The CANADA SOIL INFORMATION SYSTEM (CanSIS)
The NATIONAL SOIL DATA BASE (NSDB)

CanSIS MANUAL 1
CanSIS/NSDB: A GENERAL DESCRIPTION

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1992

Copies of this publication are available from
Centre for Land and Biological Resources Research
Research Branch, Agriculture Canada
Central Experimental Farm
Ottawa, Ontario
K1A 0C6

Published by Centre for Land and
Biological Resources Research

CLBRR Contribution No. 92–35

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1. INTRODUCTION

1.1 AN OVERVIEW

This manual is a description of the Canada Soil Information System (CanSIS). It is intended for those who want to understand the system. Those who want to use the system will require more detailed operating manuals.

CanSIS is a specific type of Geographical Information System (GIS), which, according to Burrough (1986), is a "set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes". In this case the set of tools consists of an ARC/Info Geographic Information System (Environmental Systems Research Institute (ESRI), Toronto, Canada)[1] operating on a VAX computer. The system has been customized to handle land resource data. The Land Resource Division (LRD) of the Centre for Land and Biological Resources Research (CLBRR) has compiled data on Canada's land resources into the National Soils Data Base (NSDB) using ARC/Info. The spatial data define the location of the major types of soil in Canada including some associated landscape features such as slope and rock outcrops. The non-spatial attributes comprise those characteristics that are relevant to a soil's biological productivity; that is its potential to grow plants, and indirectly to support animals. To a lesser extent, the characteristics are also relevant to how easily vehicles, animals or people can move across the soil; that is its trafficability. Where assessments of biological productivity or trafficability have actually been made, they also are included as part of the data in the system. For purposes of analysis and output, the data are frequently represented as maps, including lines, symbols and legends.

The NSDB is designed to be one layer in what constitutes a complete geographical information system. It deals with soil, and landscape features. It does not include climate (apart from some attributes of soil climate), census data or administrative information, land use or economics. If such information is needed for a particular project it must be collected and added as separate layers.

The information is stored in computers. So a complete picture of CanSIS includes not only the soil information (NSDB), but also the file structure that holds the information, the analytical procedures or algorithms that are used to process it, the software (computer programs), hardware or equipment (computers, digitizing tables, printers, plotters, graphics terminals etc.), personnel, and all the operating procedures.

The system includes regional offices as well as Ottawa (Figure 1). The central unit in LRD Ottawa (the hub) acts as the principal source of system development and the central archive; it is the national repository of information collected on field surveys or created by land use analysis projects. Arranged around the hub, and connected to it like spokes of the wheel, are the LRD regional units which collect data during field inventories or create it through regional land evaluation projects. Overlapping most of the regional units are the provincial equivalents of CanSIS, some large, some small, some quite compatible, some considerably less so. What started, years ago, as a highly centralized system is rapidly dispersing responsibility to the units.

Up until recently, the LRD was the principal custodian of federal and joint federal-provincial soil map data in digital form (British Columbia formerly had a computer system for provincial data). With the development of commercial GIS software and, in particular, software

[1] The mention of a trademark, proprietary product or vendor does not imply endorsement by Agriculture Canada to the exclusion of other products or vendors.

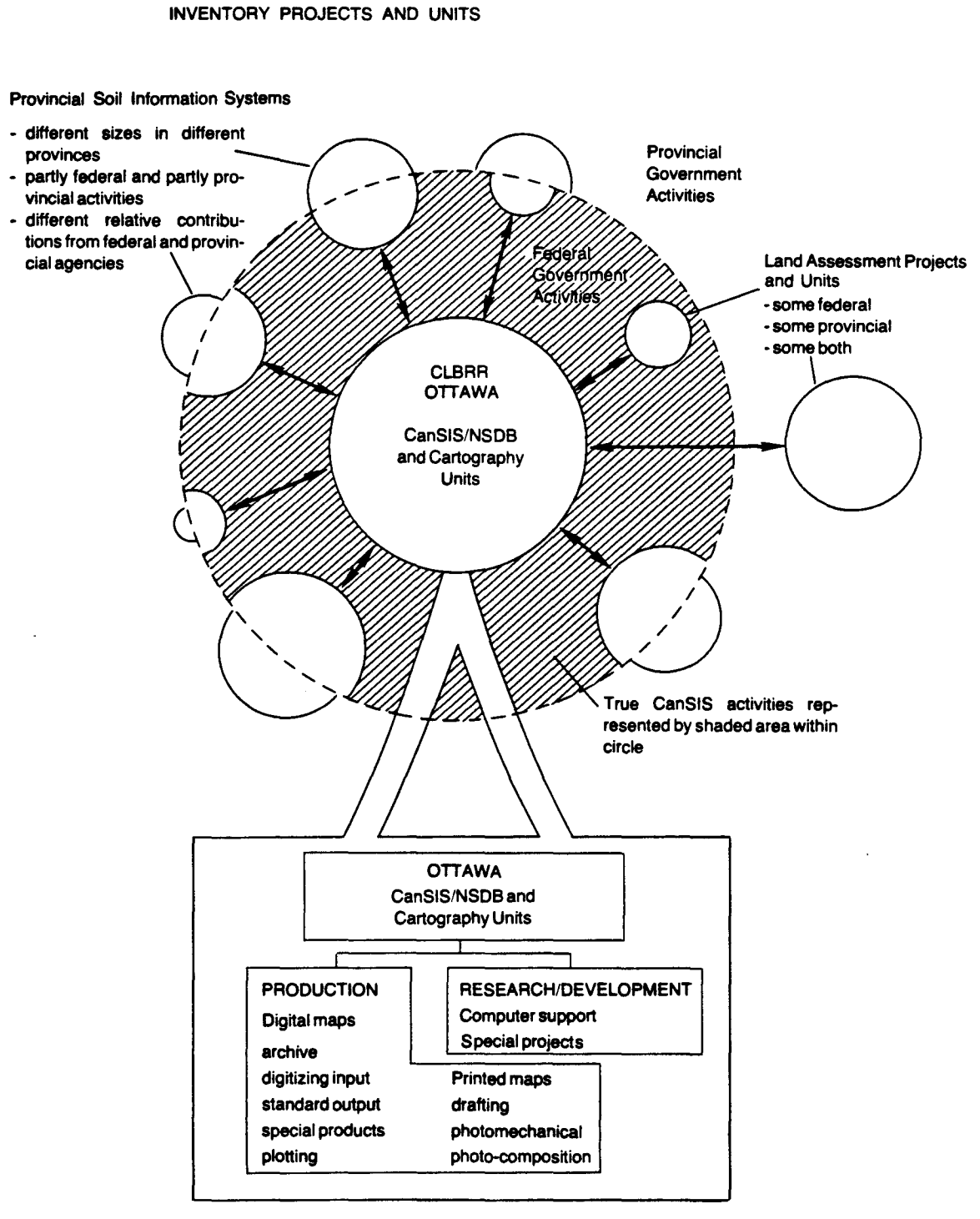


Figure 1. Schematic Representation of the Organization of CanSIS

suitable for implementation on microcomputers, many provinces are actively developing local GIS capability. There is a variety of regional GIS capability ranging from federal equipment with provincial support through joint ventures to provincial systems with federal support as well as individual agency systems.

1.2 HISTORICAL DEVELOPMENT

By 1971, the soil survey discipline had developed a complete methodology, organized the science with a taxonomy system for classifying soils and was actively working to characterize the land resources of Canada with emphasis on the agricultural regions. The quantities of data had become so large that the National Committee on Soil Survey recommended that they be organized and stored within a computerized system.

CanSIS was developed by the Land Resource Research Centre (LRRC) of the Research Branch of Agriculture Canada. From 1975 to 1986 it was run with computer programs written by the Centre's own computer scientists. Early on, as a world leader in the field, the system could be modified and developed as necessary. Later, as other agencies developed their own systems, often based on commercial GIS software, it became difficult to exchange information. The Centre's original custom designed software was not compatible with the principal types of commercial software that were becoming ubiquitous.

Prior to 1986 the CanSIS system (MacDonald and Kloosterman 1984) had the following groups of files:

- Cartographic: map lines and symbols
- Detail: soil profile (site) information
- Soil Management: productivity records
- Wetlands: site information for peatlands etc.

The information contained in these files has either been transferred to the new files, as in the case of the cartographic data, or has been stored as it stands. The three files that have been stored (Detail, Soil Management, and Wetlands) are still accessible but will not be developed further. No further additions of data are planned to these files as they exist in Ottawa; individual regions have been sent copies of the data and may choose to expand their local versions of the files.

In 1986 the centre purchased commercial ARC/Info software from Environmental Systems Research Institute (ESRI), Toronto, Canada. This software is used by many other federal and provincial agencies across Canada that deal with spatial environmental information. The transfer of the original CanSIS system to this commercial software has required not only a transposition of the fundamental data, but also a substantial revision of the structure of the system itself. The old manuals and operating procedures are out of date. The objective of this manual is to provide a general overview and description of the new version of CanSIS. Other manuals go into more detail on each of these topics.

2. ROLES AND RESPONSIBILITIES

2.1 CENTRE FOR LAND AND BIOLOGICAL RESOURCES RESEARCH (CLBRR) LAND RESOURCES DIVISION (LRD)

The LRD (formerly LRRC) conducts national programs in land resource research, dealing with four major objectives of Agriculture Canada; namely, land resource inventory, land use and evaluation, soil management and conservation, water and climate. These objectives are organized into three programs (i) land resource data and applications, (ii) sustainable land productivity, and (iii) environmental quality.

