysolic soil.

2. Prominent mottles or low chroma and prominent mottles.

The Canadian System of Soil Classification is somewhat ambiguous on this point. The Gleysolic order criteria on page 69 basically require, within 50 cm, low chromas and prominent mottling, or chroma of 1 or less. One paragraph, however, states, "either matrix colors of low chroma or prominent mottles of high chroma" (within 50 cm). Based on that statement, a soil having a B horizon 10YR 4/4 with a few mottles 10YR 4/8 could be classified as Gleysolic.

Relating to low chroma and prominent mottles, the following are recommended by the Working Group:

Chromas 1 or less without mottles, or hues bluer than 10Y; or

Chromas 2 or less in hues of 10YR or redder and prominent mottles; or

Chromas 3 or less in hues of yellower than 10YR and prominent mottles

3. Low chroma mottles.

In the Canadian System of Soil Classification little attention is paid to mottles of low chroma except for those occurring in reddish soils.

It is recommended that common or many distinct or prominent mottles of low chroma in horizons of generally oxidized color within 1 m of the surface should be diagnostic of gleyed subgroups. An exception is made for reddish soils in which prominent low-chroma mottles at specified depths are diagnostic of Gleysolic soils.

4. Few distinct or prominent mottles.

Currently, a few prominent mottles within 50 cm may be diagnostic of Gleysolic soils (Canada Soil Survey Committee 1978). Thus, one prominent mottle (7.5YR 5/6) in a 50 cm wide exposure of a grayish-brown (10YR 5/2) horizon within 50 cm of the surface could be considered as diagnostic of a Gleysolic soil.

It is recommended that at least a 50 cm wide section of the profile be examined. Within this section a subhorizon at least 10 cm thick with its upper boundary within 50 cm of the mineral surface should have at least 2% of its area occupied by prominent mottles to be considered diagnostic of a Gleysolic soil.

It is important here to note that a cleanly picked profile or broken peds should be examined to assess the percentage of the area occupied by mottles. Smearing a profile with a spade may

exaggerate greatly the apparent area of mottles.

5. Color criteria for soils developed in red materials.
Soils developed in reddish materials (5YR or redder and color does not fade rapidly on dithionite treatment) do not have subsoils of low chromas even if subjected to prolonged reducing conditions or alternating reduction-oxidation conditions.
In such soils it is recommended that the following moist color criteria occurring within 50 cm of the surface are diagnostic of Gleysolic soils:
a. Common or many, prominent mottles of high chroma in a horizon within 50 cm of the surface.
b. Common or many, prominent mottles of low chroma in a horizon within 50 cm of the surface.
Gray streaks associated with ochreous material along the fissures in fragipans are not diagnostic of Gleysolic soils.

6. Add Solonetzic subgroups to the Gleysolic order.
These would be parallel to the Luvisolic subgroups of Ferro-Humic and Humo-Ferric Podzols. They would identify soils that meet the criteria of Solonetzic soils except that they also meet the limits for Gleysolic soils. A decision would have to be made on the order of precedence of subgroups.
It is recommended that Solonetzic would take precedence over Rego and Fera. Thus a Gleysolic soil having a Bn or Bnt horizon would be Solonetzic Gleysol.

7. *It is recommended that the Ae and Ah horizons having low chroma not be diagnostic for Gleysolic soils.*

CLASSIFICATION OF FOLISOLS

The work relating to the improved classification of Folisols began in 1979 as a result of a soil correlation tour involving both federal and provincial soils people in British Columbia. Shortly thereafter, the B.C. Working Group was formed under the chairmanship of Rick Trowbridge. The objective of this Working Group was to formulate proposals to improve the classification of Folisols, humus forms and organic horizons. The B.C. Working Group submitted two reports on their progress. In 1983 and 1984, as part of the Pacific Coast peat project, C. Fox and C. Tarnocai initiated a detailed study of the characteristics of Folisols and the spatial distribution of these soils on the landscape. All of this work is described in detail in the articles by R. Trowbridge and C. Fox to be found in these proceedings.

Rick Trowbridge presented two alternate proposals relating to the classification of Folisols: (1) establishment of a Folisolic order and (2) improvement of the Folisolic great group. The B.C. Working Group strongly recommended the establishment of a Folisolic order. The presentation was followed by a lengthy and very lively discussion.

During this discussion a third proposal emerged (suggested by A. McKeague), to classify the Folisols on the subgroup level in the appropriate order, based on the underlying mineral soil. Finally, these three proposals were put to a vote and the results were: 3 for the Folisolic order (these were those people involved in the development of the classification proposals and the characterization study), 7 for the improved Folisolic great group, and 4 for classifying the Folisols in various orders according to the underlying mineral soil. Based on this vote, the second proposal, improvement of the Folisolic great group, was accepted by the Working Group and recommended for inclusion in the Canadian System of Soil Classification. A description of the recommended Folisolic great group classification is given below.

FOLISOLIC GREAT GROUP

Soils of the Folisolic great group are composed of upland (folic), organic materials, generally of forest origin, which are thicker than 40 cm, or at least 10 cm thick if over bedrock or fragmental material. Deep Folisols (greater than 40 cm of folic material) occur frequently in cool, moist, and humid forest ecosystems, particularly on the west coast of Canada. They also develop in the cold, northern regions where the soil temperatures are extremely cold. Shallow Folisols are found throughout Canada and often occur on upper slope shedding positions over bedrock and on, or incorporated in fragmental or skeletal material.

Folic material has formed under contrasting ecosystems when compared to peat organic material. Folic materials are the product of upland ecosystem development while peat materials are the product of wetland development.

Folisolic soils are well to imperfectly drained, although they may become saturated after rainfall or snowmelt. Folisolic soils contain 17% or more organic carbon (approximately 30% organic matter) by weight in the diagnostic horizons and meet the following specifications.

For folic materials, not usually saturated with water (freely-drained), to qualify as folisols they must have:

1. Folic material greater than 40 cm deep; or
2. Folic material greater than 10 cm deep, if directly overlying a lithic contact or fragmental material, or occupying voids in fragmental or skeletal material; or
3. Folic material more than twice the thickness of a mineral soil layer if the mineral layer is less than 20 cm thick.

The Folisolic great group is divided into four subgroups, based on the degree of decomposition of the folic material as distinguished by the diagnostic F and H soil horizons. Layers or pockets of decaying wood may be designated as F or H horizons and some soil pedons have significant amounts of this type of folic material (see Lignic Folisol). The L horizon, if present, is considered to be parent material.

Hemic Folisol

Common horizon sequence: L, F, H, (M*, R)

Soils of this subgroup are composed dominantly of the moderately decomposed F horizon(s) in the control section and may have subdominant H and O horizons each less than 10 cm thick. They commonly have lithic or fragmental layers, but they meet the requirements for the Folisolic great group. The F horizon is partially decomposed folic material generally derived from mosses, leaves, twigs, reproductive structures, and woody materials containing numerous live and dead roots.

Hemic Folisols usually occur on upper slope shedding positions, and are often shallow to bedrock or fragmental material, or the folic material may occupy voids in fragmental material. There may be a thin layer of mineral soil separating the folic horizon from bedrock or the fragmental material.

Humic Folisol

Common horizon sequence: L, F, H, (M*, R)

Soils of this subgroup are composed dominantly of the well decomposed H horizon(s) in the control section and they may have subdominant F and O horizons. Lithic, fragmental, or mineral and peat layers may be common in the control section but the soils meet the requirements for the Folisolic great group.

Humic Folisols occur most frequently in cool, moist, humid forest ecosystems. Although they occur in many landscape positions, they commonly develop on lower slopes and valley bottoms. Rooting channels and other voids are common in these soils.

Lignic Folisol

Common horizon sequence: (L), F, H (M*, R)

Soils of this subgroup are dominated by the F and H horizon(s) composed primarily of moderately to well decomposed woody materials; or the soil may have, in addition to typical folic horizons, a significant (greater than 30% of the surface area) F or H horizon composed primarily of decomposed woody materials. The large amount of decaying wood that makes up these F horizons is generally the result of forest blowdown. This occurs as a continual process in uneven aged forests or at periodic intervals due to major storm events that create even aged forest stands. Lignic Folisols also occur in second growth forests as a result of logging residues.

Histic Folisol

Common horizon sequence: L, F, H, O, (M*, R)

Soils of this subgroup are dominated by the F or H horizons and underlain by a significant (greater than 10 cm) O horizon. Generally, saturation or high water tables resulting from drainage impediments by mineral horizon cementation or localized bedrock configuration initially produced peat development. Subsequently, peat development became deep enough to produce surface conditions suitable for forest encroachment and folisolic development.

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* various mineral soil horizons

IMPROVED CRITERIA FOR THE PODZOLIC ORDER

The proposals for improved criteria for the Podzolic order were prepared and presented by A. McKeague with input from various regions. In the following section a summary of these proposals are given together with the recommendations (in italics) which are suggested by the Working Group for inclusion in the Canadian System of Soil Classification.

1. Classification of Podzolic soils in which the only Bhf horizon that occurs underlies the Bf horizon. Such soils are found in B.C. Commonly the Bhf horizon overlies a duric horizon or very dense till. We think of typical Ferro-Humic Podzols as having a Bhf - Bf sequence from top to bottom of the podzolic B. If the pedon to be classified has a horizon sequence as follows: FH, Ae, Bf (40 cm), Bhf (15 cm), BCc, Ccj, how should it be classified? The Canadian System of Soil Classification (Canada Soil Survey Committee 1978) could be interpreted in either of two ways:
   a) the soil has a Bhf horizon so it belongs with the Ferro-Humic Podzols, or
   b) in Ferro-Humic Podzols the dark Bhf horizon usually underlies the Ae and the color becomes lighter with depth (p. 98).

   Thus, the pedon does not fit the Ferro-Humic Podzol.

   It is recommended that a Bhf at least 10 cm thick anywhere within the podzolic B is diagnostic of a Ferro-Humic Podzol.

2. There is no consistency in the acidity requirements for Podzolic and Brunisolic soils. For example, as was pointed out by people from B.C.: Ae 0-2 cm, Bf 2-12 cm, BC 12-14 cm, Ck 14- cm, is classified as Ferro-Humic Podzol, but Ae 0-2 cm, Bm 2-12 cm, BC 12-17 cm, Ck 17- cm, is classified as Eutric Brunisol.

   It is recommended that, in the case of thin podzolic development in material with free carbonate within 25 cm of the surface, a podzolic B is diagnostic of a Podzolic soil.

3. There is no consistency for taking samples from the Podzolic B horizon for chemical analysis. Composite samples are taken from the entire horizon or, in some cases, only the most developed portion of the B horizon is sampled.

   It is recommended that, in order to determine whether a soil meets the podzolic chemical criteria, it is necessary to sample only the 10 cm of B horizon that is most strongly expressed.

4. What is the appropriate designation for the transitional horizon between a podzolic B and the C horizon?

   It is recommended that the horizon between a podzolic B and the C horizon should be designated BC rather than Bm.

5. Can the well drained Podzolic soil with brownish B horizons be classified as Humic Podzol?

   It is recommended that some well drained Podzolic soils with brown B horizons C/Fe pyrophosphate extractable>20 be excluded from Humic Podzols by requiring the Bh horizon to have chromas <2.

CONTRASTING HORIZONS OR LAYERS

The definition of contrasting horizons or layers (Tarnocai 1981, pages 56 and 57) was accepted and recommended for testing by the Soil Classification Working Group. The Working Group reviewed the modifications resulting from this testing and made the recommendations (in italics) given below for inclusion in the Canadian System of Soil Classification.

> *Roman numerals are prefixed to the contrasting master horizon or layer designation (A, B, C) to indicate lithologic discontinuities either within or below the solum. The first, or uppermost, material is not numbered, for the Roman numeral I is understood; the second contrasting material is numbered II, and others encountered are numbered III, IV, and so on, consecutively with depth. Thus, for example, a sequence from the surface downwards might be Ah, Bm1, IIBm2, IICca, IICk1, IIICk2.*

> *Lithologic discontinuity is due to the mode of deposition indicated by strongly contrasting texture (differing by two textural classes) or to mineralogical composition that indicates a difference in the material from which the horizons have formed. These contrasting materials have resulted from geologic rather than from pedogenic processes.*

A change in the clay content associated with a Bt horizon (textural B) does not indicate a difference in parent material. Appearance of gravel, or a change in the ratios between the various sand separates, will normally suggest a difference in parent materials. A different Roman numeral would not normally be used for a buried soil in a thick aeolian deposit. The difference between the properties of the buried soil and the overlying material are presumably the result of pedo-genesis. A stone line usually indicates the need for another Roman numeral. The material above the stone line is presumed to be transported. If the transport was by wind or water, one must suspect that during the movement there was some sorting of the material according to size.

All O organic horizons, which have developed from peat materials in a wetland environment, are considered to have resulted from only one mode of deposition. The same principle applies to L, F, and H horizons, which have developed from folic materials in a dominantly forest system. These horizons (O, L, F, and H) should not be designated as contrasting even if

they differ in botanical composition or degree of decomposition.

In some cases it is not necessary to use Roman numerals to show strongly contrasting horizons. This is the case if the horizon symbol already indicates the difference. For example, no Roman numerals are required if the soil is composed of peat materials overlain by folic materials and underlain by mineral soil (L, F, Om, Oh, C) or if a mineral soil has a folic or peaty surface layer (L, F, Bm, BC, C; or Om, Ahg, Cg).

SOIL SURFACE

The soil surface is defined in the *Manual for Describing Soils in the Field* (Expert Committee on Soil Survey 1983, page 63) as follows: "The top of the mineral soil is considered to be zero depth both for organic litter (less than 40 cm thick) and for mineral soils; zero depth for organic soils (more than 40 cm thick) is the top of the organic material. Organic layers (except those that are buried) are listed in descending order of depth; mineral horizons and layers in organic soils are listed in ascending order of depth." This definition is used to indicate the depth of soil horizons in the description of pedons.

Problems relating to this definition

For measuring soil temperatures and water tables and for determining the rooting depth and depth of the restrictive layer and permafrost table, the top or surface of the soil (even if the surface is formed by an organic horizon) is considered to be the soil surface. Correlation of the data relating to soil temperature, ground water depth and permafrost table with the depths given in the pedon descriptions constantly creates problems.

Recently, in relation to the computerized soil data forms, this convention has been questioned. Firstly, it created a logical problem between the depth indicated for the mineral and organic soils. In addition to this, information recorded in the monitoring file (soil temperature, ground water depth, etc.) could not be correlated with the soil description file in the case of the mineral soils.
The following two alternatives were suggested:

1. The top of the soil, composed of either mineral or organic horizons, is considered to be the soil surface. Soil horizons are then listed in descending order, starting from this surface. The new definition is then as follows:
   > The top of the mineral or organic soil or the organic surface horizon of the mineral soil is considered to be zero depth. All depths are listed in descending order from the zero depth.

   In soil descriptions, however, both the horizon thicknesses and the depth are recorded. These depths can then be correlated with other soil depth data. The horizon thicknesses provide a record for those horizons which are subject to compaction.

For example:

Horizon	Depth (cm)	Thickness (cm)
L	0-3	3
F	3-8	5
Ae	8-16	8
Bt	16-26	10
BC	26-50	24
Ck	50-65	15

2. Soil surface is defined as in the *Manual for Describing Soils in the Field* (Expert Committee on Soil Survey 1983, page 63) but in soil descriptions the horizon thicknesses are also given.

For example:

Horizon	Depth (cm)	Thickness (cm)
L	8-5	3
F	5-0	5
Ae	0-8	8
Bt	8-18	10
BC	18-38	20
Ck	38-54	16

After a lengthy discussion the Working Group voted with 8 people supporting alternative 1 and two people supporting alternative 2.

Thus, the Working Group recommended for adoption the following definition of soil surface:

The top of mineral or organic soil or organic surface horizon of the mineral soil is considered to be zero depth. All depths are listed in descending order from the zero depth. In addition to this, horizon thicknesses should also be indicated along with the horizon depths.

