INTERPRETATION OF AN ECOLOGICAL DATA BASE USING THE CANADA LAND DATA SYSTEM

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ABSTRACT

An integrated ecological land data base provides a great flexibility in interpretations to resource planners and managers. The wide variety of questions that can be asked of and answered instantaneously by such a data base is demonstrated through interactive analysis capabilities of the Canada Land Data System (CLDS). For this purpose the CLDS was adapted to store and analyse ecological data for an area of about 1800 km² mapped by the Manitoba Northern Resource Information Program. This paper was originally written as background material for an Interactive Graphics Display demonstration given at a CCELC workshop in Victoria.

RÉSUMÉ

Une base intégrée de données écologiques sur les terres permet beaucoup de latitude d'interprétation aux planificateurs et aux gestionnaires des ressources. L'éventail des questions qu'on peut poser et auxquelles on peut obtenir une réponse immédiate grâce à pareille base est mis en évidence par le potentiel d'analyse interactive du Système de données sur les terres du Canada. Ce système a été adopté pour accumuler et analyser des données écologiques visant une superficie de terrain d'environ 1800 km² qui a été cartographiée dans le cadre du programme manitobain d'information sur les ressources du Nord. Le présent document fournit les assises d'une démonstration d'affichage graphique interactif qui a eu lieu à l'occasion d'un atelier tenu par le CCCET à Victoria.

INTRODUCTION

In the past, most inventories and surveys were carried out to answer specific resource management questions. The single-disciplinary approach evolved into a multidisciplinary one when it became apparent that multiple land resource demands existed and that land use conflicts were common.

The Canada Land Inventory (CLI) project reflects the public perception, in the fifties and sixties, of what type of resource management was required to solve some of Canada's land use problems. This multidisciplinary survey provides land capability information for Forestry, Agriculture, Wildlife (waterfowl and ungulates), Sportfish, Recreation, and Present Land Use information.

In practice, however, multidisciplinary surveys such as the CLI answered only a limited number of the questions which planners ask of a data base. The use of this data base is restricted for two reasons:

(1) The inventory describes the resource potential for only a limited number of disciplines.

(2) The original ecological data, which formed the basis for the land capability rating, usually was not reported on and is therefore essentially not available for 'extra' analysis.

A third problem results from the fact that non-integrated single-and multi-disciplinary surveys create units for management and planning which, at the same scale, may show similarities, but are never identical. Overlaying maps, as part of a planning exercise, generates many boundary units with little or no significant meaning (Figure 1).

Ecological (biophysical) land classification methodology was originally developed to form the basis for an extension of the CLI in northern areas. Coverage of large inaccessible areas was contemplated in a relatively short period of time. Classification and operational approaches would have to allow the creation of a