Program 1 of the LRD includes the federal role in soil survey activities for Canada. It collects, analyses and publishes information about the characteristics and potentials of land primarily from the point of view of soil, but also taking into account climate, landform, surficial geology, hydrology etc. In cooperation with provincial soil survey agencies, it concentrates on agricultural land, however in as much as most, if not all land in Canada is put to multiple use it also works on the urban fringe, in forested land, and occasionally in the North. The national soil survey also takes responsibility for setting soil survey standards, checking quality, and acting as a repository for data about the major soils that have been mapped across the country. As part of this responsibility it has sponsored the development of CanSIS and the National Soil Data Base (NSDB).

In 1990, the soil survey role was reviewed by the Audit and Evaluation Branch (Agriculture Canada, 1990) which recommended that the centre re-orient and focus its role to:

- maintain the national soil data base; and,
- provide leadership and coordination in land inventory activity for Canada through;
    a) providing national standards for soil survey data;
    b) developing technologies and methodologies for interpretation, correlation and monitoring;
    c) fostering the development of a critical mass of soil survey expertise at the federal, provincial and private level.

In response to these recommendations the LRD has reorganized Program 1 to develop three broad series of studies.

One study group deals with soil resource information under the following headings;

- soil correlation and standards
- soil taxonomy
- national soil inventory
- provincial/territorial soil inventory
- CanSIS/NSDB (National soil data base)
- standard products/technology transfer.

A second study area deals with grouping or stratifying the soil resources within an ecological context (i.e. as they relate to other environmental data) in studies related to;

- agroecological stratification
- pedological processes.

The third group of studies is concerned with the application of land information organized into the following specific headings;

- interpretations for specified uses,
- Geographical Information System (GIS) procedures, and
- Soil quality analysis and assessment.

2.2 CanSIS/NSDB

CanSIS is the geographical information system that deals with soil, and other associated aspects of land, for the Research Branch of Agriculture Canada, for other branches of the federal government, and indeed for some provincial governments as well.

For the major types of soil in Canada, it records:

1. their position with respect to an established coordinate system, for example latitude and longitude;
2. their attributes that are not directly related to position, such as texture, pH, depth, etc;
3. their spatial relationships with adjacent and nearby soils, their topology; and
4. their suitability for various types of land use, principally agricultural.

In the past, the term CanSIS was used loosely to encompass activities related to computerized storage analysis, and management of land resource data within the LRD. The organization described above represents a recognition of the increased emphasis on data preservation in electronic form and the use of geographical information systems (GIS) to manage, manipulate and use these data. CanSIS now refers primarily to the organization (including personnel) and computer system (hardware and software) used for the compilation and management of soil resource information. It is part of the first study group of program 1. The most important component of CanSIS is the National Soil Data Base (NSDB). The activities of the CanSIS study include compilation of the NSDB and the delivery of data from the NSDB in hard copy or digital form. The delivery may be of complete copies of data or subsets but *doesn't involve development of data interpretations.*

The application and interpretation of soil resource information in combination with data from other sources, an activity formerly carried out within the CanSIS project, is now part of (but not restricted to) the third group of studies under program 1, Application of Land Resource Data. Some of the resources which were within the CanSIS project in the past are now devoted to these study areas.

2.3 FUNCTIONS

CanSIS/NSDB aims to provide information and products that can be used for the assessment of biological productivity and soil quality. This includes the potential for the growth of agricultural crops (including cereals, oil seeds, forages and horticultural crops), as well as forest crops (commercial tree species) and wildlife habitat (ungulate browse etc.). It also includes the land resource component of information necessary for assessments of the risk of water erosion, the incidence of salinity and the probable fate of pesticides and herbicides.

Some of the most detailed information (largest scale) could also be used to judge the ability of land to support heavy agricultural machinery, or to plan the lay out of a tile drainage system or a system of forest access roads.

CanSIS is designed for two principal tasks. The first, and most important, is the organization, storage and management of land resource data for analysis, i.e. assessments of biological productivity or trafficability, as has been mentioned already. The second function is to support the field inventory program. The input of data to the NSDB for current soil mapping projects facilitates the production of maps and report products specific to the project areas.

2.3.1 Land Resource Analysis

Those who wish to use CanSIS to assess the potential of land, will find that it has three major capabilities:

- It is a catalogue of what information is available; a comprehensive index file lists all digital maps in the system. Each digital map has a lineage or pedigree file to document the data sources and quality including information on where mapping has been done, when it was done and at what scale.
- It is a store of information about our major soils (their location, characteristics and potentials), and as a means of displaying that information in computer generated maps, tables, and abbreviated descriptions. This store is called the "archive", comprising, in addition to the digital soil map boundaries, a series of data files.
- It is a set of computerized procedures that extract information from the archive, subject it to analysis according to documented interpretive algorithms and develop assessments of the potential of land for various types of land use. This capability is developed by adapting the basic tools present in the ARC/Info software.

2.3.2 Support of Field Inventory

The storage and analytical capabilities of CanSIS can be used during a survey. In general these results are additional benefits to the principal activity of storing the data from new soil survey projects in the NSDB. For example, field site descriptions can be grouped by the computer to give a list of soils for the legend, and polygons can be grouped according to the soils they contain to give a list of map units. Similarly, the system can produce interim maps quickly once the lines on manuscript maps have been digitized. It can then calculate areas of map units or polygons. These results can be incorporated in reports. To a large extent these activities are carried out by the units operating in the regions on microcomputer based GIS's before the information is transferred to the NSDB in Ottawa.

3. ORGANIZATION

3.1 THE CanSIS NETWORK

Figure 1 illustrates, in a very simplified way, the organization of CanSIS. The LRD unit in Ottawa (in the centre) is responsible for receiving, storing and analyzing the information (or returning it for analysis elsewhere). Around the outside are the inventory units, or land assessment projects, that create the information or subsequently use it.

The regional units of LRD cooperate with counterpart provincial agencies. This loose association, in effect, forms the provincial soil information systems. The size and capabilities of the systems vary from province to province, as does the relative contribution of the provincial and federal agencies. The arrows in the diagram show that information is transferred both ways; initially to the central archive and analysis unit in Ottawa, and subsequently back to the regions on request.

The figure also shows that some information comes into CanSIS from projects that deal with land interpretations, subsequent to the original inventory. For example, it is conceivable that LRD in Ottawa or a Provincial agency could carry out a project to assess the productivity of certain soils for oilseeds. Such information, when developed could become part of the information attached to those soils. Moreover, the method by which the interpretation was made could be stored as a standard interpretation procedure.

3.2 ROLES AND RESPONSIBILITIES

3.2.1 LRD and Provincial Agencies

As Figure 1 implies, the relative roles and responsibilities of LRD and provincial agencies within CanSIS are closely intertwined.

CanSIS is a national soil information system developed, primarily, by LRD. LRD will remain in principal control over CanSIS in particular for development of the NSDB. It will take the primary responsibility for determining what information is required for national or regional soil information systems. It will support the system from its own resources, although provincial agencies will contribute when they prepare data for storage or analysis in the system.

LRD will ensure that the system is compatible with provincial systems whenever possible. This will be done through the CanSIS Working Group whose federal members will be expected to consult the agencies involved with soil information system in their own province or territory.

Beyond the mandatory data provinces will likely develop further lists of data that they themselves require. They will be responsible for these data, but LRD will undertake to store them in the central system and make them available to the province as long as they are in a form compatible with the core set of mandatory national data. Each province is free to record additional attributes that may be of more local significance; for example a certain characteristic of saline soils in the Prairies or depth to a fragipan layer in the Maritimes. Further documentation is provided in the User's Manual for Detailed Soil Maps.

3.2.2 LRD Ottawa and LRD Regional Units

The system is organized and run by the CanSIS/NSDB group in Ottawa, but each regional unit (or land inventory project) is responsible for the quality and content of the information they produce. This means that the Ottawa group establishes (in cooperation with the CanSIS

Working Group) the concepts and principles behind the system. They develop the structure, and are custodians of the central facilities of hardware and software. They are also responsible for receiving data, validating them, storing them in the archive, and providing data back to the regions when asked. LRD, Ottawa also produces maps, tables and figures to display and publish in standard or special formats. A Research and Development group prepares programs to analyze the information, connects it with other digital data as required, participates in collaborative research projects and undertakes the tasks necessary to keep CanSIS up-to-date.

Regional LRD units act as the regional arms of CanSIS. One member of each unit is designated the CanSIS representative who coordinates the supply of inventory data that fuels the system. CanSIS representatives are also responsible for the quality and completeness of those data following national standards. Similarly, they are responsible for any revisions and for maintaining records of which revisions are currently correct, and conveying this information to Ottawa. Consequently it is the data set that resides, or is verified by the regional unit and CanSIS representative in each Province that is the correct and up-to-date set.

Activities and responsibilities are moving away from the centre. Regional units have been taking more responsibility for their own information recently, and the larger ones are developing the ability to run local soil information systems.

4. HARDWARE AND SOFTWARE

The combinations of hardware and software in use to support CanSIS and the NSDB represent choices made to achieve the high priority needs at the time the system was acquired and are based on the capabilities available commercially. Both the hardware and software will develop and evolve as the needs change and as the variety of capabilities available in the marketplace expand.