FUTURE WORK

Two unfinished items relating to the Gleysolic order remain to be solved. The first one is the classification problem relating to Gleysols with horizons containing secondary carbonates within 50 cm of the surface. These soils occur mainly in Manitoba. The Manitoba group agreed to develop a proposal and will present it to the next Soil Classification Working Group meeting. The second item relates to the Humic Gleysol - Gleysol split, specifically the 2% carbon criteria relating to the Ah or Ap horizons of Humic Gleysol. The suggestion was that 1.5% carbon be considered for cultivated soils and 2% carbon for undisturbed soils. Some people would like to see specified a depth to which the carbon criteria would apply. No common agreement was reached and it was decided that further work is required on this topic.

The proposal for the lower case suffixes for the L, F, and H horizons was given in C. Fox's presentation. There was considerable discussion on this topic, however, and no decision was reached except

that further testing is required. C. Fox agreed to report back at the next Soil Classification Working Group meeting on the results of this testing.

A question has arisen concerning the adequacy of the current chemical criteria for a podzolic B horizon. The sodium pyrophosphate test does not indicate the amorphous inorganic products which have accumulated in the podzolic B horizon. A. McKeague and C. Wang are presently conducting research on the amorphous inorganic products present in the podzolic B horizon. They agreed to report back to the Working Group on their findings.

A new item relating to the classification of swelling clay soils was introduced by D. Acton. Soils developed on these swelling clays in Saskatchewan are excellent examples of cracking soils that have significant shrink-swell potential. These soils likely form a special part of the Vertisol spectrum of the Soil Taxonomy of the U.S. It was agreed that D. Acton would set up a small regional working group within the National Soil Classification Working Group to focus on this problem. This regional working group will be chaired either by D. Acton or by someone whom he will appoint and will report back on their work at the next meeting of the Soil Classification Working Group.

ADOPTION OF THE RECOMMENDATIONS

Recommendations included in this report were presented to the E.C.S.S. meeting on November 29, 1984. On the following day the E.C.S.S. accepted all of the recommendations with the exception of the recommendation relating to soil surface. There was considerable opposition to this recommendation, especially from the Atlantic provinces. Thus, the definition of soil surface will remain as stated in the *Manual for Describing Soils in the Field* (Expert Committee on Soil Survey 1983, page 63).

It was also agreed at the E.C.S.S. meeting that these newly-accepted changes would be published in a separate publication as amendments to the Canadian System of Soil Classification. This publication will be available sometime in the later part of 1985. In addition, it was agreed that these amendments should be applied to all new soil survey projects initiated after the publication of these soil classification amendments.

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IRRIGATION SUITABILITY CLASSIFICATION

Progress Report of ECSS Working Group on Irrigation Suitability Classification

R.G. Eilers

INTRODUCTION

The Working Group held a meeting in Saskatoon (March, '84) which resulted in the development of a tentative procedure for interpreting the irrigation suitability of soils. This new procedure utilizes soil and landscape information which can be obtained from soil maps and reports or from standard soil survey field procedures. A brief outline of the approach used, along with the data requirements and structure of the system will be presented here. The system is still under review but should be available for testing and application in the near future.

The new classification system utilizes morphological, physical and chemical attributes of both the soil and landscape. These factors are considered in order of their increasing restriction for irrigation, and are then combined in a matrix table according to their relative limitations for irrigation. The general irrigation suitability rating is obtained from this matrix, and identifies the severity and nature of the major limitations, i.e. soil or landscape or a combination of the two.

The proposed classification system will have application at various scales of mapping (from reconnaissance to detailed) provided that sufficient soil and landscape information are available. The level of generalization for the irrigation rating will vary, however, depending on map scale as well as on the quantity and quality of available soil and landscape data.

The new ISC should be easily computerized because it utilizes defined classes of soil and landscape data combined in a matrix format. The new system is also independent of irrigation methodology. The system identifies the nature and severity of the limitations for irrigation as a first step in assessing the overall irrigability of a tract of land.

The irrigability of land depends, among other things, upon the technological feasibility and economics of overcoming the indicated limitations. This is a subsequent assessment to identification of soil and landscape limitations. Other factors affecting irrigability which are not part of this interpretive classification system include: engineering, agronomy, land tenure, management skills, field sizes, market availability and proximity, and economics. It is planned, however, to develop and provide some guidelines for water quality relevant to specified soil quality limitations.

GENERAL OUTLINE

The irrigation suitability classification system is based on 4 classes of soil limitations and 4 categories of landscape limitations (Table 1). Soil limitations are identified by the numbers 1 to 4 according to increasing severity of limitation (Table 2). Similarly, landscape limitations are

identified using the symbols A, B, C and D according to their increasing severity of limitation (Table 3). The relative limitation ratings for both soils and landscapes were then combined into a matrix format resulting in a total of sixteen possible irrigation land class-categories (Table 4). Each of these land classes can be defined in terms of limitations due to soil factors, landscape factors or a combination of both (Table 5). All of these land classes fall into 4 general suitability groups defined as excellent, good, fair, and poor (Table 6).

This new irrigation suitability classification system correlates well with the systems presently in use in each of the three prairie provinces (Table 7). In some cases, the symbology of the new system is somewhat simpler and more informative than that presently in use. The symbology of the new system will always consist of a minimum of two characters. The numbers 1, 2, 3, or 4 which identify the increasing severity of soil limitations, appears first. The letters A, B, C, and D (upper case) which identify landscape limitations are indicated second. The specific limitation(s) may be indicated by using at least one and no more than three lower case symbols from Tables 2 and 3 as a third, fourth, and fifth component of the suitability rating.

e.g. 2Ad - slight limitation due to structure

3Bswp - moderate limitation due to salinity and wetness and a slight stoniness limitation

4Dmt2 - severe limitations due to low water holding capacity and steep complex slopes

The new irrigation suitability system is presently in the final draft stages. It is planned to have several test applications, preferably one or two in each province in 1985. This testing process will help to develop the application procedures as well as evaluate the relevance of the criteria as presently proposed.

ACKNOWLEDGEMENTS

Most of the credit for developing this approach to assessing irrigation suitability must go to the members of the Working Group which includes: J. Ellis, D. Anderson - S.I.P., A. Bristol - S.D.A., W. Nicholiachuk - Env. Can. & CDA, and L. Chambers - PFRA, Saskatchewan, W. Pettapiece - Ag. Can., S.S., and K. Pohjakas - ADA, Alberta. Sincere appreciation is also extended to the many other people who took time to review the various drafts of the system and make constructive suggestions.

Table 1. Factors Affecting Irrigation Suitability

Criteria	Degree of Limitation			
	Non	Slight	Moderate	Severe
Soil	1	2	3	4
Landscape	A	B	C	D

Table 2. Soil Features Affecting Irrigation Suitability

Soil Feature "Symbol" \ Degree of Limitation	1 None	2 Slight	3 Moderate	4 Severe
	'PERMANENT' SOIL FEATURES			
Texture (Classes) *	L, SiL, VFSL, FSL	CL, SiCL, SCL, FSCL, SL, LVFS	C, SC, SiC, CoSL, VFS, LS	HvC, LCoS, CoS, S, Gr
(Groups)	Medium	Moderately Fine Moderately Coarse	Fine Coarse	Very Fine Very Coarse
Structure "d"	Granular Single Grained Subangular-blocky	Platy Blocky Prismatic	Columnar Massive	
A.W.H.C. (mm/1.2m) "m"	>120	120-60	60-30	<30
K-Sat. (mm/hr) 0-1.2m "k1"	50-15	15-5 150-50	5-1.5 500-150	<1.5 >500
1.2-3m "k2"	>15	15-5	5-1.5	<1.5
Geological Uniformity 0-1.2m "g1"	1 Text. Class	2 Text. Classes coarser below	2 Text. Classes finer below. 3 Text. Classes coarser below	3 Text. Classes finer below
1.2-3m "g2"	2 Text. Classes	3 Text. Classes coarser below	3 Text. Classes finer below	
Depth to Bedrock (m) "r"	>3	3-2	2-1	<1
Intake Rate (mm/hr) "q"	>15	15-5	5-1.5	<1.5
	'NON-PERMANENT' SOIL FEATURES			
Drainage Class "w"	Well, moderately well, rapid, excessive	Imperfect		Poor Very Poor
Depth to Water Table (m) "h"	>2	2-1.2 (if salinity is problem)		<1.2
Organic Matter % *	>2	1-2		<1
Salinity (dS/m) (m) "S1" 0-.6	<2	2-4	4-8	>8
"S2" .6-1.2	<4	4-8	8-16	>16
"S3" 1.2-3	<8	8-16	>16	
Sodicity (S.A.R.) (m) "n1" 0-1.2	<6	6-9	9-12	>12
"n2" 1.2-3	<6	6-9	9-12	>12

* No symbol is proposed for texture or organic matter. Both organic matter and texture will not be identified as a subclass limitation, but rather the associated features such as AWHC, K-Sat., etc. O.M. is important in assessing crusting and erosion.

Table 3. Landscape Features Affecting Irrigation

Landscape Features "Symbol" \ Degree of Limitation	A None	B Slight	C Moderate	D Severe
Slope (%) "t1" (simple)	<2	2-10	10-20	>20
"t2" (complex)		<5	5-15	>15
Av. Local Relief (m) "e"	<1	1-3	3-5	>5
Stoniness Class(es) (% Cover) "p"	0,1,&2	3	4	5
Inundation (Freq.) (Flooding) "i"	1:10	1:5	1:1 Annual (spring)	Seasonal 1:<1
Potential Impact on non-target, non-irrigated areas "c"	none	low	medium	high
Horizontal Variability of Infiltration "v"	very low	low	medium	high

Table 4. Methodology for Determining Irrigation Land Classes

Suitability Rating		Excellent	Good	Fair	Poor
Soil Limitations / Landscape Limitations		None 1	Slight 2	Moderate 3	Severe 4
		Irrigation Land Classes			
None	A	1A	2A	3A	4A
Slight	B	1B	2B	3B	4B
Moderate	C	1C	2C	3C	4C
Severe	D	1D	2D	3D	4D

Table 5. Definition of Individual Irrigation Land Classes

Class	Description
	Irrigation Suitability Rating - Excellent
1A	Lands have no internal or external features which limit or restrict their use for irrigation
	Irrigation Suitability Rating - Good
2A	Lands have slight limitations for irrigation due to unfavorable soil characteristics
1B	Lands have slight limitations for irrigation due to unfavorable landscape characteristics
2B	Lands have slight limitations for irrigation due to a combination of both soil and landscape characteristics
	Irrigation Suitability Rating - Fair
3A	Lands have moderate limitations for irrigation due to adverse soil characteristics
3B	Lands have moderate limitations for irrigation due to adverse soil characteristics and a slight limitation due to unfavorable landscape characteristics
3C	Lands have moderate limitations for irrigation due to a combination of adverse soil and landscape characteristics
1C	Lands have moderate limitations for irrigation due to adverse landscape characteristics
2C	Lands have moderate limitations for irrigation due to adverse landscape characteristics and slight limitations due to unfavorable soil characteristics
	Irrigation Suitability Rating - Poor
4A	Lands have severe limitations for irrigation due to deficient internal soil characteristics
4B	Lands are poor for irrigation due to severe limitations of internal soil conditions and slight limitations due to landscape characteristics
4C	Lands are poor for irrigation because of severe internal soil limitations and moderate landscape limitations
4D	Lands are poor for irrigation because of severe soil and landscape limitations
1D	Lands are poor for irrigation because of severe landscape limitations
2D	Lands are poor for irrigation because of severe landscape limitations and slight soil limitations
3D	Lands are poor for irrigation due to severe landscape limitations and moderate soil limitations

Table 6. General Descriptions of Irrigation Land Classes

Irrigation Land Classes	Suitability Rating	Description
1A	Excellent	Lands in this class have no significant limitation(s) for irrigation. Lands in this class are capable of producing a sustained and relatively high yield of a wide range of climatically adapted crops. The soils are medium textured, well drained, and hold adequate available moisture. Harmful accumulations of soluble salts are absent from the soil and topography is level to nearly level. These lands are generally considered to be irrigable.
2A 2B 1B	Good	Lands in these classes have slight limitations for irrigation due to unfavorable characteristics of either the soil or landscape or both. A narrower range of crops or slightly more input to development and management may be required. They can be maintained or possibly improved with proper management. The soils in these classes may be heavier or lighter in texture than soils in Class 1A. The specific factor(s) limiting irrigation use of these lands is designated by connotative lower case symbol(s) following the land class symbols.
3A 3B 3C 1C 2C	Fair	Lands in these classes have moderate limitations for irrigation use due to deficient characteristics of either the soil, the landscape or a combination of both. The soils may be inferior because of excess salinity, sodicity, very low hydraulic conductivity or low water holding capacity. The specific factor(s) limiting irrigation utilization of these lands will be designated by connotative lower case symbol(s) following the land class symbols. Greater management input as well as more intensive soil conservation and improvement practices are required for this group of soils than for the soils in the good category.
4A 4B 4C 4D 1D 2D 3D	Poor	Lands in these classes have severe limitations for irrigation use due to adverse characteristics related to either the soil, the landscape or a combination of both. These lands may have some limited use under irrigation but generally their limitations are so severe that they do not form suitable irrigation-farm units. Special crops, irrigation system designs, and special soil and water management practices will be required to irrigate any lands in this category. In general these lands are considered to be restricted or unsuitable for sustained irrigation use.

Table 7. Correlation of New Ratings with Approximate Equivalent Ratings Presently used in each of the three Prairie Provinces

New Rating	Approximate Equivalent Rating		
	Alberta	Saskatchewan	Manitoba
1A	1 $\frac{ST}{11}$	1	1
2A	2 $\frac{ST}{21}$	2	2S
1B	2 $\frac{ST}{12}$	-	2T
2B	2 $\frac{ST}{22}$	2	2ST
3A	3 $\frac{ST}{31}$	3	3S
3B	3 $\frac{ST}{32}$	3	3ST
3C	4 $\frac{ST}{33}$?	3	3ST
1C	4 $\frac{ST}{13}$?	-	3T
2C	4 $\frac{ST}{23}$?	-	3TS
4A	5 $\frac{ST}{41}$?	4	4S
4B	5 $\frac{ST}{42}$? 6 $\frac{ST}{42}$?	4	4ST
4C	5 $\frac{ST}{43}$? 6 $\frac{ST}{43}$?	4	4ST
4D	-	4	4ST
1D	6 $\frac{T}{4}$	-	4T
2D	-	-	4TS
3D	-	-	4TS

SOIL DEGRADATION WORKING GROUP REPORT TO EXPERT COMMITTEE ON SOIL SURVEY 1984

REVIEW - The proceedings of the 3-day working group meeting, preceeding the ECSS meeting, were summarized and reviewed. These proceedings are presented on pages 2 to 11 of this publication, and are not repeated here.

RECOMMENDATIONS TO ECSS, NOV. 28, 1984

NEW RECOMMENDATIONS

1. It is recommended that the soil survey section of LRRI be provided with the resources required to complete the generalized soil landscapes maps of Alberta and New Brunswick, and prepare similar maps of the agricultural regions of the south and interior of British Columbia, Quebec and Newfoundland, in order that small-scale maps of extent and risk of soil degradation related to agricultural practices can proceed uniformly across the country.

2. It is recommended that the soil survey units be provided with the resources required to assess and record on generalized soil landscape maps the extent and severity of past soil erosion, using existing data, information provided by knowledgeable individuals in each region of each province, air photos, field observations and professional insight. The project should be coordinated to provide consistency of interpretations between regions.

3. It is recommended that each soil surveyor be requested to record the severity of past erosion, observed during new and ongoing soil surveys, on the daily form, on the detailed form and as part of the map symbol. This will provide a data base for comparisons in future years. Consistency of classes used must be reviewed.