In general terms, the operations of CanSIS and the NSDB are run on two levels of GIS. In Ottawa, the operations are developed around a shared minicomputer based environment. In the regions, the operations are carried out principally on single-user microcomputer based systems. The GIS capabilities in the regions vary from units which have no regional GIS access to units where the federal team operates a GIS independent of Ottawa and their provincial partners to units where the hardware and software and its operation is shared. Both hardware and software are constantly being reviewed and upgraded to meet new and developing requirements. Consequently, the specific details listed below represent the situation at the time of writing.

4.1 OTTAWA BASED HARDWARE AND SOFTWARE

The Ottawa group operates a shared computer facility which currently supports 15 to 25 users. Currently, all users access the same VAX 8650 computer. The computer is networked to the general Agriculture Canada VAX cluster of computers. Further development will be achieved by developing modular units to operate on separate VAX microcomputers dedicated to specific projects or parts of CanSIS. The VMS operating system is used. The data are input using large back-lit digitizing tables (Gentian and Calcomp), The standard graphics workstation used in Ottawa is a 4100 or 4200 series Tektronix terminal. Graphic output is produced on a QMS colour printer for small plots and on Calcomp 970 pen and Calcomp 68000 electrostatic plotter for cartographic quality output.

The software used in Ottawa for data storage, manipulation and output is ARC/Info.

4.2 REGIONAL HARDWARE AND SOFTWARE

In the Regions the situation is quite variable and subject to rapid change and development. All regional units use dBASE III or IV as a data base management system to manage their data files.

In Nova Scotia, the regional unit works cooperatively with the provincal ARC/Info GIS operating on a VAX microcomputer. They access the system through a Tektronix terminal and share the provincial facilities for digitizing and output.

In New Brunswick, the regional unit has access to a CARIS GIS operating on a VAX microcomputer. The system uses Tektronix terminals for access shared with the province. CARIS uses Oracle as a data base.

The federal unit in Quebec uses a Terrasoft GIS on an IBM compatible 386 computer. In Ontario, the provincial unit operates a PC version of ARC/Info. The federal unit in Ontario works on a Terrasoft GIS operating on an IBM compatible 386 computer with a small digitizing tablet and a development quality plotter for output. The Ontario unit shares a Calcomp 1073 plotter operated by the province to produce better quality output.

In Manitoba, Saskatchewan and Alberta the federal units operate a PAMAP GIS on an IBM compatible 386 microcomputer. In addition to the standard GIS capabilities, they have also acquired a software module called TOPOGRAPHER which allows digital elevation modelling. These installations are shared between the federal and provincial units in Saskatchewan and Manitoba. In Alberta, the provincial unit has an ARC/Info system operating on a VAX minicomputer.

In British Columbia, the federal unit is working on a Terrasoft GIS operating on an IBM compatible 386 computer. This operation is in conjunction with a CIDA project and not strictly a part of the LRD inventory activity.

For the remaining provinces and territories; Newfoundland, Prince Edward Island, and Yukon Territories the federal units do not have access to a regional GIS. The province is developing a corporate GIS for Prince Edward Island and New Brunswick; Newfoundland provincial ministry of agriculture has a PC ARC/Info system. There are no plans for regional GIS access in the Yukon.

5. DATA ORGANIZATION AND CONTENT IN THE NSDB

5.1 CONCEPT OF THE NSDB

The NSDB represents a collection of general purpose databases[2] of soil and land resource information for use for a variety of applications at national, regional and local scales.

The NSDB concentrates on information that is of national or regional importance, and leaves local information to local systems. There can be no absolute distinction between national or regional and local, but in principle the information that CanSIS deals with should be significant, standard and general.

- Significant: information that applies to large or important areas, or will conceivably be compared with other similar information from elsewhere in the country. This is the reason for restricting data stored to that derived from surveys of scales no larger than 1:10,000. As regions take more charge of their own data this could be further limited to scales no larger than 1:100,000.
- Standard: the requirement is for information that can be assembled and compared relatively easily. There must be a common data structure, and within that structure data should be always present and recorded the same way. A single file structure for non-spatial attribute data organization was not flexible enough to encompass the diversity of data associated with soil maps which range from the most detailed (largest scales) to the most general. In the NSDB, three levels of data and organization have been developed corresponding to national, regional and local or detailed data. The organization and formats of information coming from land evaluation or other research projects vary according to the nature of the project.
- General: information that is unspecific, that applies to considerable tracts of land, or, if quantitative, can be expressed as the most likely numeric values. It is according to this principle that the entity which soil properties (texture, pH) describe has been changed from the profile, or site (as in pre-1986 CanSIS), to a soil class (named soil). A soil class is a type of soil represented by a number of similar profiles or sites. It is the soil class, or type, that is shown on maps, and it is too time-consuming and expensive to store data, in a national soil information system, about each site at which a soil was inspected.

5.2 DATA ORGANIZATION, DATA STRUCTURE, DATA MODELS

5.2.1 Elements Common to All NSDB Map Data

5.2.1.1 The basic entity: a Digital soil Map as an ARC/Info coverage Each map (data set) within the NSDB is identified by a JOBID (a job identification number) which specifies a location on the earth and defines the area, scale and projection of the data. The data set stored is equivalent to the manuscript soil map (i.e. the individual map sheet concept has been retained in the system). There are a series of ARC/Info coverages within the data set for each map area which contain the various components of the complete map. For example, there is a SOIL coverage in which the soil thematic boundaries are stored; the HYDRO coverage contains all the water boundaries which have been stored; etc.

[2] In this publication, general purpose databases refer to collections of data characterizing a wide range of properties for a variety of uses and interpretations rather than data directed to a specific application.

5.2.1.2 The soil polygon Data in the NSDB are organized within a vector-based thematic information system. The principal spatial attribute consists of polygons of relatively homogeneous land and soil areas. Each polygon is described by four standard attributes in a file called the Polygon Attribute Table (PAT). These attributes are;

Area
Perimeter
Internal number
External number (USER-ID).

The USER-ID provides the link to all non-spatial information associated with the polygon. In general it is the non-spatial attribute information which differs in format and content depending on the level (scale) of the data.

5.2.1.3 Thematic boundaries and associated information The ARC/Info software generates a range of files to define the soil polygons. The ARC or line attribute files characterize the thematic boundaries defining features such as soil boundaries, hydrographic or administrative boundaries. So far as possible, the ARC definitions used by LRD are identical to the other agencies (e.g. Topographic Surveys Division of Energy Mines and Resources).

5.2.1.4 Project Pedigree file The project pedigree file provides a record of the lineage or history of the digital map and the data sources and checkpoints along the way to its completion. This file is produced for each map in the system.

In addition, the digital product is a model of a portion of the earth's surface; consequently, information about the georeferencing system, projection, etc becomes important. Furthermore, it is important to record the parameters of tolerance and accuracy used in the computer to produce the final digital record.

5.2.1.5 Fidelity of data representation One aspect of accuracy which had to be considered was a term carried over from published maps; namely, cartographic quality. This term has normally represented the fidelity with which the cartographer has reproduced the original manuscript map. Soil maps, produced by LRD meet a standard of cartographic accuracy on the final map to within 1 line width of the original. With computer assisted cartography, line widths from the plotter were normally 0.5 mm or less and this became the standard of accuracy for map output. In the NSDB the line data are generalized (weeded) to meet this standard in the most efficient possible fashion.

5.2.1.6 Positional accuracy The accuracy of all data is documented in the project pedigree file as calculated by comparison between points on the coverage and standard reference points. The absolute values of positional accuracy are dependent on the map scale but the criteria used are based on measurements on the map manuscript. Where the data cannot be projected to georeferenced coordinates to an accuracy equivalent to 0.5 mm on the manuscript, the data will remain in manuscript coordinates (i.e. inches).

5.2.1.7 Accuracy and precision — minimum area As a general principle, the smallest area represented on a soils map is limited to 0.25 cm^2 on the map manuscript or the equivalent of a square 0.5 cm by 0.5 cm at the scale of data compilation. Table 1 presents estimates of the minimum area which can be effectively portrayed at various map scales.

Table 1. Minimum Land Area Displayed Effectively in Comparison to Map Scale.

Map Scale	Approximate Dimensions for Map of Canada (cm)	Minimum Area (ha) Displayed in 0.25 sq. cm
1:25 million	21 x 18	1,562,500
1:5 million	107 x 91	62,500
1:1 million	535 x 455	2,500
1:500 thousand	1070 x 910	625
1:100 thousand	5350 x 4550	25

5.2.1.8 Geodetic reference system (Datum) A geodetic reference system provides a common comprehensive coordinate system. In Canada this reference system is referred to as the North American Datum (NAD). At the present time all maps in CanSIS/NSDB are based on NAD27 (the North American Datum established in 1927). A more recent standard, NAD83, has been developed based on improved measurements of the shape of the earth made by the *US Navy Navigation Satellite System*. NAD27 has been the legal standard for definition of locations; however, NAD83 will be the standard in the future. Procedures have been established in CanSIS to convert maps from NAD27 to NAD83. This conversion will be carried out as requests are made for information in the new datum. GIS users should verify that the information is in the same NAD when the data are to be combined. The implication of changing from the old datum to the new is a shift in the location coordinates. This shift is variable across Canada and corresponds to a range of 2-300 metres on the ground.

5.2.2 Non-standard Aspects of the NSDB Data Files

The non-spatial attribute data base specifies properties of the soil and landscape components of the thematic polygons. It is the major area of variability in the NSDB data structure. Three structures have been developed; national, regional and detailed. The principal attributes of these levels are described in the following sections.