4. It is recommended that the soil survey units be provided with the resources to prepare generalized erosion RISK maps, using the USLE to indicate average rainfall erosion potential, excluding spring conditions, and in the prairie provinces, using the wind erosion equation to indicate average annual wind erosion potential.

5. It is recommended that resources be provided to LRRI to have climate station and existing erosion research data analyzed to identify, and compute the probability of, severe winter-spring water and wind erosion events, and estimate the importance of these relative to the average summer or annual erosion predicted by the USLE and wind erosion equation. Where soil erodibility and movement data are inadequate or lacking, resources should be made available to have additional research undertaken.

6. It is recommended that LRRI provide criteria to soil surveyors to identify man-induced compaction encountered in soils during soil surveys, and that soil surveyors record the incidence of any compacted layers on the detailed and daily forms at all affected sites.

7. It is recommended that resources be provided to LRRI and soil survey units to investigate reported soil compaction, and develop procedures or models to predict its occurrence, estimate its significance to soil productivity,

and permit mapping to proceed.

8. It is recommended that the LRRI undertake a thorough evaluation of the requirements of a long-term monitoring program in which representatiave sites in all regions would be characterized and monitored for changes in degree of erosion, compaction, salinity, acidity, organic matter content, productivity, and other pertinent factors to permit regional assessment of the state of the soil resource. Resources should be provided so that actual sites can be selected and established as soon after this evaluation is completed as possible.

REPEATED RECOMMENDATIONS

Recommendations remain as presented in 1983 for salinity, acidity, contamination and loss of organic matter.

PROGRESS REPORT ON A MANUAL FOR THE INTERPRETATION OF LAND RESOURCE SURVEYS FOR FORESTRY

D.E. Moon

This will be a brief update on the progress of the Working Group on Forestry Interpretations chaired by Dr. H.H. Krause. At last year's meetings the working group submitted a brief outline for the production of a national document pertaining to soil evaluation for forestry and recommended that the task of producing the document be taken on by the Land Resource Research Institute. Subsequent to the meeting D.E. Moon was assigned as the editor with the task of preparing sections I and II, editing the examples of regional interpretations to be presented in section III and seeing the production through to completion. H.H. Krause agreed to continue in the role of chairman until December 1984, to collate the regional examples, and to submit them to the editor for inclusion in the document.

A meeting to work out a more detailed outline of the manual and to finalize the contributions to be made was held in March, 1984 at Fredericton N.B. It was attended by R.K. Jones, H.H. Krause, D.E. Moon, H.W. Reese, and K.W.G. Valentine and produced the attached outline of a manual for Soils Interpretation for Forestry. Subsequent to that meeting Moon proposed a format for the regional examples which was distributed to the contributors. A copy of the proposed format is also attached. An initial deadline of March, 1985 for completion of the first draft was proposed but is unlikely to be met. A draft should be completed before the end of 1985.

Attachment 1: An outline for the proposed manual

Soils Interpretation for Forestry

1. INTRODUCTION

   1.1 Purpose
   - who is reader 1° soil surveyor 2° forester
   - assist in interpreting the way in which land properties may limit the use of land for forestry
   - why was it produced
     - consistency
     - make available existing knowledge
     - ensure documentation of how and why that approach

   1.2 Aspects of Forestry Addressed
   - included
     - silviculture, hazards, engineering
   - does not include
     - urban forestry, parks, highways

   1.3 What is Being Interpreted*
   - land
     - soil, climate, vegetation, landform (F.A.O. defin.)
       - use those which are relevant to the interpretation
       - do not use economics, socal preference, market, etc.
     - deals with attributes regardless of source or data (eg soil surveys, biophys, etc.)

   1.4 Interpretations and Planning
   - does not deal with suitability, feasibility, capability include defn's
   - evaluates limitations of land
   - only one step in planning discuss

   1.5 Outline of Manual
   - rest of manual discusses the following things in the following order

   * Interpretations = predictions

2. METHODS (How to make interpretations)
   PRINCIPLES OF INTERPRETATIONS

   2.1 Approaches
   - empirical vs process based models (with examples
   - implications of each to
     - development and application
     - scope, sampling etc.
   - nature of algorithm, weighted classes, penalty points, etc.

2.2 Kinds of Interpretation
- quantitative - interval — S.I.
- qualitative
  - categoric unranked — species that will grow
  - categoric ranked — limitation to off road traffic

2.3 What do you interpret (interpretive individual)
- 2.31 To what data do we apply model
  - single record
  - summaries of multiple records
- 2.32 To what do we attach the data
  - point
  - single area
  - class
  - map unit

2.4 Interpretations in relation to scale intensity (S.I.L.) and reliability (predictive ability)
- 2.41 Nature of the data base and the nature of the interpretation (info appropriate to interp)
- 2.42 discuss S.I.L.

SIL 3-4 scale	1:50,000 - 1: 125,000	regional planning
SIL 2-3	1:20,000 - greater	operational planning
SIL 1	1: 2,000	nursery

- 2.43 factors influencing reliability
  - accuracy of data base (map)
  - appropriateness of algorithm
    - is the necessary data available
    - scope of application (is it applicable to area and this interp.)
    - does it work
- 2.44 methods for determining confidence limits of interps
  - tests for
    - ordinal — categoric unranked
    - ranked — categoric ranked
    - interval — quantitative
  - requires definition of classes
    - rank position on, absolute value or does it fit classes

2.5 Documentation, Presentation, Checklist
- definition of particular interpretation and classes
- define assumptions (ie ecosion assumes have mineral soil)
- statement of algorithm
  - matrix, formula, key etc.
- define conditions under which applicable (scope)
  - limitations
- confidence
  - statistical
  - non-statistical

2.6 Presentation
- tables
  - polygon
  - class
  - map work
- maps
  - class
  - legend (open closed)
  - symbol (complexity)

3. INTERPRETATIONS AND/WITH CASE STUDIES (Regional Examples)

3.1 Intent of Section to produce:
- state of the art discussion only, not necessarily the recommended approach
- examples where applicable
- warning not to use uncritically, indiscriminately
- organization of section silvics, engineering, hazard

3.2 Soil interpretations for Forest Roads
a. suitability of soil as a material for the construction of forest access roads
   - subgrade and surface
   - include bedrock rippability
   - exclude location, access
b. Soil limitations that may be encountered in the building or use of forestry access roads in a particular place

3.3 Off-road operations
a. Soil limitations to off road trafficability (transportation)
   The constraints (degree or kind) that soil attributes have on the movement and operation of machines across forest land, considering only traction, suppot and manoueverability. The effects such as compaction as opposed to the east of mechanized operations are the subject of a separate interpretation (3.3.b)
b. Susceptability to compaction
   The liklihood that forest operations will reduce future production by altering the existing soil structure or porosity, bulk density etc.
c. Susceptability to disturbance of organic soils
   The liklihood that forest operations will reduce future productivity by altering the existing surface properties to limit access or produce an unfavourable rooting medium

3.4 Soil potential to yield sediment following disturbance due to forest operations
a. Road construction
b. Site treatment and harvesting

3.5 Potential for mass movement following road construction
- the potential for shallow planar failtures in non-cohesive granular materials following disturbance

3.6 Soil limitations to the windfirmness of trees
- the degree to which soil properties limit the ability of a tree's root system to support it against the force of wind

3.7 Forest Productivity
- statistical determination of classes of site index by species for defined soil classes as soil map units
- what about inadequate sample size? Go outside survey area?

3.8 Forest Regeneration
The degree to which soil attributes may restrict the successful establishment of new forest growth following harvesting
- water excess or deficit
- aeration, temperature

3.9 Tree Species Suitability
- some information pertaining to this can be found in section 3.7
- other factors such as market, resistence to disease etc. must be considered
- concept requires further research/development in order to be applied with confidence under Canadian conditions

4. SUMMARY AND CONCLUSIONS

Attachment 2: The format for submissions to Section III "Regional Examples of Soil Interpretations for Forestry".

INTERPERETATION TITLE

Author

SYNOPSIS

Definition: The definition should identify, in precise terms, what interpretation is being made.

Applicable Conditions: Outline the conditions under which the interpretation is valid and, if necessary, the conditions under which it is not.

Classes: Define the interpretive classes to be used. Be quantitative if possible. At a minimum, give unambiguous definitions. Where applicable, translate ratings into management terms (eg. area disturbed, expected yield, etc.).

Information Required: List the precise information which will be required to make the interpretation. This should include all variables or properties used to calculate or estimate any required parameters

The Interpretive Model: Give a concise form of the model which emphasizes the concepts being used rather than the specifics of calculating or estimating the necessary properties. For example, present the interpretive table being used or the form to be used when summing, not assigning, penalty points.

RATIONALE FOR THE INTERPRETATION

Discuss the basic theory being applied to the interpretive procedure. Explain the concepts and assumptions being used in enough detail so that the readers can evaluate the validity and the limitations of the interpretation for application to their conditions.

Discuss factors which are unavailable from the land resource inventory but will influence the interpretation. Explain the consequences of ignoring these factors.

THE INTERPRETIVE PROCEDURE

Present, in detail, the actual procedure to be used in arriving at the interpretation. For example, the form and steps to be followed when assigning penalty points. Discuss the methods available for estimating necessary parameters and the method of calculating, weighting, or shuffling them to produce the final interpretation.

SOURCES OF ERROR

For each variable or property disccuss:

1) Possible sources and magnitudes of error
2) The influence errors will have on the interpretation
3) The level of confidence which should be placed in the interpretation and whether it tends to err on one side or another.

CONCLUSIONS

Reiterate important points (eg. applicable conditions, limitations, etc.).

SOIL SALINITY MAPPING GUIDELINES

Progress Report to the ECSS Working Group on Soil Degradation

R.G. Eilers

The terms of reference for the Working Committee on Soil Salinity were as follows:

A. To develop a standardized approach to assessing the salinity status of prairie region soils by proposing a set of guidelines and criteria for:

   I. Diagnosing
   II. Defining
   III. Classifying, and
   IV. Mapping Saline Soils

B. To develop a legend and small scale map (1:1 M) of saline soils on the prairies.

The Working Committee held a meeting (March 16, 1984) in Saskatoon to discuss the above objectives. At this meeting, a preliminary outline of the criteria and terminology were proposed. This outline has been reviewed once and is now in the process of a second revision. A progress report of the highlights is presented here.

A. STANDARDS FOR:

I. Diagnosis

The recognition and identification of soils containing sufficient concentrations of soluble salts to adversely affect crop production is a primary requirement for mapping soil salinity. To aid in the diagnosis of soil salinity, the following list of "field clues" and procedures has been prepared. Note that these are indicator clues only and that the actual level of salinity can only be determined by soil sampling and laboratory analyses. The presence of one or more of these "field clues", however, should be very helpful in determining the existence of a salt problem and where and when to sample:

1. Presence of white salt crusts on the soil surface.
2. Presence of white (gray) salt precipitates (crystals) in the soil profile.
3. Presence of salt tolerant native vegetation such as: Saline Goosefoot (Chenopodium salinum), Red Samphire (Salicornia rubra), Alkali Grass (Distichlis stricta), Salt Meadow Grass (Puccinella spp.), and Sea Blight (Sweeda depressa). Other plants common to saline areas, although not necessarily indicative of salinity include: Kochia, Russian Thistle, Wild Barley, Gumweed, Smartweed, and Cockle Bur.
4. Presence of high levels of salinity will produce barren spots and stunted growth in forage and cereal crops.

5. The presence of low levels of salinity will cause irregularity of growth and reduced crop vigor.
6. Abnormally wet areas in the field could indicate potential salinity development.
7. Presence of lush green growth of crops in localized areas of the fields may foretell the development of salinity.
8. The presence of abnormal leaf conditions such as tip burn and firing along the margins, stunted plants and withering of lower leaves, and the presence of deep blue-green colored foliage.
9. EM38 - An electronic device using electro-magnetic induction principles to detect soluble salts in soils. Once calibrated to soil texture and salt content, it can be extremely useful for detecting salinity when visual soil and plant indicators are not present.
10. Sample and Analyze - The only way to quantitatively determine the depth, type and degree of soil salinity. The saturated paste extract procedure (or equivalent) is the recommended method.

II. Definitions

The Working Committee proposes the following guidelines for adoption and use in assessing and describing the soluble salt status of prairie region soils.

1. Terminology - It is proposed that "soil salinity" be used as the standard term in reference to the status of soluble salts in soils.

   Most reviewers felt that the term "salt-affected" was too broad and, therefore, potentially confusing to the general public.

2. Control Section - It is proposed that the soluble salt content of the soil be determined according to the average salinity level within a bi-level control section.

   This bi-level control section is defined as 0 to 60 and 60 to 120 cm, and will be referred to as the upper and lower root zone, respectively. The rationale for selecting each level is as follows:

   0-60 cm
   - upper root zone (70-80% of roots mass)
   - conforms to standard depth recommended for soil testing
   - approximates depth of horizontal reading of EM38

   60-120 cm
   - lower root zone (20-30% of root mass)
   - maximum depth often used for reporting available soil moisture
   - approximates maximum depth of vertical reading of EM38
   - salts in this zone represent more of a potential than actual hazard for crop production

   Any number of soil samples can be taken within these depths to determine the average EC value. The method used to determine the average EC value for each level of the control section should be

explained in the map legend or report. The recognition of salts in the lower part of the root zone (60-120 cm) is one way of identifying potential areas for increasing salinity if land management is not cognisant of its presence.

3. Electrical Conductivity - It is proposed that the average EC value for defining a saline soil be lowered from 4 dS/m to 2 dS/m within 60 cm of the ground surface.

   The tolerable level for soluble salts in the upper rooting zone as determined by the electrical conductivity of a saturated paste extract, has been defined for general application purposes at 4 dS/m (Handbook 60). However, this level of salinity is sufficient to adversely affect the growth of the more sensitive, mainly non-cereal crops, "special crops" such as corn, beans, peas, horticultural and vegetable crops.

4. Sampling - It is recommended that fall sampling be the standard reference for diagnosing, sampling and characterizing salinity.

   The salt distribution patterns are generally more stable and the vegetation indicators are most strongly expressed at this time of year.

5. Measurement - It is recommended that the saturated paste method be used as the standard procedure for determining the level of salinity in soils.

   If other methods are used, such as the 1:1 or 1:2 soil water suspensions, the EC values should be converted to saturated paste equivalent. A conversion table will be developed to facilitate this conversion.

III. Classification

The classification of soil salt status will be based on the "limiting factor" concept. This means that classes will be determined by whichever level of the control section has the highest concentration of soluble salts. Five classes of salinity are recognized: non, weak, moderate, strong, and very strong. Standard definitions for each depth and class are presented in Table 1. Each class is allowed to have a higher concentration of soluble salts in the lower part of the control section because of its generally lower content of plant roots and, therefore, lesser adverse impact on plant growth. Standard designations shall use the convention of "depth" (a or b) followed by "class" (1, 2, 3, 4 or 5).

e.g.	a1b1	non-saline
	a2b1	weakly saline
	a2b3	moderately saline
	etc.	

Table 1. Criteria for Classifying Depth and Severity of Soil Salinity

	Class (dS/m)* / (cm) Depth	Non	Weak	Moderate	Strong	Very Strong
a	0-60	<2	2-4	4-8	8-16	>16
b	60-120	<4	4-8	8-16	16-24	>24

* Det. by Sat. Paste Extra. Method.

IV. Mapping

Mapping salinity presents special problems because of the extreme variability of soluble salts in the soil. As previously discussed, many factors must be taken into consideration when mapping salinity, for example: the level or severity of salinity, the depth of salinity in the soil, the type and location of salinity in the landscape and the probable origin of the soluble salts. Determining the class of salinity consistently without extensive sampling and measurement must therefore rely heavily on the recognition and extrapolation of visual soil and vegetation indicators of salinity as well as on some ancillary land use patterns. The detail and accuracy of mapping also depends upon the scale of the map. To some degree, the level and extent of significant salinity depends upon the relative tolerance level of the crops to be grown. As a general guide, an EC level of 4 dS/m is commonly used as the critical cutoff level for saline and non saline soils for generalized small scale maps. Narrower salinity classes may be more useful for detailed salinity maps.