5.2.2.1 Organization of National level data: the Soil Map of Canada (SMC) and the Land Potential Data Base (LPDB) For the Soils of Canada Map (scale of 1:5,000,000) an extensive series of attributes have been compiled and stored in the Land Potential Data Base. The Land Potential Data Base is described in the Users' Handbook (Kirkwood et al. 1989). Figure 2 illustrates schematically the association of data between the Soil Map of Canada and the files of the Land Potential Data Base.

The significant characteristics of this level include:

- compilation scale 1:5,000,000
- map projection is Lambert Conic Conformal in units of metres
- based on re-compilation of data existing prior to 1977
- coverage of entire country in one map sheet (one dataset)
- non-spatial attributes are associated with polygons by matching against USER-ID to published map symbol
- Map symbols unique by polygon
- associated data stored in standard ASCII files with specific files compiled for each project
- no cross reference to soil name or soil layer information

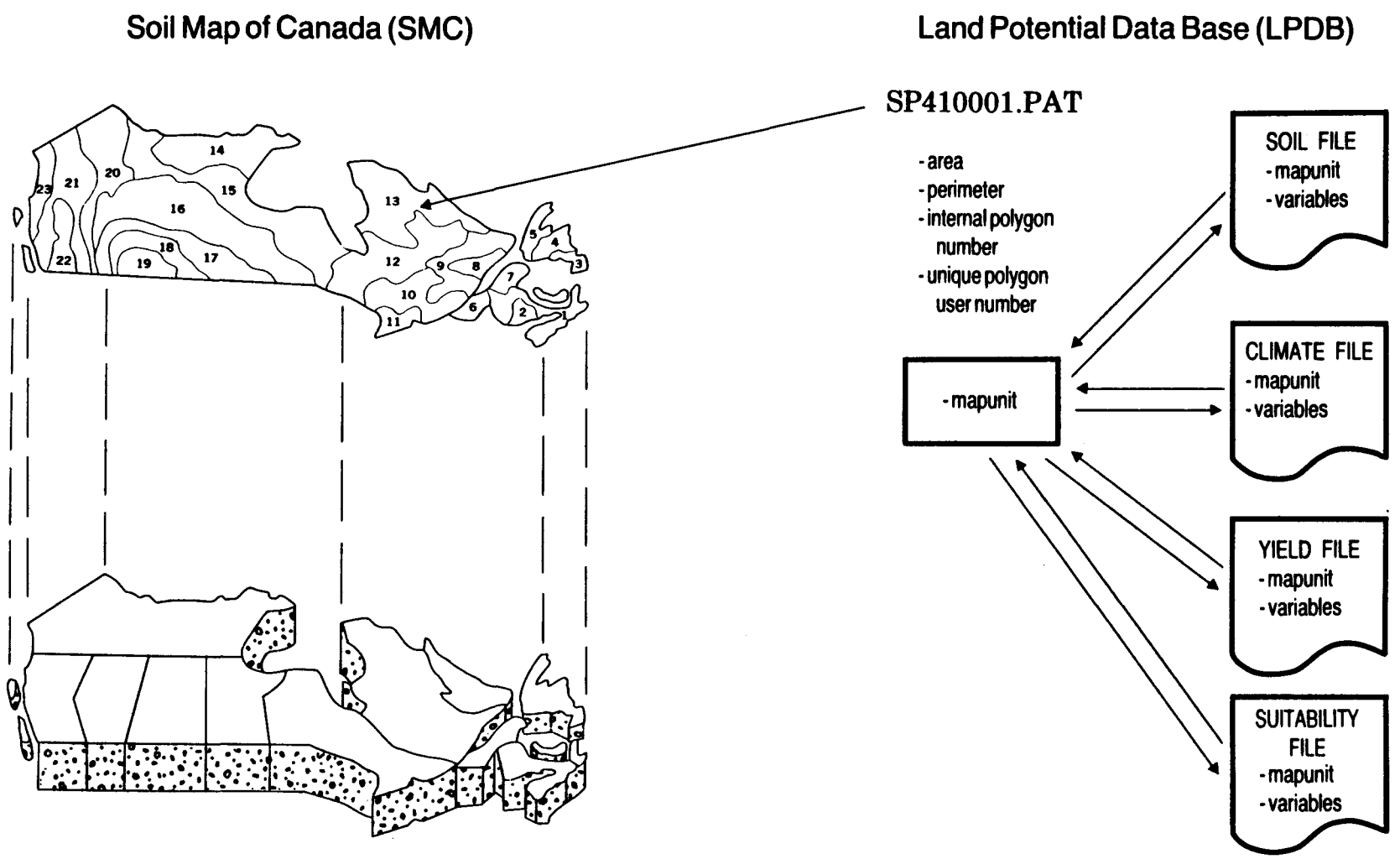


Figure 2. NSDB Organization for National Level Data: Soil Map of Canada (SMC); Land Potential Data Base (LPDB)

5.2.2.2 Organization of regional/provincial level data; the Soil Landscapes of Canada Maps (SLC) Figure 3 shows the way in which landscape attribute data is coordinated with polygons on the soil landscape maps. Figure 4 summarizes the attributes associated with the dominant and subdominant components of the polygons. A full description of these data is to be found in a companion CanSIS manual: the *Soil Landscapes of Canada Procedures Manual and Users Handbook Guide* (Shields *et al* 1991).

The significant characteristics of this level of data include:

- compilation scale 1:1,000,000
- map projection is Lambert Conic Conformal in units of metres
- based on re-compilation of data existing prior to 1988 where previous surveys exist (predominantly in the settled areas) and on actual surveys where existing data are not available.
- coverage of entire country in 23 map sheets (23 datasets)
- coverage nearly complete at date of this publication
- symbolization and legend is consistent across all map sheets and map edges are matched and correlated.
- non-spatial attributes are associated with polygons by matching against USER-ID to a unique polygon number
- map symbols may repeat over the landscape but the attribute information is specific for each polygon
- each polygon has a non-spatial attribute file to describe the DOMinant soil landscape, and *may* have a SUBdominant attribute file where a second landscape is present. These attribute files have a standardized format and complete data content.
- each attribute file (dominant and subdominant) provides reference to up to two "typical" soils thus providing a link to the soil names and soil layer files.

5.2.2.3 Organization of detailed level soil maps Soil surveys have been published for all the agricultural areas, and many surrounding areas, across the country. Data from these surveys comprise the most detailed soil inventory information that we have. Figure 5 shows the direct combination of attribute information about the polygon and its constituent soils for an ARC/Info coverage. Further details of the contents of this level of data are documented in the *User's Manual for Detailed Soil Maps* (MacDonald and Patterson, in preparation).

The significant characteristics of this level of data include:

- compilation scale 1:10,000 up to 1:250,000
- map projections UTM in units of metres (exceptions; maps crossing UTM zone boundaries are in Lambert, PEI maps are in PEI double stereographic, NB maps are in NB double stereographic, and maps on uncontrolled bases (line or photo) are retained in inches
- coverage consists of 1300 map sheets (datasets) mainly of the significant agricultural areas but only a small part of the Canadian land area is covered.
- within survey projects symbolization and legend is consistent and correlated between map sheets; in general map edges have not been matched to computer toler-

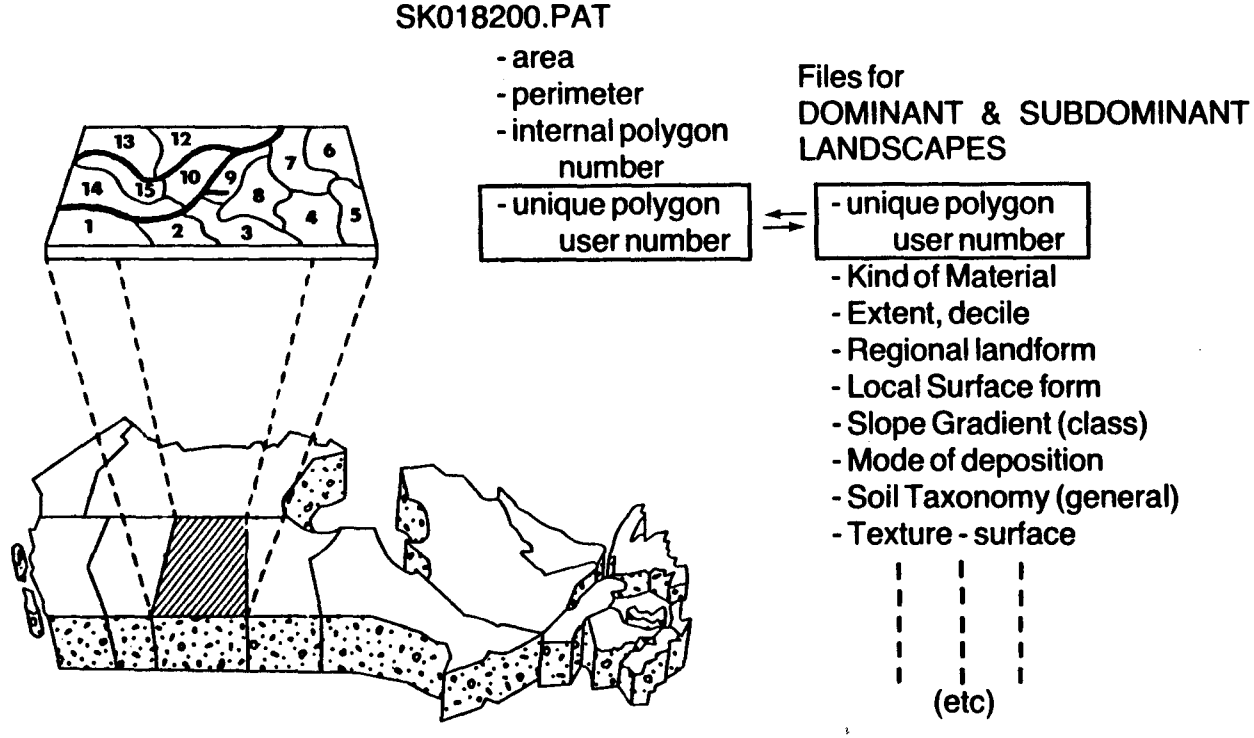


Figure 3. NSDB Organization for Regional/Provincial Level Data: Soil Landscapes of Canada Maps (SLC)

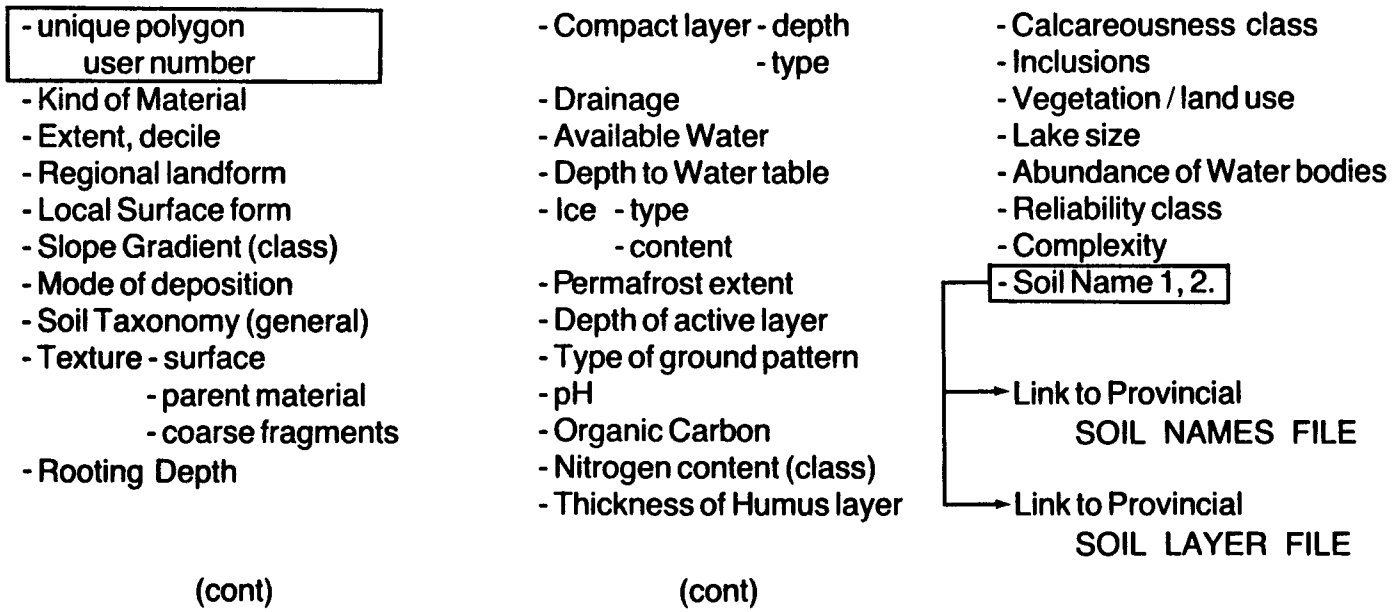


Figure 4. Attributes Files for Dominant and Subdominant Soil Landscapes

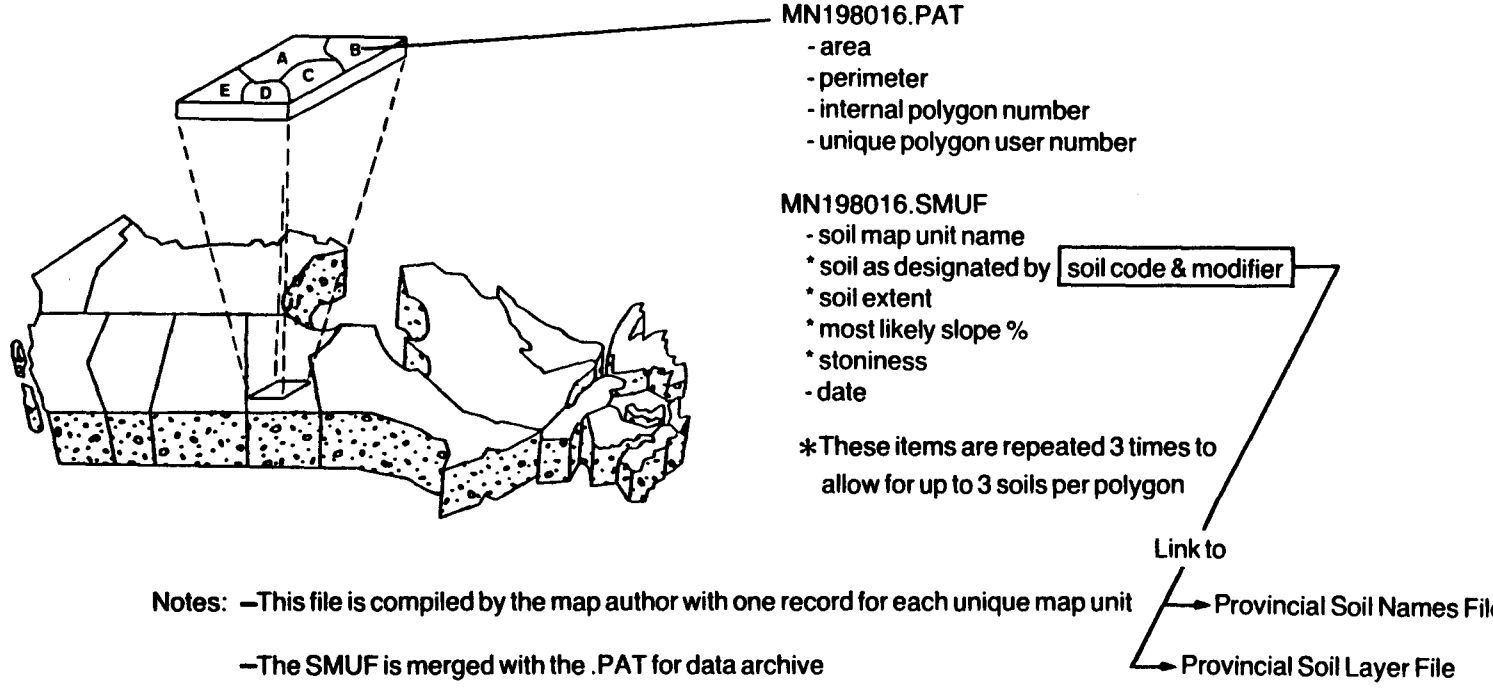


Figure 5. NSDB Organization of Detailed Level: Soil Map Data (DSM)

ances and between projects inconsistencies in symbolization and correlation may make combination of the data quite difficult.

- non-spatial attributes for the polygon area are linked to the polygon by the addition of soil map unit information (SMUF) to the PAT file.
- map symbols and the associated information in the map unit file are not unique but may be repeated in other map polygons.
- for each polygon, the map unit file may define up to three soils and an estimate of the proportion of each soil within the map unit
- each soil referred to in the map unit file is described further in the soil name (SNF) and soil layer files (SLF). The linkage between the map unit and the soil name and soil layer files is made based on a three letter soil code and a three character soil code modifier.

5.2.2.4 Organization of data from LRD research projects In the research phase of CanSIS, efforts are directed towards major cooperative applications e.g. a Prairie Land Evaluation Project (PLEP), pest risk assessment studies or soil degradation risk assessment. The specific activities include; data collection, testing of the data and structures, and refinement of the database.

For many kinds of interpretation, the data in the NSDB must be supplemented with information from other sources. Pest risk assessment (PRA) studies have been carried out using climate and soils data compiled at a national (1:5,000,000) level. For certain studies, it has been necessary to collect climate data from weather stations rather than the general area estimates. This is particularly true in mountainous areas where temperature and precipitation data is quite variable reflecting the high relative relief.