B. DEVELOPMENT OF LEGEND AND SMALL SCALE MAP (1:1 M) OF SALINE SOILS ON THE PRAIRIES

It is proposed that a three to four component approach to mapping salinity could be adopted for a general salinity map at a scale of 1:1 M. It is also proposed that the generalized soil landscapes map be used as the base. The components include an assessment of:

1. Severity - Utilizing a combination of the components previously described; a general ranking of severity may be feasible according to weak, moderate, or strong.

2. Area Affected - An indication of the extent of salinity in each map delineation would be attempted using a minimal number of 3 to 5 defined classes.

3. Location - This component would attempt to indicate where salinity would most likely occur within the map delineation and thereby, possibly indicate the most probable source or cause of salinity.

4. Type - This component would attempt to differentiate the different types of salinity. This may also be a useful indicator of the probable origin of the soluble salts in the soil.

This legend is preliminary and will be used to produce a preliminary regional map of soil salinity for the prairies. It is proposed that this map be prepared for field edit and testing during the 1985 field season.

SOIL CLIMATE WORKING GROUP PROGRESS REPORT

G.F. Mills

INTRODUCTION

The Soil Climate Working Group activities, although removed from the ECSS list of work priorities for the next 2 years, are being maintained at an operational level to ensure that data collection, analysis and evaluation be continued. The purpose of this report is to provide an update on working group activities during 1984. A brief summary of reports submitted by regional working group members is presented here.

REGIONAL PROGRESS REPORTS

British Columbia - R. Trowbridge

Budgetary restraint has necessitated dismantling all long term monitoring sites maintained by B.C. Ministry of Forests and the Ministry of Environment. Analysis of currently available long term soil climate data will be done in 1985. Current emphasis on fire ecology research will include the impact of management and soil climate on conifer productivity. This program will permit continuation of some soil climate studies. Sites monitored by the Ministry of Agriculture are being maintained.

Alberta - R. Howitt

Ten monitoring sites have been terminated; data was thought to be adequate for some sites and others were deleted as soil inventory activity was shifted to other survey areas. Increasing costs of servicing remote sites has resulted in establishment of a second site utilizing a data logger to automate the monitoring of aerial and soil climate data. No analysis of data has been attempted but this will receive a high priority in 1985.

Saskatchewan - R.J. St. Arnaud

Soil climate monitoring activities in Saskatchewan are being maintained through the FARMLAB program. There was no installation of new sites and no analysis of longer term data has been attempted.

Manitoba - G.F. Mills

Longer term sites in northern and eastern Manitoba are no longer monitored on a regular basis as existing data is thought to be adequate. Detailed benchmark sites are being maintained and monitored and several new sites have been installed to increase the efficiency of the monitoring network in southern Manitoba. A mixed-woods site in the central Boreal Forest was instrumented and the thermal regime is being compared with soil temperatures in an adjacent clear cut site planted to jack pine.

Ontario - D. Aspinall

Monitoring and data collection was continued with no change from the status reported in 1984. Most data collected to date resides with the collecting organization and no analysis of data has been attempted on a provincial basis.

Quebec - J-M. Cossette

A detailed study to monitor soil temperature, water table and aerial climate was initiated at 4 sites near St. Hyacinth. This cooperative study involving the Quebec Soil Survey, the Agrometeorology Section and the Department of Soil Science at Laval University is monitored on a weekly basis and the data is being related to the growth of corn. In 1985, three additional crops will be monitored. The study is expected to continue for 3 years.

A second soil climate study was established on 10 sites with a range of soil properties in the St. Lawrence Lowland. This project is part of a Ph.D. graduate study.

New Brunswick - H. Rees

As of November, 1984, there are 15 active soil climate monitoring sites in New Brunswick (reduced from 29 sites in 1983). The Canada-New Brunswick Soil Survey Unit is monitoring a network of 11 sites (a reduction from 21 sites due to vandalism, clear cutting, destruction by animals and to a minor extent, sensor failure). A cooperative effort with AES personnel at one AES meteorological station has worked satisfactorily and considering staffing restraints, monitoring on a province-wide basis will have to be approached in a similar fashion. Future instrumentation will be based on thermistor type sensors and unless cooperation is arranged with AES, will be confined to the headquarters region (Fredericton Research Station) or to an active survey project area.

Nova Scotia - K. Webb

During 1984, the Canada-Nova Scotia Soil Survey has expanded its soil temperature monitoring network from 24 to 30 sites. Five of the new sites are positioned in close proximity to recently established weather stations. All sites utilize diodes as sensors and are now installed with a free (non staked) technique to circumvent frost heave and avoid any error in observation resulting from influence of the wooden stake. All data up to July, 1984 has been encoded and submitted to CanSIS. Analysis for 3 sites have been completed.

Newfoundland - A. Stewart

Limited monitoring of water table and frost penetration was initiated near St. John's. Water tables were observed to lower during freezing periods and rise when temperatures are rising. Vandalism was a problem with some installations and the accuracy of the frost tubes for depicting very shallow frost penetration is in doubt. A study of cryoturbated

ground utilizing reference pegs at 4 sites was initiated and frost movement and heaving was monitored over one winter. It is expected that this current level of activity is all that can realistically be maintained with the extremely limited resources available to the soil survey unit.

Yukon - S. Smith

Eight soil temperature sites were installed on a variety of northern boreal and subarctic ecosystems. Instrumentation was by thermistors and monitoring is done by cooperators at each site every 2-4 weeks. Monitoring will continue next year and an additional research site will be established to study change in the permafrost table upon cultivation of Cryosolic soils.

Northwest Territories - C. Tarnocai

Maintenance and repairs were completed on all sites in the Inuvik area. A new technique for installation of the thermistor probes was employed using a "slurry" of water and soil material similar to the materials at each benchmark site to freeze the probe into the borehole. It is hoped that this method will prevent frost heaving of the probe. All recent temperature measurements have been encoded and the data for each site have been analyzed.

Agrometeorology Section - A. Bootsma

Soil temperature data archived by A.E.S. have been acquired by the Agmet section for archiving and data analysis. These data are being scrutinized for completeness of record and will be used to evaluate procedures used in monitoring and analyzing soil temperature data by the Soil Climate Working Group. In addition, the data will be used to improve the existing soil temperature model to better predict average monthly soil temperatures in the Maritime provinces.

Data Handling - CanSIS - K.B. MacDonald

Currently in the monitoring file of CanSIS, there are some 12,215 records of soil temperature values. Reports similar to those presented at the 1983 Workshop for Manitoba data have been produced for British Columbia, Northwest Territories and Nova Scotia. These data handling procedures are routine and available.

SUMMARY

All soil survey units report continuation of soil climate working group activities although budgetary restraint has seriously curtailed monitoring in some regions. Longer term data from British Columbia, Nova Scotia and the Northwest Territories have been submitted to CanSIS and are being analyzed.

Modification to existing installation procedures have been developed and are being evaluated in the Northwest Territories and Nova Scotia. These techniques will be included in the revisions to the Methodology for Monitoring Soil Temperature.

The Agrometeorology Section of LRRI has archived AES soil temperature data and is initiating additional analysis in support of working group activities.

RECOMMENDATIONS

Although progress has been made in achieving Working Group goals, two areas of concern expressed at the 1983 workshop have not been adequately addressed:

1. Methodology for Monitoring Soil Temperature

   No progress was made on revisions to the "Methodology". Working Group members recommend that revisions be made to the "Methodology" as quickly as possible. A loose-leaf format should be adopted to facilitate updating of the "Methodology" as new techniques and instrumentation develop. The "Methodology" should include documentation of available techniques for automating data collection from benchmark sites.

2. Standardization of National Monitoring Network

   Evaluation of available sensors indicates several advantages to using thermistors. Thermistors are also compatible with sensors utilized by the AES soil temperature network. The relatively high cost of thermistor instrumentation if purchased in small quantities is prohibitive for individual survey organizations. A major saving can be achieved through the bulk purchase of thermistors sufficient for the instrumentation of the national network. The bulk purchase should be through a central agency such as Land Resource Research Institute. Each survey unit would be responsible for assembly of their own sensor probes with local budget.

ACKNOWLEDGEMENTS

The chairman of the Soil Climate Working Group acknowledges regional input provided for this progress report: R. Trowbridge (British Columbia), R. Howitt (Alberta), R.J. St. Arnaud (Saskatchewan), D. Aspinall (Ontario), J-M. Cossette (Quebec), H. Rees (New Brunswick), K. Webb (Nova Scotia), A. Stewart (Newfoundland), S. Smith (Yukon), C. Tarnocai (Northwest Territory), A. Bootsma (Agrometeorology Section) and K.B. MacDonald (CanSIS, Land Resource Research Institute).

PROGRESS REPORT ON DATA QUALITY AND METHODS OF ANALYSIS

P.W. HALUSCHAK

Activities of this working group have been limited to standard sample analysis and revisions of method manuals.

Results of analysis of a sample 83.01 previously distributed to laboratories have been received. These results are being summarized and will be returned to the respective laboratories for examination.

An Analytical Methods Manual (1984) has been prepared by B.H. Sheldrick and provides methods of analysis currently in use at the Land Resource Research Institute, Ottawa. Statements of accuracy and precision have been included whenever sufficient data was available.

A similar manual has been prepared by P.W. Haluschak for procedures presently being used by the Canada-Manitoba Soil Survey laboratory in Winnipeg. Error values are provided for most methods and an indication of the time required to perform these analyses is also noted. The inclusion of standard or reference samples in batch analyses is used as a check of data quality.

Six bulk samples of organic soils have been collected during the 1984 field season by the Land Resource Research Institute. These will be used to provide subsamples for analysis by laboratories in the development of reference samples. Allen Eagle will be responsible for the distribution of the samples to participating laboratories.

Concern has been expressed as to the quality control procedures in laboratories, continued and expanding use of standard samples, and editing of analytical results and data-entry into CanSIS. Therefore these should be the focus of activities for the coming year.

BRITISH COLUMBIA REPORT TO 1984 MEETINGS OF EXPERT COMMITTEE ON SOIL SURVEY - NOVEMBER 26 - 30/84, GUELPH, ONTARIO

H.A. Luttmerding, P.Ag.

Provincial restraint continues to prevent me from attending and participating in the annual meeting of the Expert Committee on Soil Survey. Terry Lord has again kindly agreed to act as the official provincial representative and for this I would like to extend to him my sincere thanks and appreciation.

In spite of restrain, substantial advances in soil survey and related endeavours has occured during 1984. These are highlighted in the following:

1) Progress has continued during 1984 in Computer Assisted Planning and Map Production (CAPAMP). In addition to the computer derived/interpreted maps and summaries reported last year, soil drainage and agriculture management group maps for the Lower Fraser Valley and parts of eastern Vancouver Island have been produced. Reports dealing with the agricultural management groups have also been published. Example maps rating soils for their constraints to septic tank effluent absorption has also been generated and a report detailing the methodology for determining the constraints has been published.

A CAPAMP based land evaluation pilot project centering on Langley Municipality in the Lower Fraser Valley has been initiated to explore various agricultural cropping and management scenarios. Initially the data base will consist of soils, crop suitability/productivity, agricultural capability, agricultural land reserves, parcel size and present land use.

2) The detailed soil survey of eastern Vancouver Island continued during 1984 with the mapping of about 38,000 ha. The interim report covering the Duncan-Nanaimo portion is nearing publication while field work was completed in the Qualicum Beach-Parksville area and new mapping initiated in the Courtenay-Comox area. The project is basically designed to provide detailed agricultural capability information for 'fine-tuning' Agricultural Land Reserves as well as other soil data needed for agricultural and urban land management.

The high intensity (1,20:000) survey of the Gulf Islands by the federal soil survey unit continued as well, with mapping being completed on Kuper and many small islands, as part of Volume 3 report area (Galiano, Valdes, Thetis, Kuper and lesser islands) and with 60% of the mapping being completed for Gabriola island and lesser islands near Nanaimo (Volume 4 report area); area surveyed in 1984 was 5500 ha. The report covering Saltspring Island (Volume 1) has been completed and Volume 2 (Pender. Prevost, Mayne, Saturna and lesser islands) will be completed next spring.

High intensity surveys were also conducted by the federal unit of three Indian Reserves in the Peace River to identify potentional development opportunities; the supervision of a detailed soil survey of a number of small reserves in the Central Interior was carried out. Soil maps @ scale 1:100,000 and reports were published or submitted for publication, for the Horsefly, Barkerville, Taseko Lakes, Williams Lake, and Nazko areas in the Cariboo and for the Fort St. John-Dawson Creek and McAllister-Graham areas in the Peace River District. These reports, covering about 6,750,000 ha were produced with the assistance of a contracting pedologist.

3) Land Capability for Agriculture ratings for the Lower Fraser Valley are being revised according to the methodology in "Land Capability Classification for Agriculture in British Columbia", MOE Manual, Ministries of Environment and Agriculture and Food, 1983. The revision, at 1:25,000 scale, updates the CLI ratings developed in the late 1960's and early 70's and presents the new ratings at a more detailed scale. Updated agricultural ratings, using the 1983 manual, are also being generated as part of the detailed survey of eastern Vancouver Island. As well, the 1983 methodology has been applied in revising ratings in the Pine Valley.

4) A 1:2 mil provincial map, entitled "Soil and Geologic Characteristics Significant to Acidic Input Sensitivity" has been produced as part of the LRTAP program. Two derivative maps have also been produced. The first, "Potential of Soils and Geology to Reduce Acidity of Incoming Acidic Deposition", identifies the ability of soils and terrain to ameliorate acidic inputs as they affect waterbodies. The second, "Soil Sensitivity to Acidic Inputs", rates the ability of soils and terrain to resist acidic inputs and indirectly indentifies those areas which, from the standpoint of agriculture and forestry, are most sensitive to increased acidic inputs.

The Canadian Forestry Service is establishing long term soil and vegetation monitoring sites as part of ongoing LRTAP studies. Three sites, located at Shawnigan Lake, UBC Research Forest and on Saltspring Island, are currently in place.

5) An atlas (1:50,000 scale) dealing with grape production in the Okanagan and Similkameen valleys is currently at LRRI for publication. The atlas, based on soil and climatic parameters, provides information and ratings regarding suitability (or limitations) for commercial grape production in these valleys.

6) Soil and terrain mapping in support of wildlife interpretations continued to be a priority during 1984. Small scale mapping covering the equivalent of one 4-mile sheet was completed in parts of 104H, 94E and 104A and forms, together with vegetation mapping, the basis for ungulate capability and habitat studies in the area.

Similarily, soils, terrain and vegetation mapping at 1:50,000 scale was completed of Wells Gray Provincial Park and will form the basis for ungulate capability and habitat interpretations in the Park. Areas identified as having high potential for habitat enhancement (for moose mainly) will be studied in more detail during 1985.

7) Several mapping projects relating mainly to watershed stability and water quality/quantity were undertaken during 1984. Detailed terrain (surficial geology) mapping was completed in three coastal watersheds (Champman, Norrish and Cascade Creeks) in which substantial forest harvesting has occurred. Several interpretive products dealing with geologic hazards (e.g. mass wasting) are anticipated in addition to supporting reports quantifying anticipated debris entering watercourses.

Detailed soil and terrain mapping was also completed in the Nelson City Watershed (about 10,000 ha.). Logging in the watershed is anticipated in the near future and the study is aimed at providing information for planning pur-

poses. Products include, among others, erosion/sedimentation potential and slope stability (geologic hazards) interpretations and interpretations relating to regeneration, road location, harvesting method and other forest management.

8) The B.C. Ministry of Forests Ecosystem Classification program is continuing with the major field work mainly completed in most forest regions. Pilot mapping projects at the ecosystem level are being conducted in the Prince Rupert, Vancouver and Kamloops regions to define methodology and miniumum standards. These are required since subsequent mapping will be carried out by industry in areas where preharvest assessment is required. The Humus Form Classification system continues to be used and tested throughout the province.