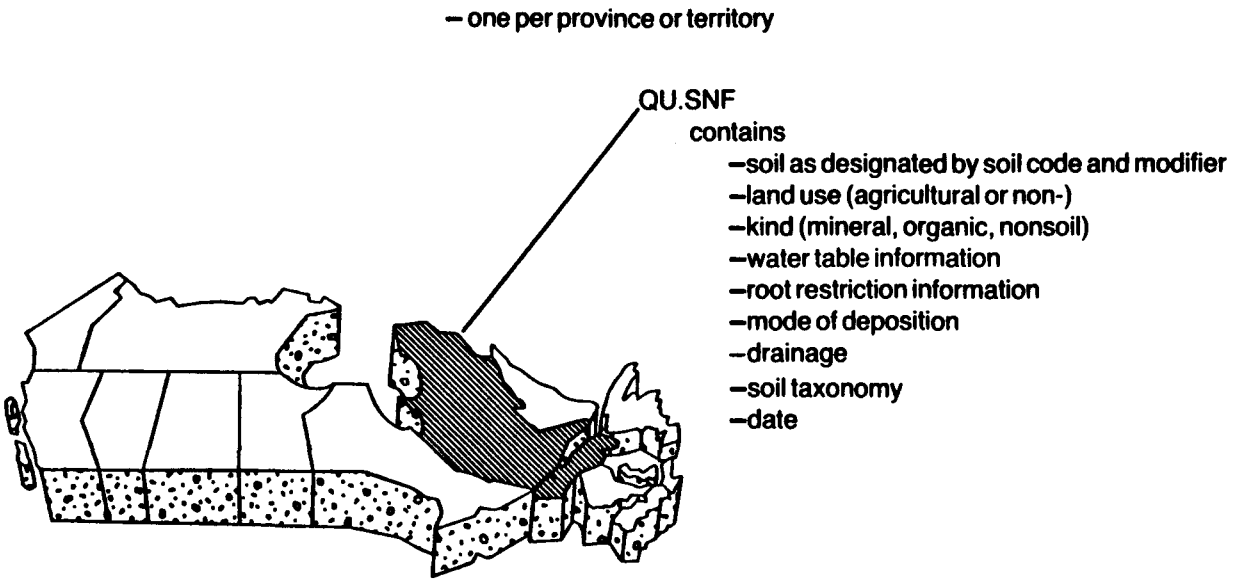
The PLEP represents a project to carry out land evaluation on a broad regional basis. A complex question such as land evaluation draws on data from the NSDB to provide the land base. It also requires climate data and farming systems information. Modelled data for climate and crop indices and yield are created. The CanSIS research effort has been directed to developing a data model which allows for the organization, storage and integration of these diverse types of data.

Data produced in conjunction with LRD research projects and stored in the NSDB may have other specialized formats documented within the project file.

5.2.2.5 Description of the soil properties in the Soil Names and Soil Layer files There are also two other files which contain information that is more efficiently arranged by province or territory; Soil Names File (SNF) and Soil Layer File (SLF). These two files contain the basic description characteristics of the major types of soil in each Province. Many soils in these files can occur over a wide geographic region and consequently, on several maps across the province or territory. They are characterized by general properties of the soil (e.g. drainage, watertable, mode of deposition) as illustrated in Figure 6. The soils also exhibit specific properties of the layers or horizons (e.g. particle size and general physical and chemical properties); these are summarized in Figure 7.

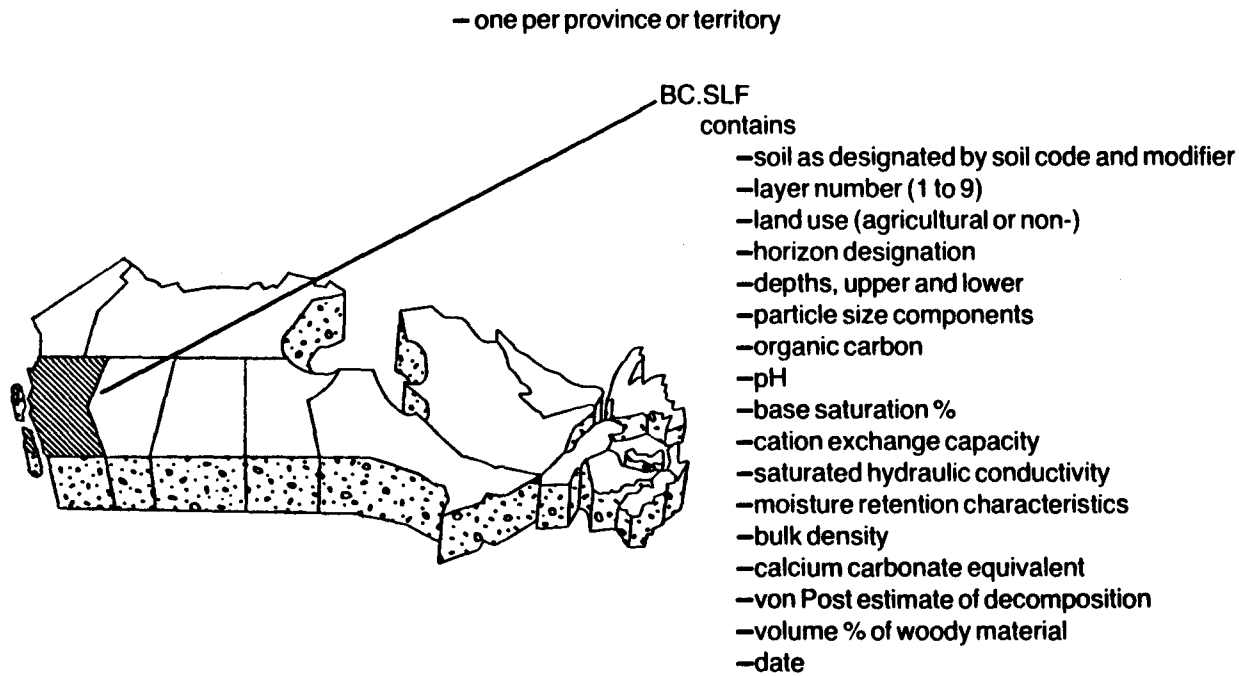
5.3 DATA CONTENT OF THE NSDB

Data status and availability can be determined by contacting LRD offices in Ottawa or the regions. This information is updated frequently; consequently, it is not published as a part of this manual.



Note: This file is compiled and correlated by the regional soil survey staff. A subset of soils is related to each map by matching the soil code and modifier. Data are complete for each soil.

Figure 6. NSDB Organization of the Soil Names File (SNF)



Note: This file is compiled and correlated by regional soil survey staff. A subset of soils is related to each map by matching the soil code and modifier. Data are complete for each layer.

Figure 7. NSDB Organization of the Soil Layer File (SLF)

Soil Map of Canada/Land Potential Data Base (SMC/LPDB)

- complete data for entire land mass of Canada
- details documented in LPDB user's handbook

Soil Landscapes of Canada (SLC)

- coverage available for Southern (settled) portions of Canada, map compilation and survey nearly complete for the rest
- details documented in Soil Landscapes of Canada Procedures Manual and Users Handbook

Detailed Soil Map Data (DSM)

- coverage predominantly for significant agricultural areas; varies by province or territory (provincial indexes available), work in progress but complete coverage is unlikely in foreseeable future
- details documented in *User's Manual for Detailed Soil Map Data*

Data from Other Agencies

- Data obtained from other agencies and used for research or publication by LRD will not normally be available for distribution. This includes base map, cultural and hydrological information. These data which have not been digitized by LRD and will be subject to the data release policies of the agency of origin.

6. CanSIS/NSDB OUTPUT

6.1 GENERAL

An important part of the power of the ARC/Info software is its ability to select, assemble, and display selected data from the total that the system contains. This applies to map line information as well as soil properties or interpretations. The display can be on a video screen or plotted onto paper. This capability allows for the creation of products "on demand" rather than the standard printing of reports and maps. CanSIS can form an integral part of the publishing process.

There are two types of output from CanSIS/NSDB;

1) Maps on paper or plastic plotted and/or published for final use, and
2) those that are in digital (machine readable) format for use on other GIS computer systems.

Within each of these groupings, the format and kinds of data may be standardized so that their production can be a routine selection of information from the NSDB or the request may involve a specific combination of data and formats which requires customized output. Special formats are possible but because non-standard formats will require programs to select the information from within CanSIS and then arrange it in a special way on the page or map, they take time and cost money.

More complex requests require significantly more time and effort because they require not only data and analytical tools but also personnel to provide expert interpretation and some of the following attributes; models to synthesize new information, additional data to describe new situations and sometimes restructuring and reorganization of the original data. While these complex questions are of great importance and interest, in most cases they are beyond the capability of CanSIS/NSDB and are generally dealt with through cooperative research projects in which the research staff of CanSIS form part of the team.

6.2 MAPS ON PAPER OR PLASTIC PLOTTED AND/OR PUBLISHED FINAL USE

There are standard formats for soil maps, interpretive maps and soil descriptions. The standard formats allow CanSIS to reproduce selections of the data quickly and efficiently.

Maps and reports can be produced in English or in French and can be supplied as computer generated plots or printed on paper (hardcopy). Plotted maps can be one colour (black) or full colour and can also incorporate black or coloured patterns.

1. Soil maps. The map boundaries are reproduced from the digital ARC file. The map symbol and selected information from the attribute (Info) files is put in legends. Polygons can be identified by polygon number or by a map unit number.
2. Derived maps. Single or multiple factor maps can display selected soil properties either by legend or patterns; examples of such properties include texture, slope, depth to watertable.
3. Interpretive maps. These maps show interpretations of soil information which required secondary analysis of the information in the CanSIS files and may incorporate additional types of data. Legends can be related to the polygons on the map by numbers or patterns. They contain fixed boxes which define the assess-

ment, specify how it was done, define the interpretive classes (suitable, unsuitable; Class 1, Class 2, etc.) and give references and credits.

4. Base information. The base information is needed to locate the soil or derived map in relation to administrative boundaries, rivers, roads, towns, etc. The client can specify what base information is required from a list of features.
5. Standard soil descriptions. One or two page descriptions of soils can be produced from the Soil Names and Soil Layer files.

6.2.1 Checklist of Items for Inclusion in hardcopy output from the NSDB

The following list has been developed to assist users in specifying the components to include on plotted or printed maps.

Mandatory information to include:

- Title of the data set (JOBID title)
- Date of plot creation and precise reference to the version of digital data used
- Credit note to acknowledge CanSIS/ISU data source and production expertise
- CanSIS logo reproduced from digital forms

Optional information prepared by CanSIS staff; user specifies which items to include:

- Heavy Border Surround - to frame the entire map and legend.
- Latitude, longitude references for the corner points or corners plus subdivisions
- Geographic grid
    - lines
    - coordinate values (metres) or other
- Abridged or complete base information
- Annotation of base information
- Legend for base information (key to line types)
- Key map (specific for a project e.g. locating the map within a county)
- Key map (general for a province or the country)
- Scale bar (recommended because it changes with plot size)
- Actual scale - representative fraction (i.e. 1:100,000)

Information provided by the user for inclusion:

- Specific title describing information on the plot Subtitle: (if required)
- Thematic lines (may chose all original thematic lines or reduced number based on user specified criteria
- Map symbols (may be directly from attribute files (single item) or derived from attribute files (combination of items or supplied from an external file or model
- Patterns/shades/colours (may be assigned based on a single item from attribute files or a combination of items or supplied from an external file or model)
- Thematic legend (symbols and/or patterns) (user will supply the legend text in the desired format)
- Text blocks to explain codes used in legend
- Explanation of model or algorithm used for derived or interpreted maps.

- Acknowledgement/citation of data source or reference to scientific basis or expert responsible for interpretation.

6.3 DIGITAL (MACHINE READABLE) FORMAT FOR USE ON OTHER GIS COMPUTER SYSTEMS

Land resource data in digital form is much more dynamic than similar data in traditional published paper form. The data in digital form are more volatile in at least three important ways; namely,

1. output content - the content can range from very rudimentary, consisting of lines and polygon identification number, to a full set of attributes of the map unit, soil names and layers; and true geographic coordinates with accurate registration and associated coverages of hydrography, base data, annotation etc. The data may be at the accuracy and detail of input or may be generalized.
2. output format - the data may be stored on disk, tape, or cartridge. It may be in ARC/Info format or DLG or other GIS formats.
3. date/stage of completion - unlike a published report and map there is no final date of completion. Therefore it is extremely difficult to define a MASTER copy.

The data prepared by LRD, Ottawa is available in a number of standard formats produced by ARC/Info software. Currently, procedures have been established to transfer data on diskette (either 5.25 or 3.5 inch) or on 9 track tape.

6.3.1 Requests for NSDB Digital Data

Requests for copies of NSDB digital data should be made in writing to the Head Can-SIS/NSDB and should include the following information.

CLIENT INFORMATION

- Contact name of end user -
- Contact address and phone/fax number
- Description of data requested
- Graphics requested by JOBID and Map title
- Attributes requested - SMUF for DSM
  or - DOM and SUB attributes for SLC
  or - items from LPDB for SMC
  and - SNF and SLF data for DSM or SLC
- Exchange format and medium:
  (ARC/Info on VAX) - ARC EXPORT on 9 track tape
  (ARC/Info on PRIME) - ARC EXPORT on 9 track tape
  (CARIS on VAX) - DLG-3 on 9 track tape
  (TYDAC SPANS on DOS) - ARC EXPORT (uncompressed) on diskette
  (PAMAP on DOS) - DLG-3 on diskette
  (Terrasoft on DOS) - ARC EXPORT
  (pcARC/Info on DOS) - ARC EXPORT on diskette
- Is a verification plot required? Medium - paper/mylar
  (Include plot description if other than standard
  consisting of thematic lines and -ID)

7. INTERACTION WITH CanSIS

7.1 POLICY

CanSIS/NSDB contains information that has been gathered at public expense. Therefore, this information is fully accessible to the public with certain limitations dictated by practicality. Inasmuch as the information is from numerous government agencies across the country, each agency must release its information for public distribution when it submits it for storage in CanSIS/NSDB. The policies regarding printed or plotted (hardcopy) formats of the information and their citation have been well established over the years and will continue. Digital data and its use is a new area where policy is evolving. The documentation here generally represents an interim stage in the policy development.

The following areas of policy are discussed:

- data input
- data maintenance and update
- data release plan, cost recovery
- crown copyright
- digital data citation format and acknowledgement
- conditions on use of the data, liability, limitations, scale, data release, finalization

7.1.1 Data Input

The dynamic aspect of land resource data is an important and useful feature of the technology. The update and maintenance of data in the National Soil Data Base is an essential part of the operation. This ensures that the data are as accurate and reliable as possible and maintains the ongoing utility and credibility of the data. It is the responsibility of all participants in the NSDB (both provincial and federal) to maintain the quality of the information base. Data from major land evaluation research projects are also stored in the NSDB under the same conditions as soil inventory data.

Any data in digital form, in particular, data which relate to interpretations or applications of land resource information can be designated for storage in the NSDB archive. In addition to the actual data, the following elements of classification, documentation and description must be prepared.

1. The data file(s) will be assigned a unique CansIS JOBID and descriptive title. These "Special Project" numbers will provide identification throughout the system and will distinguish digital (ARC/Info) projects from others.
2. Project PEDIGREE files are prepared to document the source, quality, nature, content, vintage of the data files and to specify which other NSDB data (maps) are related to the data files.
3. A validation procedure is carried out to provide quality control and quality assurance for all data in the archive.
4. A READ.ME file documenting the specific structure, fields and codes used in the data file is prepared. This file is distributed with the data and allows any user to understand the information.
5. Because the data input to the NSDB are prepared for general distribution (i.e. electronic publication) it is recommended that they be submitted to the LRD pub-

lication committee for review and assignment of a publication number prior to input.

6. Where possible and appropriate, the data will be verified by a correlator or second researcher prior to its input.
7. Where the data involve digitization of map information, this will normally be carried out by the NSDB unit of LRD. Where the data are input by other resources, the NSDB unit will act as a consultant to ensure that consistent standards and quality are maintained.
8. Where map information is included, the quality control group in the NSDB unit will verify the cartographic/geographic quality prior to archive.

The master copy of the digital soil map is then stored in a secure FINAL ARCHIVE.

7.1.2 Data maintenance and update

There are three ways in which data in the NSDB need to be maintained; ad hoc error correction, major projects to upgrade the quality of data, and technical upgrades to reflect changes in technology.

A. Ad Hoc Error Correction

After the data are published (finalized) there will frequently be small errors in content or accuracy which are detected during use and interpretation.

The provincial and/or national correlator must approve all error corrections to maintain quality control. The changes will be noted in the project/PEDIGREE file as they are reported and maintained in the associated hardcopy file. As the data are requested for use, changes reported will be incorporated into the digital soil map.

B. Major Projects to Upgrade the Quality of the Data

Some of the data in the NSDB represents digital forms of soil maps and reports which are not complete by modern standards. In some cases this requires additional data added to the existing soil delineations (e.g. slope). In some cases, the new requirements for the data will be at a larger scale requiring both additional data and new delineations. These major upgrades will be carried out either using conventional means such as additional field surveys or increasingly, they will be done using other digital forms of data such as digital elevation models etc. They will be planned as projects and the data input and upgrade will follow a cycle of verification and quality control similar to the original input of a digital soil map.

C. Technical Upgrades

Technical upgrades represent changes to the format or structure of data in the NSDB but not to its content or accuracy. They will be required for a variety of reasons such as changed software, changes in the standards of geographic projections e.g. from NAD27 to NAD83 or changes in the design and organization of the data e.g. from a combined PAT and SMUF to two separate files. These changes will be made as part of an overall upgrade project and will have verification from the NSDB unit and programmer/analysts. They will not normally involve the author or correlation staff.

7.1.3 LRD plan for release of National Soil Data Base products

At the date of this publication there was no accepted plan in place. A draft was prepared in February, 1991 in which the plan objective was stated as follows:

"Objective: Maximize the availability and benefit of the information in the National Soil Data Base to clients and users, with a minimum impingement on LRD resources."

Agriculture Canada provides the administrative facilities and overhead to ensure and maintain storage of this information. Customers for the raw data could logically obtain it at minimal cost, and with the understanding that it is subject to conditions of copyright. On the other hand, information synthesized from the data for clients entails a cost, and can be viewed as a service rather than the base LRD mandate of research and other forms of data collection.

The purpose of the current *ad hoc* policy and the plan under development is to facilitate and ensure the transfer of the technology, but not unduly side-track LRD resources meant for its primary mandate.

7.1.4 Conditions of Use of Digital Soil Maps

7.1.4.1 Crown Copyright The following information is abstracted or interpreted from a Treasury Board Circular entitled Crown Copyright (1986). All data in the NSDB is protected by the Government of Canada copyright. The Canadian Government Publishing Centre located within Supply and Services Canada administers and protects this copyright. "*Use* means to translate, print, publish, sell, reproduce, or convert into an electronic or other format". Users of the data will give the Government of Canada full credit for the data used through the use of a copyright note on the product. The Government of Canada copyright of the data will be preserved.

"No fees shall be required if the copyright material to be used forms less than 25% of the work to be published. Unless otherwise indicated (in the Treasury Board Bulletin), a one-time permission fee or an on-going royalty will be required in instances where copyright material requested will form 25% or more of the work to be published."

"When the request made (for copyright material) involves the use of any production material such as negatives, artwork, magnetic tapes and the provision of these materials involves costs, these costs will be borne by the requester."