9) Various aspects of soil degradation continues to be a focus of endeavour. The Fish/Forestry Interaction program on the Queen Charlotte Islands is addressing the impact of forest harvesting induced mass-wasting on fish habitat. Studies include documentation of frequency and size of natural and man related landslides, their effect on forest productivity and the success or rehabilitation techniques. Methods to reduce mass wasting using alternative harvesting methods and improved planning are also in progress.

Serveral studies, under the auspices of CFS and BCMOF, continue with regard to skidder logging. More specifically, these include the effect of rutting (formed during wet conditions) and downhill skidding on forest productivity.

The B.C. unit of LRRI continues to measure agricultural erosion at three sites in the Peace River area while BCMA&F maintains a measuring and monitoring site in the Lower Fraser Valley. BCMOF continues monitoring of erosion and sediment control by grass seeding of forest roadsides.

10) Several studies throughout the province have been initiated by the BCMOF aimed at quantifying soil climate (moisture and temperature regimes). An intergrated study has been initiated to determine the effect of site treatment on establishment and growth of white spruce through improved soil warming and drying. The competition for soil moisture between Douglas-fir and salal understory is being determined by observing the effect on the tree's water balance, photosynthesis and growth when the salal is removed.

11) A new soils course is being offered by the Soils Department at UBC which emphasizes the field aspects of soil survey - identification, mapping and description, together with interpretations. The course is mainly presented by staff of LRRI in Vancouver, with support from others as required. Eight students are currently enrolled. The course utilizes a 35 ha farm in Langley as a case study.

A major reorganization of the Surveys and Resource Mapping Branch, BCMOE, occurred in the fall of 1984. The Branch used to contain the majority of the provincially employed pedologists and surficial geologists whose primary responsibility was mapping, classification and related interpretations. With the reorganization, most of these personnel are now transferred/relocated to other Branches in the Ministry (i.e. Waste, Water, Fisheries and Wildlife Management Branches), resulting in only a core of four remaining with the Surveys and Resource Mapping Branch. Although assurances have been given that

the transferred staff will be available for soil/surficial geology surveys if required, the future ability of the Surveys and Resource Mapping Branch to rapidly respond to mapping requests may be substantially curtailed. Additionally, the provincial soil survey laboratory has been amalgamated with BCMOA&F's Soil, Feed and Tissue Testing Laboratory.

EXPERT COMMITTEE ON SOIL SURVEY
ALBERTA REPORT

T.M. Macyk

This report briefly describes some of the current issues and concerns relative to soil inventory and land use in Alberta as well as some of the strategies in place or proposed to address these concerns. The information provided herein is summarized from a number of sources including the Subcommittees of Alberta Soil Advisory Committee, the Alberta Institute of Pedology and Alberta Agriculture.

Soil/Land Inventory and Data Management

Soil/land inventories in Alberta are conducted by several public and private sector organizations for a variety of purposes. At present, no agency or organization has a mandate to co-ordinate this effort. As a result there has been considerable duplication of effort in some areas, while in other areas there has been a deficiency of information. Use of different, and incompatible, inventory systems results in unnecessary conflicts between agencies. There is a great need to co-ordinate all soil/land inventory efforts, to capture all of the information which is being collected in a common soil/land data base and to develop a provincial strategy for soil/land inventory so that relevant information about the soil/land resource in the province will be available when it is needed.

Although most of the province has been covered by reconnaissance-level land inventory, much of the coverage is out of date and/or of insufficient detail, both in terms of the attributes recorded and the scale of mapping, to support the level of decision making which is currently required.

In addition to the concerns relative to data collection (field survey) there is also a strong desire to convert existing land information to electronic form. This conversion would improve accessibility and reduce the potential for duplication. However, the information resides with many different agencies and the transfer of data or access to data will only occur if a concerted effort is made to ensure standardization of the information and the storage formats. The standardization issue becomes even more critical with the move into an era of private sector involvement and contracting out of survey work.

Presently, it may still be possible to attain a reasonable level of compatibility, however, it is unlikely that this will last for much longer.

A proposed coordination strategy to respond to the concerns described above was initiated in 1983 by the Alberta Soils Advisory Committee and the Alberta Institute of Pedology. The general objective of this proposed strategy was to put in place a mechanism which would ensure that adequate information about the soil/land resource was available when needed for land use planning and land management decisions. Furthermore, it would ensure that the necessary soil/land inventory information was collected, stored, and distributed in the most cost-effective manner. Discussions with provincial government depts. and agencies resulted in the formation of the Alberta Soil/Land Inventory Co-ordinating Committee (ASLICC) comprised of representatives from:

Soil Science Department, University of Alberta
Terrain Sciences Department, Alberta Research Council
Soil Survey Unit, Agriculture Canada
Alberta Agriculture
Alberta Energy and Natural Resources
Alberta Environment
Alberta Municipal Affairs

The rationale for the membership is that the four above-named provincial line departments are the major users of soil/land information in the province. All four departments are also involved in collecting or sponsoring the collection of soil/land information. The three member organizations of the Alberta Institute of Pedology are involved in collecting soil/land information and/or research related to improving the interpretation of soil/land information.

The initial activities of the Committee involve three major tasks:

Task 1. To identify user needs for soil/land information, (a) for the next five-year period, and (b) for the longer term.

Subobjectives - 1. To identify the major users of soil/land information.

2. To identify, for each major user, the management programs which require the availability of soil/land information.

3. To identify, for each management program, the management decisions which require the availability of soil/land information.

4. To identify the soil/land information which is required for each decision in terms of location, scale, and content.

Task 2. To compile a comprehensive list of existing soil/land data bases.

Subobjectives - 1. To identify the kinds/types of soil/land information which exists (e.g., ELC, PLC, soil survey, etc.)

2. To describe for each kind/type of soil/land information the following attributes:

a) location and extent of the area described

b) where this kind/type of soil / land information is available

c) who produced this information

d) the methodology which was used to collect the information including the remote sensing information base, the intensity of ground-truthing, the kind of ground-truth data collected, analysis procedures, etc.

e) the content of the soil/land information in terms of the descriptive elements of information supplied

f) scale - including presentation scale, map unit size (minimum and average)

3. To evaluate the various data sets with regard to linkages, similarities and differences (in terms of content, scale, format, etc.), etc.

Task 3. To identify any differences which exist between user needs for soil/land information (Task 1) and the soil/land data base (Task 2), (a) for the next five-year period, and (b) for the longer term.

Subobjectives - 1. Identify the programs that are in place to collect soil/land information.

2. Estimate, using defined assumptions, the information which these programs are likely to collect (a) within the next five years, and (b) in the longer term.

3. Describe the soil/land data base which is likely to exist (a) five years from now, and (b) in the longer term.

4. Identify any differences which exist between user needs for soil/land information and the soil/land data base (a) for the next five-year period, and (b) for the longer term.

Maintenance and Expansion of Agricultural Land Base

In recent years a number of concerns about the long-term security of the agricultural land base have arisen. Some of the major issues relate to the reduction of in size and quality of the land base through loss of land to non-agricultural uses and a reduction in soil quality resulting from erosion, salinization, acidification, organic matter loss, etc.

Concern by the various levels of government has been demonstrated through the organization of the Environment Council of Alberta (Thompson 1982) hearings on "Maintaining and Expanding the Agricultural Land Base in Alberta" held in the latter part of 1983. Furthermore, Alberta Agriculture (Alberta Agriculture 1984) is now focussing more effort and resources on the conservation and management of soil and water resources. Programs are being developed to increase the farmer awareness of soil degradation problems and the management alternatives available to maintain and improve soil productivity.

An interdepartmental study of the potential for expansion and intensification of the agricultural land base has been undertaken by Agriculture, Energy and Natural Resources, Environment, Municipal Affairs and Transportation. The objective of the study is to determine the potential for a range of agricultural resource development alternatives, both from a physical inventory perspective and from the perspective of economic costs and returns.

REFERENCES

Alberta Agriculture. 1984. Response to Environment Council of Alberta questions arising from public hearings into maintaining and expanding the agricultural land base in Alberta.

Thompson, P.S. 1982. Maintaining and expanding the Agricultural land base in Alberta: Terms of reference and background information. ECA82-17/1B18. Edmonton: Environment Council of Alberta. 24 pages.

SASKATCHEWAN REPORT 1984

Mr. Chairman:

Details of the Soil Survey accomplishments during the last year are available to the Secretary and are also published in our Institute's Annual Report. Suffice it is to report to my colleagues that:

1. THE TECHNICAL COMMITTEE of the S.I.P. made the decision that future Soil Survey Publications in the Basic Survey Program will be on an R.M. Base at a scale of 1:100,000. The new publications will contain soils and 8 interpretative maps plus an explanation of the significance of each interpretation. The first of these publications, the R.M. of Melville, will be available for public adjudication in early 1985. It is being published by the L.R.R.I. The compilation of the first R.M. has been under the initiative of Don Acton.

2. A CORRELATION TRIP in the Swan River Area of Manitoba regarding Chernozemic and Gleysolic Soil Orders was held with the Manitoba Survey and Federal Correlator Jack Shields.

3. WE WERE PLEASED to have the E.C.S.S. Chairman at the S.I.P. Executive meeting in Saskatoon and, finally,

4. PROSPECTS OF E.R.D.A. funding to expand survey activities and interpretations relative to soil degradation look promising.

There are two suggestions which the S.I.P. would like to place on the records. These suggestions express the views of the Technical Committee which consists of Stewart, St. Arnaud, Acton, Stonehouse and myself.

1984 S.I.P. SUGGESTIONS TO E.C.S.S.

The Working Groups within the Expert Committee on Soil Survey are similar in structure to those within the former Canada Committee except for the participation in regional meetings and field trips to confirm the "national application" of proposed criteria and methods.

The advantages of regional events were that:

1. they orientated the Chairman regarding the concept of "National application";

2. they created the opportunity of on-site observation and resolution.

   (The on-site observation and discussion enhanced the professional status of both the Working Group and local workers—and the on-site resolution resulted in a sense of accomplishment that was reflected throughout the entire Committee).

The Saskatchewan Institute of Pedology, therefore, proposes that provisions be made so that Chairman can validate the "national application" of their Working Group's recommendations before they are "sanctioned as an official procedure of E.C.S.S. for both federal and provincial survey units".

The recommendations of the Expert Committee on Soil Survey are nearly all formulated so they endorse the priorities expressed by the "Agri-Food Strategy" proposals (see Recommendations 1982 and '83).

With these priorities the Expert Committee on Soil Survey has repeatedly recommended the need for increased staff to prepare regional soil inventories and interpret same for all aspects of soil conservation and soil management programs.

The Saskatchewan Institute of Pedology has and continues to endorse these recommendations. The Institute is, however, concerned about the fate of the Expert Committee's recommendation and the lack of action regarding these very worthy objectives.

It is suggested, therefore, that the Expert Comittee membership be informed regarding the fate of its recommendation to the Canada Agricultural Services Co-ordinating Committee through the Canada Committee on Land Resource Services and that a record of same be placed in future annual reports.

J.G. ELLIS

MANITOBA REPORT TO ECSS - NOVEMBER, 1984

G.F. Mills

This report outlines concerns formulated by The Canada-Manitoba Soil Survey for discussion by the provincial Soil Survey Advisory Subcommittee. The concerns deal mainly with program and service requirements related to data handling and information flow, soil inventory and soil interpretation needs in Manitoba. The first two concerns have been presented by the Soil Science Lead Committee to the Manitoba Agricultural Services Coordinating Committee (M.A.S.C.C.) as recommendations for support in 1984.

A major concern relates to the need to enhance soil survey capability to support new soil degradation and conservation programs proposed by PFRA and Provincial Agriculture. Additional support for soil survey is required to more effectively manage existing soil resource data and to accelerate soil inventories in critical land areas seriously affected by soil degradation.

It is recommended that the supporting agencies of the Canada-Manitoba Soil Survey explore all avenues available to fund person-year and operating budget requirements outlined as provincial concerns in the following section. In particular, a review of current allocation of Economic Regional Development Agreement (ERDA) funding in support of PFRA and provincial soil conservation programs is required. The review is required to more realistically recognize the necessary role that soil survey must play in support of these programs. It is noteworthy that adjustment has already been made to the support of soil survey in Saskatchewan.

PROVINCIAL CONCERNS

1. Data Handling and Information Flow

There is need to provide a responsive user-oriented computer assisted soil resource information system (CanSIS). To effect development of this data management system, an adequately supported in-house data analyst-programmer is required. The emphasis for this in-place expertise would be to develop the standardized SOIL PROPERTIES FILE needed for quantitative land evaluations to support crop insurance, farm credit, grain stabilization subsidy and tax assessment programs. Additional uses of this data base would be to support soil interpretations for land use planning, infrastructure planning, environmental concerns, waste management, irrigation suitability and drainage requirement.

The present level of activity supporting development of CanSIS is not sufficient to manage the volumes of data currently available to provide more quantitative land evaluation. Current demands for soil resource data indicate that without additional person-year and budget committment, the efficient handling of data and timely information flow in the province is becoming a critical limitation to implementation of land use planning policies and programs.

2. Soil Inventory

Manitoba needs accurate, more detailed description of the soil resources for approximately 30 700 square kilometers (12,000 square miles) of agricultural soils seriously affected by wind and water erosion, spreading salinity, loss of natural fertility, pollution by agricultural chemicals or poor drainage.

Soil maps and descriptions available for this area are general in nature and not sufficiently detailed for effective implementation of policies and programs to combat the various soil deterioration processes that prevent the realization of agricultural production potential in Manitoba.

With present staff it is estimated that the soil survey would require approximately 18 years to complete the survey of critical areas at a suitable level of detail. Proposed Federal Regional Development Branch activities in support of enhanced soil and water management and soil conservation programs being developed by PFRA and The Provincial Department of Agriculture are dependent on timely delivery of more detailed soil data. Provision of four adequately supported pedologists would be required to reduce the time to resurvey critical areas by approximately 50 percent. This additional support is necessary if soil survey responsibility for new programs related to PFRA and Provincial soil degradation concerns is not to reduce current capability for soil inventory and land evaluation.

3. Monitoring Program to Assess Extent and Severity of Soil Degradation

There is need to initiate soil degradation studies of wind and water erosion, salinity, acidity, organic matter loss, soil structure and soil compaction resulting from long-time agricultural practices. Assessment of effects of soil degradation should be in terms of crop productivity and environmental impact. Soil survey committment to these studies is in two phases:

Phase 1 - A joint PFRA - Soil Survey activity has been initiated to assess extent and severity of soil salinity and soil erosion. This phase is scheduled for completion in 1986 with compilation of generalized 1:1,000,000 scale maps showing extent and severity of wind and water erosion and salinity. This phase will require 1 person-year to complete.

Phase 2 - Will key on establishment of a monitoring program to assess rates of degradation on specific sites linked to crop yields. Monitoring should assess the benefits of control programs and provide data that can be extrapolated to on-farm situations. Criteria for monitoring and the exact nature of the program have yet to be established.

In addition to assuming the lead role for assessing severity and extent of soil degradation (Phase 1) the soil survey will have responsibility for selection and characterization of benchmark sites for monitoring programs (Phase 2). It is estimated that the monitoring program will affect the soil survey program mainly in terms of reduced capacity to process backlog mapping projects and provide correlation to current mapping projects.

4. Crop Productivity Modelling

During the past year an Agriculture Canada research supported training position dedicated to modelling soil-climate-crop growth relations has been established in Manitoba and will carry on for the next three years. The crop growth model developed for wheat under this program is now being applied under varying soil and climatic conditions in the province.

Continuing technical support for this program is required to demonstrate the application of the model under a greater range of soil conditions. At the present time, inadequate distribution of AES monitored temperature and precipitation data causes some difficulty for extrapolating soil-crop yield relationships to large homogeneous land areas. The Agrometeorology Section is requested to provide guidance in developing appropriate techniques to extrapolate weather data (particularly precipitation) between AES stations.

5. Soil Survey Brochures

The Canada Committee on Land Resource Services is requested to facilitate printing of all Soil Survey brochures that are ready for publication.

6. Small Scale Regional Interpretive Maps

The Expert Committee on Soil Survey should, where at all possible maintain the manipulation of the regional maps as an "inhouse" operation within Land Resource Research Institute.

7. Attendance at ECSS Working Groups

The current lack of support for provincial attendence and participation in ECSS working group activities precludes in many cases a complete regional representation of expertise and concerns. The Canada Committee for Land Resource Services is asked to explore all avenues available to support provincial involvement through provision of funds for attending workshops at regional and national meetings.

QUEBEC

Dominique Carrier

Nos besoins de recherches dans le domaine de la pédologie sont identifiés, décrits soumairement et résumés dans la brochure intitulée: "Besoins de recherches 1983-1985. Productions végétales, Agrométéorologie, Génie rural, Sol". Ces priorités comprennent la cartographie détaillée et semi-détaillée des sols minéraux et organiques; l'évaluation et l'utilisation des sols et des terres; la dégradation et la réhabilitation des sols. Les activités de recherche des trois équipes oeuvrant principalement dans le domaine de la pédologie au Québec sont donc axées sur la réalisation de ces objectifs.

1. Classification et cartographie des sols minéraux aux échelles régionales et détaillées.

A - Equipe provinciale

Le ressource-sol utilisée pour les productions végétales doit être connue définie, classée et inventoriée pour en arriver à son utilisation rationnelle. A cette fin, l'équipe pédologique du Service de recherche en sols du MAPAQ poursuit les travaux d'inventaire et de cartographie en vue de compléter la carte des sols à l'échelle 1:50 000e pour l'ensemble des régions agricoles du Québec. Durant l'année 1984, de telles études ont été menées dans les comtés de Beauce et de Frontenac. Il y a eu également parution de l'étude pédologique du comté d'Arthabaska.

En relation avec leurs travaux cartographiques, les pédologues de cet organisme ont poursuivi leur programme d'échantillonnage et d'analyse des sols développés sur les tills des Appalaches, afin d'indexer les critères les plus caractéristiques qui permettront une meilleure définition, compréhension, reconnaissance, délimitation et séparation des différentes roches-mères qui les constituent.

Le projet d'étude des sols dans le territoire de l'Abitibi-Témiscamingue a aussi progressé. Récemment, plusieurs sols cultivés de l'Abitibi-Ouest et du Témiscamingue ont été décrits et échantillonnés afin d'établir la clef nécessaire à l'amorce de la cartographie des sols de ces régions. Il s'agit d'un vaste territoire 1,300 000 ha dont environ 200 000 ha sont des terres défrichées. La cartographie des sols cultivés de ce territoire est une de nos priorités dont la réalisation débutera au cours de l'année.

B - Equipe fédérale

Dans la plaine du St-Laurent, en particulier dans la région périphérique de Montréal, qui est un secteur soumis à une utilisation et à un aménagement intensifs, l'équipe pédologique de l'Institut de recherches sur les terres au ministère de l'Agriculture du Canada effectue la cartographie des sols à l'échelle 1:20 000e. L'état d'avancement des travaux est le suivant: comtés de Richelieu et de Verchères, la cartographie est terminée et les rapports sont en préparation; comté de Chambly, environ 30% du territoire a fait l'objet d'une cartographie détaillée; comté de Rouville, la cartographie préliminaire a été entreprise au cours de l'été 1984.

En relation avec leurs travaux cartographiques, les pédologues de cette équipe en collaboration avec ceux du Département des sols de la Faculté des Sciences de l'Agriculture et de l'Alimentation de l'Université Laval, font l'essai et la mise au point de techniques plus quantitatives de cartographie des sols. L'ensemble de leurs résultats a d'ailleurs été présenté à l'atelier du "Mapping System Working Group" (4-23 mars 1984). L'avancement de leurs travaux dans ce domaine, nécessite l'utilisation intensive de micro-ordinateurs pour produire des statistiques sur les propriétés des sols (séries)et des unités cartographiques et commande maintenant l'incorporation d'un analyste en informatique au sein de cette équipe.

Il faut noter également qu'il y a un poste de pédologue qui n'est pas comblé au sein de cette équipe depuis 2 ans.

C - Equipe de l'Université

Le Département des sols de la Faculté des Sciences de l'Agriculture et de l'Alimentation de l'Université Laval a perdu, depuis décembre 1983, un élément important dans le domaine de la pédologie. En effet, M. Roger Baril, en retraite depuis ce temps, laisse un vide qu'il n'est pas aisé de combler. De plus cet organisme, tel qu'énoncé dans un plan triennal, désire avoir une équipe permanente oeuvrant dans le domaine de la cartographie des sols.

Les recherches effectuées par le Département des sols de la Faculté des Sciences de l'Agriculture et de l'Alimentation portent principalement sur:

- L'étude micromorphologique de quelques horizons diagnostiques.
- L'altération des minéraux argileux.
- L'étude des relations matière organique-matière minérale-microorganismes.
- La caractérisation des sols argileux.

NEW BRUNSWICK REPORT TO THE EXPERT COMMITTEE ON SOIL SURVEY

H. W. Rees

(November 1984)

This report briefly outlines New Brunswick's position regarding requirements related to the land resource sector which are needed to optimize land planning and management and bring commodity development in line with potential soil capability.

CURRENT ISSUES AND CONCERNS (not necessarily in order of importance)

Concern No. 1 - Accelerated Soil Inventory

Soil inventory and data collection continues to be of high priority in New Brunswick. It is realized that a prerequisite to planning and management decisions, such as soil improvement practices, cropping systems and crop adaptability, necessitates a properly scaled soil survey data base supplemented with suitable interpretive techniques.

Detailed survey of intensively used agricultural areas is the primary inventory emphasis of the soil survey program in New Brunswick. With dismantlement of the Atlantic Institute of Pedology and the subsequent reassignment of staff activities from that office to the Province of Nova Scotia, the LRRI efforts directed towards soil survey in New Brunswick have decreased by two person years.

Provincial efforts to expand its contribution to soil inventory are hampered by severe fiscal restraints. Inventory personnel have had to assume additional responsibilities. Interpretation and application of soil survey information is recognized as being critical for the planning and developing of agriculture soil management programs. Provincial staff are devoting major efforts to responding to this need as well as to the promotion of the utilization of soils data through their on-farm survey program.

Of New Brunswick's agricultural land base less than one-fifth has been surveyed in sufficient detail to suffice the needs of modern agriculture. Soil resource data base expansion is essential in view of recent emphasis on land development and conservation as expressed in the Canada-New Brunswick Agri-Food Development Subsidiary Agreement, the Standing Senate Committee on Agriculture, Fisheries and Forestry, the New Brunswick Institute of Agrologists, various Soil and Crop Improvement Associations, and other groups.

Concern No. 2 - Land Evaluation

Land evaluation for various uses requires the collection, analysis, and classification of large quantities of data in an organized manner. In the past, large volumes of data have been generated on soil, climate, crop production and management practices as a resut of research and related activities. Unfortunately, only a minor amount of that collected and otherwise available data is ever reported. The majority of it remains in personal or other files in jeopardy of being lost to obscurity, or has accumulated to an unmanageable size in terms of physical handling.

The CanSIS Performance/Management file provides the means for storage of this data in a format which is readily accessible for incorporation into the decision-making process. At present the main constraint to utilization of this system is the time required to investigate existing sources of data and enter it into the CanSIS file. Consideration should be given to Agriculture Canada providing the technical support to do this on a continuing basis.

Concern No. 3 - Data Handling Systems

As of the present there is no information system in place in the Province of New Brunswick which can respond effectively to the decision-making needs in the agricultural land area. An information explosion is taking place and it is imperative that this data be stored in an easily accessible format if it is to be useable in the planning process. Improvements could be made in land development and land management if soil information were more readily available in more useable forms for on-farm activities. The improved handling of soil information should also assist in the monitoring and evaluation of land development projects under the Canada-New Brunswick Agri-Food Subsidiary Agreement.

Concern No. 4 - Soil Quality and Degradation

New Brunswick's agricultural land base is characterized by soils with inherent limiting features which impose severe restrictions upon the type and level of crop production. Coupled with these land base limitations, improper selection of tillage implements, poor timing of field operations, improper choice and rate of application of soil amendments and improper selection of farming systems has resulted in instances of severe soil degradation. An intensive research program is needed to: 1) devise methods of overcoming these soil limitations; and 2) identify land management practices which will minimize land deterioration and increase land productivity. In order to achieve these goals methods should be devised to better characterize soil limiting factors and assess soil degradation occurence and potential. The Soil Degradation Working Group should continue its efforts in this vein. Guidelines or recommendations concerning soil improvement and conservation should also be researched.

Concern No. 5 - Canada-New Brunswick Agri-Food Development Subsidiary Agreement (Economic and Regional Development Agreement - ERDA)

On June 25, 1984 the Canada and New Brunswick governments signed the Canada-New Brunswick Agri-Food Development Subsidiary Agreement to stimulate and support the development of the agri-food sector. Four major programs have been identified on livestock feed development, livestock industry development, potato industry development, and horticulture and specialty crops development. These programs will be implemented under the following initiatives:

(a) Land Resource Development
(b) Marketing
(c) Technology
(d) Human Resource Development, Industry Infrastructure and Support Services.

Land will be addressed under both the Land Resource Development and the Technology initiatives.

The objective of the Land Resource Development initiative "is to encourage and accelerate the adoption of land management practices and activities that increase agricultural productivity, product quality, consistency of supply and efficiency of production. This will be achieved by providing financial incentives and support services for land improvement work including planning, engineering and crop management. Initiatives will be undertaken in the areas of water and soil management, erosion control and farmland expansion".

In order to maximize the benefits from financial incentives for on-farm land improvements and soil conservation, it is necessary that these activities be conducted in accordance with soil conditions. Provincial concerns exist that these initiatives, which total $12 million, are not adequately considering the soils of the land involved. It is requested that the importance of using soils information in assessing applications for land development under this Agreement be impressed upon the implementing agencies.

Under the Technology initiative a comprehensive sub-program on land has been instituted with the objectives of a) assessing resource capability of specific geographic areas for production of livestock feed and b) developing and/or adopting methodologies to improve and maintain land productivity. Tentative projects include the following:

Soil Evaluation and Mapping for Agricultural Production in Westmorland County, New Brunswick.

Identification and Characterization of Dense, Compact Subsoils in N.B.'s Agricultural Lands, with Single Parameter Interpretive Maps.

Improving the Climate Data Base for Agriculture.

Frost Risk Zonation for Horticultural Production.

Performance Evaluation of Subsurface Drainage Systems.

Field-Scale Soil Profile Modification on N.B. Compacted Basal Till Soils.

Management of Eroded Soils.

Appended correspondence:

- N.B. Department of Agriculture, Plant Industry Branch
- Agriculture Canada, Fredericton Research Station
- N.B. Institute of Agrologists

NOVA SCOTIA REPORT TO THE

EXPERT COMMITTEE ON SOIL SURVEY

D. Holmstrom

(November 1984)

Following are the provincial concerns in regards to soil survey. They are not in the order of priority.

1. Pictou, Hants and Colchester County and Kentville Research Station/Sheffield Research Farm Soil Surveys are planned to be completed in 1985. It is recommended that LRRI provide technical editing and cartographic support for these reports. In addition, it is recommended LRRI publish these reports as soon as possible.

2. Three AFDA soil evaluation projects are in progress. The staff of the federal soil survey unit in Truro have responsibility as scientific authority. It is recommended that this continue.

3. The provincial soil survey unit is planning to initiate on farm surveys (LEAPS-Land evaluation and planning service) in 1985. It is recommended that LRRI provide technical advice on the soil survey portion of the program.

4. Impermeable subsoils and poor soil structure are major problems of agricultural soils in Nova Scotia. Continued research into the factors which restrict yields and the effects of various amendments on these soils is recommended.

5. Agronomic interpretations will be required for the AFDA projects. Productivity information for major soil types should be collected. Work on soil-crop relationships, productivity ratings and the effect of amendments and their cost on yields should be documented in order that interpretation guide lines may be developed. It is recommended that effort be increased in this area.

6. Classification of soil moisture regimes and their relationships to bulk density, structure, porosity and other soil features needs further work. It is recommended that LRRI increase research in this area.

7. The acquisition of computer hardware by the federal soil survey unit in Truro is supported. Future cooperation in regards to hardware acquisition and software development is recommended.

8. Soil climate data has been collected for various soil types in Nova Scotia. It is recommended that this data be correlated with the provincial climate units by LRRI.

9. Recommend filling the Eastern Correlator position of LRRI, Ottawa which has been vacant for four years.

Report on the Startup Aspects of the Nova Scotia Contract Survey

D. Holmstrom, November 1984

In Nova Scotia, there are three contract surveys. Hardy Associates has two of the contracts and MacLaren Plansearch one. Hardy Associates initiated their contracts January 1984 while MacLaren started March 1984. The problems encountered during the first year were minor and were a result of contractors' inexperience, scientific authorities' inexperience and lack of detail in the contracts.

The first two items of the contract dealt with survey, classification and interpretation requirements. Although soils were not classified taxonomically, data was collected on major horizons. The interpretation requirements were eventually dropped as it was decided that the federal unit would be responsible for interpretations thereby retaining their expertise for future work.

The third and fifth items of the contract dealt with establishing a legend and map symbolization, pretyping and selecting transects for mapping. These were altered as follows:

1) Legend was supplied by the Scientific Authorities because of their experience, the desire for greater control over the contractors, and for consistency between contracts. In addition, the decision was made to revert to a more open legend so as to accommodate new map units to be found in the areas which had no previous SIL 2 surveys.

2) Transect design was modified during the field season to provide for improved correlation and mapping quality.

Items 4, 6 and 7 of the contract dealt with recording site data on computer compatible forms, digitizing maps and symbols, map output, and data analysis. As a result of a meeting between Bruce MacDonald and Brian Edwards of LRRI with the contractors and the Scientific Authorites, the following amendments were made for two of the three contracts 1:

- all site data must be keyed in a specific format and data must be transferred to CanSIS
- contractor will analyze within map unit transects and provide frequency distribution for data collected,
- map delineations will be numbered uniquely. The lines and numbers will be digitized. A corresponding list of numbers and map delineation symbols will be keyed by the contractors,

The preceding points allowed analysis of site data, its transfer to CanSIS and also accommodated the larger symbols previously indicated.

1/ Amendments to the third contract are under negotiations.

Report of Activities in Newfoundland
1983 - 84

(A verbal summary of this report was presented at the Expert Committee on Soil Survey, Guelph, Ontario, November 30, 1984).

Survey Activities

Staff of the Federal unit undertook field work in two project areas; the Provincial unit continued field work in five project areas (Table). Both units devoted considerable time to report preparation, including some project areas in which field work was completed earlier and are not therefore listed in the Table.

Belleoram-St. Lawrence	1M, 1L	1:250,000	J. van de Hulst
Robinsons-South	12B/2	1:50,000	J. Whelan
Robinsons-North	12B/7	1:50,000	F. Hender
Grandy's Lake-Friars Cove	110/15, 12B/3	1:50,000	E. Woodrow
Bay-of-Exploits	2E/3 & 6 (parts)	1:25,000	J. van de Hulst
Pasadena-Deer Lake	12M/4 (parts)	1:25,000	G. Kirby
Markland	1N/5 & 6 (parts)	1:12,500	R. Ricketts

In addition to work in the Grandy's Lake-Friars Cove area, E. Woodrow participated in work in the Baker Lake area, N.W.T.

Other Activities

G. Kirby had a week of training with CanSIS at LRRI, Ottawa. The objective was to develop a survey field sheet

that would satisfy local needs and be compatible with the national system. A second purpose was to get a basic knowledge of the use of P.C.'s for soil survey.