"The inclusion of a copyrighted work in any electronic data base for subsequent distribution will be subject to royalty payments if the data base publisher levies separate access charges for subsequent access to the work."

"The Canadian Government Publishing Centre shall levy royalty or permission fees."

7.1.4.2 Scale of Application A scale of 1:5 million provides a convenient format for addressing national issues, but may be too general for most sub-provincial applications and many provincial issues. The spatial resolution offered by scales of approximately 1:1 million provide adequate coverage for provincial and sub-provincial evaluations and can also be employed nationally. The larger scale data are appropriate for local and municipal land use planning. Individual sites should never be evaluated exclusively on the basis of soil map data without actual field inspection for confirmation.

When map data in digital form are loaded into a GIS they become independent of scale. It is very important to realize, however, that the data still carry the limitations of the scale at which they were collected, compiled and input. In sections 5.2.1.5, 6 and 7 the aspects of positional accuracy, map fidelity and minimum area represented were discussed. These criteria should be used to indicate the best conditions in the subsequent use of the data and suggest that the scale for analysis should not be markedly increased beyond the original

manuscript scale. Research at LRD indicates that small increases in scale are tolerable but increases beyond a factor of four leads to data which are unacceptable for analysis or for cartographic representation. The following are some additional rule-of-thumb guidelines for use of the data.

Digital soil maps from CanSIS/NSDB are not intended for use in evaluating individual sites for the following reasons:-

(i) the full coverage is at a scale of compilation. Any enlargement could be misleading. Where a more detailed classification of an area is required, a re-survey is necessary.

(ii) Although the division between different soils is necessarily indicated by a line on the map, in practice the boundaries are not so sharply defined. In some cases, one soil polygon may merge into another over a short distance while in others the change may be gradual occurring over a very considerable distance.

(iii) where the depth, texture and/or drainage of the soil vary appreciably giving rise to a complicated pattern of patches of different classes, the separation of which would entail very detailed mapping, an assessment is made of the predominant class for assignment to the whole area.

(iv) except where class changes are determined by obvious physical features or detailed information on soil available, the accuracy of the delineation between classes is dependent on map scale and corresponds approximately to the minimum area which can be represented (Table 1). Difficulties may also arise in the interaction of climate with topography (e.g. slope, aspect, exposure) producing mesoclimate differences affecting the assessment of land quality but too small for the map scale. They may be of practical importance particularly for horticulture.

7.1.4.3 Finalization of data There will be full access to data in CanSIS/NSDB which is complete and finalized. Digital data which does not meet the minimum level of completeness and/or which has not been published (i.e. received an LRD contribution number and entered into final archive) can be released only by the author as personal communication.

7.1.4.4 Data Release A signed DATA RELEASE FORM must be returned and maintained on file for all digital data released to other individuals or agencies. Other than the terms outlined in the DATA RELEASE FORM there are no additional conditions on the use of the data by an outside agency.

Normally, the author of the map or the survey unit responsible for its compilation will be advised of the release of the data in digital form.

7.1.4.5 Liability Liability of the Crown in the use/misuse of the data has been considered by the legal section of Agriculture Canada and is summarized in the current Data Release Form as:

> "The USER hereby releases Her Majesty The Queen In Right of Canada, Her servants and employees from all claims, demands, damages, actions or causes of action arising or to arise by reason of any inaccuracies, errors, omissions, misrepresentations or limitations in the CanSIS data."

and

> "The USER shall indemnify and save harmless Her Majesty the Queen In Right of Canada, Her servants and employees from and against all claims, losses, damages,

costs, expenses, actions and other proceedings made, sustained, brought, prosecuted, threatened to be brought or prosecuted, in any manner based upon, occasioned by or attributable to the release to or use by the USER of the CanSIS data. "

7.1.4.6 Citation and Acknowledgement The Project/PEDIGREE file(s) accompanying the data contains details of the author(s) of the data, their agency and the date of publication (finalization). These are the normal elements to be included in a citation. In addition, because the data in digital form tend to be somewhat volatile, the citation should also include a date of last update.

The order of elements to be included in citations of digital soil maps are as follows:

1. Author (primary, responsible intellectually)
2. Title [material designation]
3. Statement of responsibility [person or corporate body as principal investigator, sponsoring agency]
4. Edition
5. Distributor [where to access]
6. Scale
7. Place of publication
8. Publisher
9. LRD Publication Number
10. Date of original; date of update
11. Series
12. JOBID number

The first element is always the author: e.g. MacDonald, B., B, Smith, J. Jones. The title should be underlined.

Citation example:

Presant, E. and C. J. Acton. Soils of Haldimand-Norfolk Regional Municipality. Sheet 6, Ontario. [computer file] Version 1. 1st ed. Ottawa: Agriculture Canada, 1986. Ottawa: LRRI, 1990 [update] (Soil survey report ; 57) 0N067406

When citing a "subfile":

Presant, E. Norfolk Polygon Attribute Table [computer file] Version 2. Ottawa: Agriculture Canada, 1986. Ottawa: LRRI, 1990 [update] In Soils of Haldimand-Norfolk Regional Municipality. Sheet 6, Ontario.

The ACKNOWLEDGEMENT should include the citation and also the archive facility from which the data were obtained; e.g. NSDB, LRD, Research Branch, Agriculture.

8. PEOPLE RESPONSIBLE FOR CanSIS (1992)

8.1 CENTRE FOR LAND AND BIOLOGICAL RESOURCES RESEARCH, OTTAWA

The person directly in charge of CanSIS/NSDB is:

Head of CanSIS
Centre for Land and Biological Resources Research
Research Branch, Agriculture Canada
K.W. Neatby Building
Central Experimental Farm
Ottawa, Ontario
K1A 0C6

Tel: (613) 995-5011
Fax: (613) 995-7283

Requests for information or analyses from the central archive should be made to this address. Requests for cooperative projects requiring considerable time, money and expertise should be addressed to:

The Director of LRD at the same address as above.

8.2 REGIONAL CanSIS REPRESENTATIVES

Each regional unit of LRD has one person designated to handle CanSIS information and projects. Requests for information on cooperative projects within provinces should be addressed to that person. For each province and the Yukon they are:

Newfoundland

Mr. Ed Woodrow
Canada Soil Survey
Research Branch, Agriculture Canada
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St. John's West, Nfld. A1E 3Y3

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Fax: 306-966-4226

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Phone: 604-224-4355
Fax: 604-666-4994

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Burrough, P.A. 1986. Principles of Geographical Information Systems for Land Resources Assessment. Clarendon Press, Oxford. 193 pp.

Clayton, J.S., Ehrlich, W.A., Cann, D.B., Day, J.H. and Marshall, I.B. 1977. Soils of Canada. Agric. Can. Publ. 1544, 2 vols

MacDonald, K.B. and B. Kloosterman. 1984. The Canada Soil Information System (CanSIS); General User's Manual. Land Resource Research Centre, Research Branch, Agriculture Canada, Ottawa. 56 pp. plus appendices.

Kirkwood, V., J. Dumanski, A. Bootsma, R.B. Stewart and R. Muma. 1989. The Land Potential Data Base for Canada Users' Handbook. Land Resource Research Centre Technical Bulletin 1983–4E, Research Branch, Agriculture Canada, Ottawa. 12 pp. plus appendices.

Shields, J.A., C. Tarnocai, K.W.G. Valentine, K.B. MacDonald. 1991. Soil Landscapes of Canada Procedures Manual and Users Handbook. Land Resource Research Centre Technical Bulletin 88–29, Research Branch, Agriculture Canada, Ottawa.

GLOSSARY OF TERMS AND ACRONYMS

ARC	The GIS software modules for managing line and polygon data
ARC/Info	A commercial GIS produced by ESRI.
ARC/Info coverage	A layer of information within the GIS; including all associated data files
CanSIS	Canada Soil Information System
CARIS	A commercial GIS produced by Universal Systems Ltd., NB
CLBRR	Centre for Land and Biological Research (formerly LRRC and BRC)
dBASE	A commercial microcomputer based data base management system (versions III+ or IV) produced by Ashton-Tate
DBMS	Data Base Management System (computer software), generic term
DLG	Digital Line Graph - a graphic exchange format
DSM	Detailed Soil Map Data (large scale maps for which the SMUF is directly attached to the PAT).
ESRI	Environmental Systems Research Institute produces ARC/Info
GIS	Geographical Information System, generic term
IBM	International Business Machines Ltd.
Info	A relational database management system which makes up the portion of the ARC/Info GIS which manages attribute and tabular information.
JOBID	A CanSIS job identification number (map number)
LPDB	Land Potential Data Base
LRD	Land Resources Division
LRRC	Land Resource Research Centre
NAD	North American Datum (for absolute geographic reference)
NSDB	National Soil Data Base
PAMAP	A commercial GIS produced by PAMAP Technologies of British Columbia
PAT	Polygon Attribute Table
PC	Personal Computer (microcomputer)
PLEP	Prairie Land Evaluation Project
PRA	Pest Risk Assessment (Unit)
SLC	Soil Landscapes of Canada (Maps)
SLF	Soil Layer File
SMC	Soil Map of Canada

SMUF	Soil Map Unit File
SNF	Soil Names File
Terrasoft	A commercial GIS produced by Digital Resource Systems British Columbia
Tydac/SPANS	A commercial GIS produced by Intera-Tydac
UTM	Universal Transverse Mercator (map projection)
VAX	A series of computers produced by Digital Electronics Corporation
VMS	The operating system used on VAX computers in CanSIS