A soil water-table monitoring site was established in the fall of 1983. The objective was to gain experience and evaluate the level of commitment required prior to considering a monitoring program proper.

A demonstration of frost-effects was conducted in the winter of 1983-84. The objective was to confirm visual assessment of cryoturbated soil vs unaffected soil.

A field correlation tour was organized around a visit by Dr. Chang Wang of LRRI, Ottawa. Specific topics considered were placic horizons, fragipans, gleysols (including red soils), and folisols.

Milestones

P. Heringa of the Federal unit retired this year. His knowledge of the province and its soils, and his appreciation of the problems in characterizing and mapping the soils will be missed. Perhaps most of all, we will miss his prorocative lines of questioning that always brought us back to basics and promoted interest in understanding the material we work with.

Assessment

A number of problems continue to plague soil survey in Newfoundland. Schedules continue to be made and broken for a number of reasons including:

- slow turn-around for samples submitted to the lab
- problems in characterization in the field
- lack of supportive research

In addition to the problems of scheduling locally, our delays do, and will continue to, affect cartographic and editing schedules in LRRI.

Correlation is becoming increasingly problematical. In part the difficulty is historical, stemming from the need to correlate with older surveys that were conducted in widely separated areas. In part the problems are related to scale, as is the case where more detailed surveys are being conducted in areas covered by previous work. To a considerable degree correlation is a problem at the level of soil characterization; for example, much effort has been devoted to identifying fragipans and distinguishing them from dense tills. More often than not, specific problems in correlation involve more than one kind of difficulty.

The lack of soil research in Newfoundland by Agriculture Canada is also detrimental to the survey programs. Questions which perplex the surveyor in the field result in time loss investigating the problem in the literature and time loss in report preparation because it is difficult to discuss the unknown. Although there are ways about this kind of difficulty, they are generally at the expense of a quality product. On the other hand, a soil research presence in the island would lead toward answers. The research presence would also provide local surveyors with a sounding board for ideas and problems.

Conclusions

The basic needs of Newfoundland are:

1. An Ottawa-based correlator to:
   a) provide technical support in the field
   b) assist in provincial correlation
   c) assist in implementing local plans by ensuring LRRI support where it is needed
   d) coordinate activities and schedules involving local units and LRRI
   e) ensure communication (of program and technical developments, procedural changes etc.) between Newfoundland and LRRI.

2. An increased research presence to:
   a) develop, in LRRI, resource persons familiar with the nature, properties and problems of Newfoundland soils and soil mapping
   b) undertake and assist in undertaking research in soil characterization and assessment.

REPORT OF

EXPERT COMMITTEE ON SOIL SURVEY

TO

CANADA COMMITTEE ON LAND RESOURCE SERVICES

NOVEMBER 1984

Guelph, Ontario

The format for the sixth annual meeting of the ECSS included both working group activities and a business meeting. Work group sessions were held concurrently from Monday, November 26 to Wednesday November 28 including a presentation by Mr. Steve Smith from the D.S.I.R. Soil Bureau, Dunedin, New Zealand who reviewed current soil-water research investigations in his homeland. The banquet held on Tuesday evening was highlighted by an after dinner presentation by Mr. David George on the contribution of the Institute of Pedology to Ontario Soil Conservation Programs. Mr. George is Executive Director and Advisor of Technical Services, Ontario Ministry of Agriculture and Food.

The business meeting was held on November 27-28. The Chairman reported that he attended the Canadian Forest Statistics (CFSC) Committee in May 1984. The chairman of ECSS was made a member of the CFSC and Dr. Keen chairman of that committee was named an ex officio-member of ECSS. Considerable interest was shown by the Forest Statistics committee in improving the quality and extent of soil survey information for forestry applications and for increasing the accessibility of soil survey information for forest management.

Working group progress reports presented to the business meeting on priority topics included soil mapping systems, soil degradation, agronomic interpretations, CanSIS-computer and soil classification. Additional working group updates were presented for the soil survey handbook, forestry interpretations, soil water investigations group, soil climate, irrigation suitability and soil salinity mapping guidelines.

SOIL DEGRADATION

Many aspects of soil survey involvement with soil degradation causes were discussed. Invited speakers included;

Dr. M. Miller	Univ. of Guelph
Dr. T. Dickinson	Univ. of Guelph
Dr. E. de Jong	Univ. of Sask.
Dr. D. Anderson	Univ. of Sask.
Dr. J. de Vries	Univ. of B.C.
Dr. B. Kay	Univ. of Guelph
Dr. D. Chanasyk	Univ. of Alberta
Dr. G. Mehuys	MacDonald College

Actions:
- estimation of past erosion and its effect on crop production were documented for Waterloo Country (M. Millar).
- an attempt was made to predict, from climatic data, the incidence of rain in early spring during highly erodible snow melt conditions. (E. de Jong).
- a new wind erosion factor was developed which correlated well with the number of "dust blowing" days at Lethbridge and Saskatoon (E. de Jong).
- a map was prepared showing erosion risk for southern Ontario (T. Dickinson)

- generalized maps (1:1 million) for Manitoba and Saskatchewan showing wind erosion reduction due to crop residues were compiled (R. Coote).

Requirements

- Soil Inventory section LRRI ensure that generalized soil landscape maps be prepared for Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Quebec and B.C.
- resources be provided so the soil survey units can prepare generalized erosion RISK maps using the USLE.
- resources for soil survey units to assess and document the extent and severity of past erosion on generalized soil landscape maps.
- LRRI develop criteria to identify man-induced compaction.
- resources to obtain information on slope position, erosion severity, organic carbon level and its mineralization rate with a view to developing a landscape model for predicting changes in organic matter.

MAPPING SYSTEMS

Actions:
- an index to better characterize survey intensity level was developed by combining the area represented by one inspection with the percentage of delineations that had at least one inspection.
- soil survey specifications were reviewed for three examples of detailed surveys.
- minimum data sets were reviewed and discussed in relation to requirements of the Agronomic Working Group.
- four publication formats were designed which varied according to their completeness of information, presentation format and the time required to produce.
- an outline for the planned revision of the mapping systems manual was prepared and authors assigned to the main topics.

Concerns:
- development of minimum data set criteria is dependent on the activities and progress of the agronomic working group.
- the working group suggested that it should no longer have priority status and could hereby change its role from one of advocation to one of communication by functioning as a clearing house for various ideas and procedures.

CANSIS - COMPUTER

The name of the former CanSIS Working Group was changed to the CanSIS-Computer Working Group and the terms of reference were broadened to include regional activities as well as the Ottawa based ones. The Group reviewed computer based applications across Canada. Within the past year, four groups operating independently have developed significant micro-based data handling capabilities which were specifically tailored to soil survey applications.

Actions:
- activities on the mainframe cartographic system were designed to increase the allowable number of map symbols per map.

- soil names file was revised to include English and French reports.
- the CanSIS Users Manual was printed in English and French.
- microcomputer procedures to manage data collected under contract in Nova Scotia were developed and tested.

Requirements:

- standardization of the general purpose micro computer application is a highly desirable goal.
- role of this Working Group include a strong liason component at both the regional and national levels.
- that the developing role of EDP correlation be recognized and supported.
- intensive support on implementation and development of microcomputer capability from personnel outside the units.

Future Activities:

- preparation of a section for the Soil Survey Handbook on computer based application.
- CanSIS Ottawa personnel with assistance from correlation and regional staff will review and critically evaluate existing CanSIS files to develop a clear statement of specifications of the data content and input format.

AGRONOMIC WORKING GROUP

Agronomic interpretations were defined by this new Working Group as those kinds of interpretations that will benefit both field crop production and soil management. In comparison to other soil interpretive systems, relatively little has been done in terms of practical applications for specific soil and crop interpretations.

Actions: - the following objectives were established as the Working Group mandate:

1. To modify and improve the 1964 C.L.I. guidelines for agriculture that will bring the system in line as to what is required for the various S.I.L. levels of mapping. Special consideration will thereby be given to the significance of the C.L.I. system for the various commercial field crops.

2. To develop guidelines for the interpretation of soils information for agriculture (crop specific) as well as soil management, applicable at various levels of mapping and to publish this information at the earliest feasible time.

3. To assess the feasibility of including an economic evaluation for soil management and land improvement recommendations and where possible to include these in the guidelines.

4. To determine the need for research projects in support of improved agronomic interpretations and to promote their undertaking by qualified scientists.

Concerns: - requirements for agrometerological data for crop yield model development must be reviewed.

SOIL CLASSIFICATION

Working group activities focused on fine tuning the classification of the Gleysols, Podzols and Folisols. Excellent participation by the Working Group members resulted in formulation of a number of recommendations to the E.C.S.S.

Actions:
- improved criteria were developed for the classification of Gleysolic and Podzolic soils.
- reviewed the classification of the Folisolic Great Group and recommended that it be included in the Canadian System of Soil Classification.
- revised the definition of contrasting horizons or layers.

Concerns:
- two unfinished items relating to classification of Gleysolic soils remain to be solved.
- the adequacy of current chemical criteria for a Podzolic B horizon was questioned.
- classification of swelling clay soils requires further review.

Adoption of Recommendations:

- a number of recommendations were put forward (see Working Group Report by C. Tarnocai). These recommendations were accepted by ECSS with exception of the item on Soil Surface Criteria which was held in obeyance. The accepted items as documented will be implemented on all new projects.

Thursday, November 29. The Business Meeting consisted of a number of Working Group progress reports and invited papers which are published in the Proceedings;

Soil Degradation	R. Coote
Mapping Systems	K. Valentine
CanSIS - Computer	B. MacDonald
Some Current Applications of Microcomputers to Soil Survey	D. Moon
Agronomic Interpretations	B. van den Broek
Soil Classification	C. Tarnocai
Soil Survey Handbook	G. Coen
Irrigation Suitability	R. Eilers
Soil Salinity Mapping Guidelines	R. Eilers
Forestry Interpretation Manual	D. Moon
Soil Water Investigation Group	R. Eilers

Friday, November 30. The business meeting continued with attendance by ECSS members and several invited resource persons. ECSS members were given the opportunity to discuss concerns arising from the Working Group.

The major concerns have been previously indicated under their respective Working Group heading. Of particular interest was the concern about long term EDP equipment purchase plans in relation to maintaining compatability with Provincial Government EDP purchases. The response indicated that CanSIS EDP would continue to purchase "Core Equipment" and that documentation of Provincial EDP purchase plans should be submitted to CanSIS by the provincial Working Group member. The Committee recommended that close coordination of EDP equipment purchases be maintained at all levels of government in order to strengthen the integration of computerized systems among the various groups.

Acceleration of Soil Survey Procedures

The continuing concern regarding the purported high cost and slow progress of soil surveys was reviewed by Dr. Clark. He expressed concern about these statements and the fact that statements had been made by members of the Canada Committee on Land Resource Services that soil survey could be accelerated by improving and simplifying field procedures. It has been suggested that the required procedures could readily be developed if some research was undertaken.

It is no longer possible in Dr. Clark's opinion to dismiss these criticisms of the rate of soil survey. There would appear to be two main possibilities for increasing the rate of soil survey coverage:

a) reducing the number and the complexity of observations (minimal data)

b) developing new sampling procedures which might allow fewer actual site observations in the field

It was considered essential that the Soil Survey itself undertake to assess these possibilities without delay. If possible, arrangements will be made in the forthcoming field season to undertake a research project on field survey methodology in two locations in Canada (possibly B.C. and Ontario). In the

proposed research project, the reliability and utility of simplified field procedures would be assessed. This would be done in relation to standard soil surveys. The utility and reliability of "simplified" soil surveys for making designated sets of interpretations could be a key consideration in assessing the utility of any new approach.

The assessment is to be undertaken under the auspices of the Working Group on Soil Mapping Systems by K. Valentine and D. Moon if funding and other necessary arrangements can be made.

Dr. Clark also stated he would investigate the possibility of developing a project to assess methodology for upgrading soil surveys using controlled sampling. Spatial variability, sampling statistics and modified field survey procedures were proposed as an integral part of the study project. To be successful, such a project would require adequate statistical support and means of obtaining the necessary statistical support would be investigated.

Dr. Clark also brought out the continued concern regarding the costs and slow rate of publication of soil maps and reports. This was an issue that soil survey must address if it hopes to get continued support. A great deal of attention has been given to the development of automated map production and information systems. However, the full capability of these systems for accelerating the preparation of soil survey maps and reports has not been adequately explored.

It was pointed out to the Committee that one of the important federal roles in the land resource area could be research and development on soil survey methodology. It was on this basis that Dr. Clark proposed the "research" projects on the problems of accelerating soil survey be undertaken within the federal soil survey program.

Provincial reports highlighting current programs and concerns were also presented by the Committee members. These reports are included in the Proceedings.

RECOMMENDATIONS:

A number of recommendations were put forward and have been arranged in two groups:

1. These pertaining to internal ECSS Working Group activities:

1.1 It is recommended that the soil survey units be provided with the resources required to assess and record on generalized soil landscape maps the extent and severity of past soil erosion, using existing data, information provided by knowledgeable individuals in each region of each province, air photos, field observations and professional insight. The project should be coordinated to provide consistency of interpretations between regions.

1.2 It is recommended that each soil surveyor be requested to record the severity of past erosion, observed during new and ongoing soil surveys, on the daily form, on the detailed form and as part of the map symbol. This will provide a data base for comparisons in future years. Consistency of classes used must be reviewed.

1.3 It is recommended that resources be provided to LRRI to have climate station and existing erosion research data analyzed to identify, and compute the probability of, severe winter-spring water and wind erosion events, and estimate the importance of these relative to the average summer or annual erosion predicted by the USLE and wind erosion equation. Where soil erodibility and movement data are inadequate or lacking, resources should be made available to have additional research undertaken.

1.4 It is recommended that resources be provided to LRRI and soil survey units to investigate reported soil compaction, and develop procedures or models to predict its occurrence, estimate its significance to soil productivity, and permit mapping to proceed.

1.5 The Agronomic Working Group recommended that formal arrangements be made with Expert Committee on Agrometerology to ensure reciprocal representation on both Committees.

1.6 It was recommended that a standardized data base for site specific soil and climatic information be designed in such a way that information could be used at any desired scale.

2. RECOMMENDATIONS submitted to CCLRS for R and D.

2.1 That Agriculture Canada establish a national soil conservation program to provide degradation monitoring, applied research and conservation planning to ensure the maintenance and improvement of Canada's Land Resources for food production.

Background

There is a persistently growing concern over the general deterioration of our land resources. A key requirement to ensure conservation of land resources and the enhancement of their productivity is the capability to monitor the quality (or degradation) of land resources. An adequate monitoring capability is necessary to assess the current state of Canadian land resources as a basis for policy and program development, the impact of agricultural practices on land quality, the remedial soil conservation practices recommended and the need for research to improve soil quality.

It is also clear that the assessment intensity must be adequate to provide information on processes at specific representative sites, and measurements to provide data on the extent and distribution of degradation. A reliable assessment will require a well supported and equipped field program.

2.2 That Agriculture Canada expand its research programs in soil management in all regions of Canada. It is also recommended that the current work in soils and all expanded activities be developed under the soil-management objective of the Research Branch to ensure the appropriate focus and orientation to soil research.

Background: Efforts are being made in all regions of Canada to improve the viability, efficiency and productivity of agriculture. The effective utilization, improvement and preservation of the soil are to be realized. The importance of improving soil and water Agri-Food objectives, has been fully and clearly documented in the Land Resource Research Strategy prepared for CARC. Little progress has been made in the implementation, the strategy, and the current level of work in all areas of soils is considered seriously inadequate.

Work on all aspects of soil management must be rapidly expanded. Information on tillage, maintenance of fertility, improved drainage techniques, more efficient water use, management of salinity, prevention of acidification, control of erosion, is urgently required as a basis for planning and managing agricultural development and production in all regions of the country. It is also considered essential that work on soil management be developed on an interdisciplinary basis to ensure that research in soils and related fields of economics, engineering and plant science is integrated to assure the establishment of viable farming systems that allow the effective utilization, preservation, and enhancement of soil and water resources.

OTHER BUSINESS

Membership: The term of the following member ended following the CASCC meeting in June 1984. T.M. Macyk; J.L. MacMillan;

Appointments include: T.M. Macyk (reappointed for one year);
H. Rees

The current membership list is given in Appendix 1.

Government of Canada / Gouvernement du Canada

MEMORANDUM **NOTE DE SERVICE**

TO / A: J. Nowland
Secretary CCLRS

FROM / DE: Jack Shields
Secretary ECSS

SECURITY - CLASSIFICATION - DE SÉCURITÉ	
OUR FILE – N / RÉFÉRENCE	
YOUR FILE – V / RÉFÉRENCE	
DATE	October 19, 1984

SUBJECT / OBJET: Membership List of Expert Committee For Soil Survey

The current members, full addresses and termination dates are listed below:

	Regional members	Term Ends*
B.C.	H.A. Luttmerding Terrestrial Studies Branch B.C. Ministry of the Environment 1873 Spall Road Kellowna, B.C. V1Y 4R2	1985
Alta.	T.M. Macyk Soil Survey Unit, Agr. Canada 6th Floor, Terrace Plaza Tower 445 Calgary Trail South Edmonton, Alberta T6H 5C3	1985
Sask.	J.G. Ellis Research Scientist Saskatchewan Institute of Pedology University of Saskatchewan Saskatoon, Saskatchewan S7N 0W0	1985
Man.	G.F. Mills Canada Manitoba Soil Survey Soil Science Building University of Manitoba Winnipeg, Manitoba	1986
Ont.	B. van den Broek Ontario Institute of Pedology Guelph Agriculture Centre University of Guelph, Box 1030 Guelph, Ontario N1H 6N1	1985

	Regional members	Term Ends*
Que.	D. Carrier Service de la recherche en sol du MAPA 2700, rue Enstein, B-1-28 Saint-Foy Québec, G1P 3W8	1986
N.B.	H. Rees Canada-New Brunswick Soil Survey Agric. Canada Research Station P.O. Box 280 Fredricton, New Brunswick, E3B 4Z7	1987
N.S.	D.A. Holmstrom Canada Soil Survey Res. Branch, Agr. Canada Nova Scotia Agricultural College Truro, Nova Scotia B2N 5E3	1986
P.E.I.	A.T. Raad Plant and Industry Branch P.E.I. Dept. of Agriculture Box 1600 Charlottetown, P.E.I. C1A 7N3	1985
Nfld.	A. Stewart Soil & Land Management Div. Dept. of Rural, Agricultural & Northern Dev. Prov. Agricultural Building Brookfield Road Mount Pearl, Nfld. A1C 5T7	1985
	Departmental representatives	
Envir.	J. Thie Lands Directorate Dept. of Fisheries and Environment 20th Floor Place Vincent Massey Hull, PQ K1A 0E7	
INA	I. Sneddon Resource Inventory Manager Land Mangement Division Northern Water, Lands and Forests Indian and Northern Affairs Hull, PQ K1A 0H4	

EMR	R. Fulton Terrain Sciences Division E.M.R. 601 Booth Street Ottawa, Ontario	
P.F.R.A.	L. Chambers P.F.R.A. Motherwell Building 1901 Victoria Ave. Regina, Saskatchewan S4P 0R5	
C.F.S.	R. Keen Forest Management Institute Petawawa National Forestry Institute Canadian Forestry Service Chalk River, Ontario K0J 1J0	
	Departmental representatives	Term ends*
Chairman	J.S. Clark (Reappointed) Land Resource Research Institute Central Experimental Farm Ottawa, Canada K1A 0C6	1986
Secretary	J.A. Shields Land Resource Research Institute Central Experimental Farm Ottawa, Canada K1A 0C6	1985

* End of term occurs following the spring meeting of CASCC

Appendix 6.1

Agendas for the 1984

ECSS (Guelph) Working Groups meetings

Nov. 26-28, 1984

AGENDA for the Soil Degradation Working Group Meeting
E.C.S.S. Meeting, Guelph, November 26-28, 1984

Monday Nov. 26: 9:30 a.m. to 4:30 p.m.

Erosion:

i)	Past soil erosion:	Murray Miller (U. of Guelph) Dave Chanasyk (U. of Alberta) Darwin Anderson (U. of Saskatchewan) Eeltje de Jong (U. of Saskatchewan)
ii)	Erodibility and erosion risk:	Trev Dickinson (U. of Guelph) Eeltje de Jong Irene Shelton (U. of Guelph) Harold Rostad Laurens van Vliet
iii)	Erosion monitoring:	Murray Miller Eeltje de Jong Dave Chanasyk Laurens van Vliet

Tuesday Nov. 27: 8:30 a.m. to 4:30 p.m.

Soil Structure deterioration (compaction):

i)	Characterization:	Jan de Vries (U. B.C.) Bev Kay (U. of Guelph)
ii)	Risk mapping possibilities:	
iii)	Monitoring:	Jan de Vries Bev Kay

Wednesday Nov. 27: 9:30 a.m. to 12:00

Update on activities of Work Group:

i)	Salinity:	Bob Eilers
ii)	Acidity:	Harold Rostad, Herb Rees
iii)	Contamination:	John MacMillan
iv)	Organic matter:	Darwin Anderson

Recommendations for report to ECSS:

Wednesday Nov. 27: 1:00 p.m. to 4:30 p.m.

Concurrent Meetings of Soil Survey/PFRA Ad-Hoc Work Groups

i)	Salinity	Bob Eilers (Chairman)
ii)	Erosion	Dick Coote (Chairman)
iii)	Productivity	Glen Padbury (Chairman)

AGRONOMIC INTERPRETATIONS WORKING GROUP.
GUELPH WORKSHOP, NOVEMBER 1984.

TENTATIVE AGENDA.

Monday, November 26.

9.00	Introduction and review of agenda.
9.15 - 10.00	Discussion of the provisional mandate (see Jack's letter, June 15, 1984).
10.15 - 12.00	Presentation of regional reports (see Bob's letter, September 13, 1984). Take 15 minutes for each presentation).

- B.C. L. Kenney
- Alta. W. Pettapiece
- Sask. D. Acton
- Man. R. Smith
- Ont. B. van den Broek
- Que. J.M. Cossette
- N.B. H. Rees

1.00 - 1.45	Continuing with presentation of regional reports.

- N.S. D. Holmstrom
- P.E.I. C. Veer
- Nfld. J. van der Hulst

1.45 - 3.00	General discussion on the regional reports and synthesis of a national picture.
3.15 - 4.30	General discussion C.L.I. for agriculture (mandate I).

- should it be retained as an "agricultural" interpretation with specific references to a certain range of crops? It so, what changes do we envisage for the system?
- should it be retained as an "agricultural" system without specific references to a certain range of crops? If so, what changes do we envisage for the system?

A Consensus on the action to be taken.

Tuesday, November 27

9.00 - 10.00	General discussion on soil management interpretation aspects (mandate 2).

- should it be the role of soil survey to develop a set of soil management interpretations to be included in the overall concept of soil interpretations?

- whom do we serve with this kind of a package?
- what would be an appropriate scale?

A concensus on the action to be taken.

10.15 - 12.15 Joint meeting with MAPPING SYSTEMS and CanSIS. Minimum data sets: Agronomic Interpretations at S.I.L. 2 (K. Valentine).

1:30 - 3.00 Joint meeting with MPAAING SYSTEMS and CanSIS. Minimum data sets. (B. van den Broek).

3.15 - 4.30 General discussion on economic evaluations for soil management and land improvement recommendations (mandate 3).

- would we benefit from this type of information (complementing info.)?
- what type of info. would be desirable and how attainable is it?

A concensus on the action to be taken.

Wednesday, November 28

9.00 - 10.00 Summary of our deliberations and setting priorities, (mandate 4).

10.15 - 12.00 Drafting action plan, delegation of tasks.

1.00 - 2.00 Drafting interim rapport for E.C.S.S. business meeting to be presented on Thursday.

2.00 - 4.00 Tour of the O.I.P. facilities at the Guelph Agriculture Centre (computer facilities).

4.00 Tour and reception Collins and Moon Ltd.

Mapping System Working Group
First Agenda
ECSS Meeting Guelph 26-28th Nov. 1984

Monday 26th Nov.

9.00 am	Introduction and Review of Agenda	
9.15-10.00	General/Special purpose surveys SIL Specifications	- K. Valentine
10-15-12.15	Survey procedure, design and specifications for an intensity level 2 survey for agriculture - Objectives - Properties and classes of properties - Design (including reliability checks) - Presentation - Client Liason	
	Short examples to start discussion Nova Scotia, contract surveys Quebec, St. Lawrence Valley Manitoba, Assiniboia British Columbia, Peace River British Columbia, S.E. Vancouver Is.	 - D. Holmstrom - J-M. Cossette - M. Langman - K. Valentine - J. Jungen
1.30-3.00	Survey Procedures SIL 2 Agriculture, contd.	
3.15-4.30	Survey procedures SIL 2 Agriculture, contd.	

Tuesday 27th Nov.

8.30- 10.00	Joint Meeting with CanSIS W.G. National Files	- K.B. MacDonald
10.15-12.15	Joint Meeting with CanSIS and Agronomic Interpretations W.Gs. Minimum Data Sets: Agronomic Interpretations at SIL 2	- K. Valentine
1.30-3.00	Minimum Data Sets: Agronomic Interpretations at SIL 2 - continued	- R. van den Broek
3.15-4.30	Summary: Implications of Minimum Data Sets to local interpretations and standards for National Files	- K.B. MacDonald

Wednesday 28th Nov.

8.30-10.00	Information Packaging	- C. Tarnocai (or substitute)
10.30-12.15	Evaluation and Possible Implementation of New Approaches Alberta Provincial Concerns and initiatives in soil mapping	- R. MacMillan or R. Howitt
1.30-3.00	Summation and future plans	

CANSIS - Computer Working Group of ECSS

Monday, November 26, 1984
Review of Existing Regional EDP Applications

Session 1: Selected Applications Review

Field Data Collection with a hand held Microcomputer and Field Office Processing
by D. E. Moon

(The text of this presentation is included under the proceedings of the ECSS Business Meeting Thursday, November 29, 1984 as;
Handheld computers applied to Soil Survey - D. E. Moon)

Adapting procedures to use a hand held microcomputer and Data processing using local mainframe facilities
by W. Fraser

Ontario Institute of Pedology Overview - cartographic stand-alone digitizing work station status update and data management - review of files and applications
presented by J. Greuel and J. Lodder.

(Stand-alone Digitizing System text prepared by K. Jones and J. Lodder; text of data management applications not available)

CASPIR - A program to calculate family particle size class from horizon data (computerizing the Canadian system of soil classification)
by M. Schweiger

(Summary only - full documentation and copy of program available on request from OIP)

Organizing, managing and storing data from contract soil surveys - the Nova Scotia example
by L. Boardman and K. B. MacDonald

Adapting a mainframe APL based application to a microcomputer
by M. Nolin

Session 2: Regional Reports

Alberta - R. Howitt
Saskatchewan - B. H. Stonehouse
Yukon - S. Smith
Newfoundland - G. Kirby
Nova Scotia - G. Patterson

Session 3: Performance Requirements for Regional Computer Hardware and Software

DBMS (Data Base Management Features) for Regional Applications
by D. E. Moon

Tuesday, November 27, 1984
Joint Working Group Session with Mapping Systems and Agronomic Interpretations

Data Files of Long Term Importance and Implications of Minimum Data Sets for Local Interpretations and Standards for National Files
by B. MacDonald with sections by P. A. Benson and M. Brklacich

Wednesday November 28, 1984
Recommendations Future Plans and tour

CanSIS - Computer Working Group Membership

AGENDA FOR THE SOIL CLASSIFICATION WORKING GROUP MEETING
E.C.S.S. Meeting, Guelph, November 26-28, 1984

Monday, Nov. 26

9:00-9:15	Welcome and introductory remarks.	C. Tarnocai
9:15-10:00	Proposal for the improved criteria for the Gleysolic order.	J.A. McKeague and C. Wang
10:20-12:20	Presentations of the regional representatives on the results of the tests carried out on the improvements in the Gleysolic order.	
	British Columbia	T. Lord
	Alberta	L. Turchenek
	Yukon	S. Smith
	Saskatchewan	J. Ellis
	Manitoba	W. Michalyna
	Northern Manitoba	R. Eilers
		G. Mills and H. Veldhuis
	Ontario	L. Evans
	Quebec	J.-M. Cossette
	Atlantic	K. Webb
2:00-3:00	Discussion and proposal on the Gleysolic order.	
3:20-5:00	Discussion and proposal on the Gleysolic order.	

Tuesday, Nov. 27

8:30-9:00	Background information on the work carried out on the Folisols.	R. Trowbridge
9:00-10:00	Characteristics of Folisols.	C. Fox.
10:20-11:00	Proposal for the classification of Folisols.	R. Trowbridge
11:00-12:00	Discussion on the classification of Folisols.	
1:30-3:00	Discussion and proposal on the classification of Folisols.	
3:20-4:00	Classification of Podzols.	J.A. McKeague
4:00-4:30	Contrasting horizons and layers.	C. Tarnocai
4:30-5:00	Definition of soil surface.	C. Tarnocai

Wednesday, Nov. 23

8:30-9:00	Progress on the development of an international soil classification.	J.A. McKeague
9:00-10:00	Classification of clay soils.	D. Acton
10:20-12:00	Discussion and proposals relating to contrasting horizons and layers and the definition of soil surface.	

6.2 LIST OF WORKING GROUP PARTICIPANTS

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J. Gruel
R. Howitt
K. Jones
G. Kirby
J. Lodder
J. MacMillan
D. Moon
M. Nolin
G. Patterson
M. Schweiger
S. Smith
B. Stonehouse

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L. Grenon
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L. Turchenek
K. Webb
E. Woodrow

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M. Black
D. Charnasyk
E. De Jong
J. De Vries
T. Dickinson
R. Eilers
W. Eilers
B. Kay
J. MacMillan
M. Miller
G. Padbury
H. Rees
L. Van Vliet
G. Wall

6.3 1984 ECSS Meeting Attendance List

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J. DeVries	Dept. of Soil Science	Vancouver
L. Kenney	Dept. of Soil Science	Vancouver
T. Lord	Canada Soil Survey	Vancouver
D. Moon	Canada Soil Survey	Vancouver
S. Smith	c/o Dept. of Soil Science	Vancouver
R. Trowbridge	B.C. Forestry Service	Smithers
K. Valentine	Canada Soil Survey	Vancouver
L. Van Vliet	Canada Soil Survey	Vancouver
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P. Benson	Parks Branch, Environment Canada	Calgary
D. Chanasyk	Dept. of Soil Science	Edmonton
G. Coen	Alberta Canada Soil Survey	Edmonton
R. Howitt	Soil Survey Unit	Edmonton
T.M. Macyk	Alberta Canada Soil Survey	Edmonton
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D. Anderson	Saskatchewan Institute of Pedology	Saskatoon
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W.R. Fraser	Canada Manitoba Soil Survey	Winnipeg
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W. Michalyna	Canada Manitoba Soil Survey	Winnipeg
G.F. Mills	Canada Manitoba Soil Survey	Winnipeg
R.E. Smith	Canada Manitoba Soil Survey	Winnipeg
Ontario		
C.J. Acton	Ontario Institute of Pedology	Guelph
F. Aspinal	Ontario Institute of Pedology	Guelph
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S. Collins	Collins and Moon Ltd.	Guelph
D.R. Coote	Land Resource Research Institute	Ottawa
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B. Haddon	Petawawa National Forestry Institute	Chalk River
B. Hohner	Ontario Inst. of Pedology	Guelph
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Quebec		
D. Carrier	Service de la rech. en sol du MAPA	Ste. Foy
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