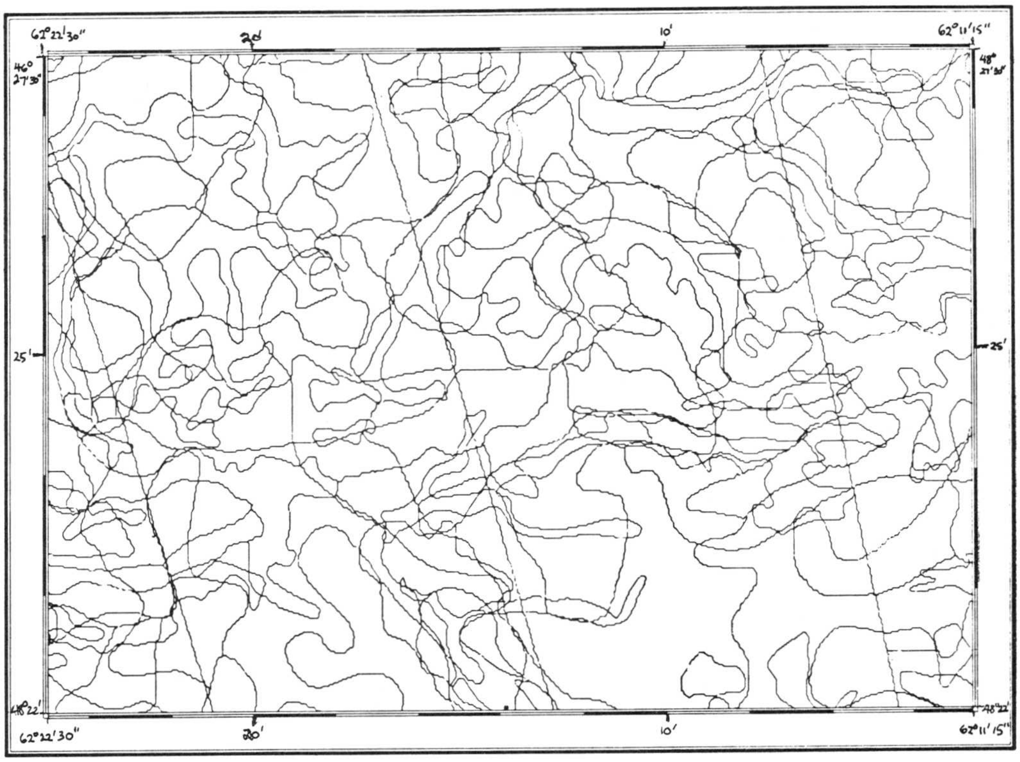


Figure 1: A multiple overlay of 1:50,000 scale CLI maps (reduced in this figure) showing forestry, agriculture, waterfowl, recreation, present land use and administrative boundaries.

data base for resource management at a reasonable cost. Considering the experience with the CLI data and reflecting the new perception offered by integrated, environmental resources management, it is not surprising that an ecologically-based integrated survey approach evolved. Though the extension of the CLI did not materialize, ecological (biophysical) land surveys have been carried out in many parts of Canada by a wide range of agencies (CCELC, 1977). Initially, primarliy CLI-type interpretations have been attempted. However, due to the integrated ecological basis, the data lends itself to a far wider range of interpretations as well demonstrated by Jurdant et al (1977).

To demonstrate the flexibility of interpretation of an ELC data base to potential users, a pilot study was carried out by the Lands Directorate (Environment Canada) and the Manitoba Northern Resource Information Team. This study was also intended to demonstrate the effectiveness of the computer storage and retrieval of ELC information. One 1:125,000 - scale biophysical map (Figure 2) was stored in the Canada Land Data System. The complex geomorphology legend (Figure 5) and soil and vegetation legends (Figure 3) are stored in such a way that each parameter can be retrieved and mapped separately or in combinations with one or more other parameters.

NORTHERN RESOURCE INFORMATION PROGRAM IN MANITOBA

A systematic biophysical land classification of Northern Manitoba was initiated in July 1974. A detailed description of this program is given by Mills (1976). To-date, over 100,000 km^2 has been covered and maps and reports are in various stages of production. The purpose of the Northern Resource Information Program is to provide basic data for resource use planners. This means generally the provision of data useful for macro-scale planning, although the data may be in some instances sufficient for limited micro-scale planning. Because of the reconnaissance nature of the program, the usefulness of the data will be greatest when applied at a broad regional level. This means that the data will be useful for the planning for the development of renewable and non-renewable resources on a regional basis — for planning for industrial and community development, the protection of the environment, the development of infrastructure, etc.

The system of classification used by the NRIP is closely patterned after that of the Sub-committee on Biophysical Land Classification (Lacate, 1969).

Data Presentation

Although the basic document of the biophysical land classification in Manitoba is a map and legend depicting land systems at a scale of 1:125,000, the relationship between patterns of Land Types and Land Systems is always considered in the context of Land Regions and Districts. Region and District boundaries are superimposed on the Land System map, and a description of their biophysical condition is included in narrative form in an accompanying text.

The boundaries of most map units are based initially on landform and related surface deposits and are delineated on panchromatic, black-and-white, 1:60,000-scale aerial photographs. The landform units are usually further refined in terms of topographic variation and patterns of soils, drainage condition, and vegetation. Such characterization of the landform units is accomplished through the field program involving detailed descriptions of the soil, vegetation, and topographic conditions on selected portions of a landform. These site descriptions generally apply to a landscape segment equivalent to a Land Type or a complex of Land Types.

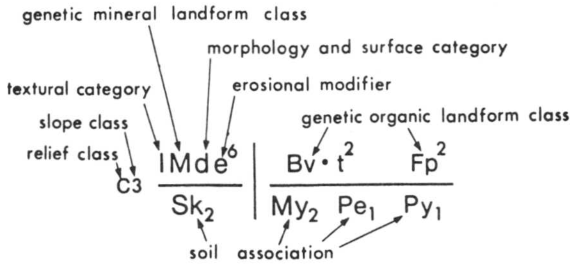
Land Systems depicted at the 1:125,000 scale are characterized by a recurring pattern of landforms, soils, and vegetation. The unit is described by a map symbol providing the user with a fair account of the land characteristics; for more detailed information, however, the user must consult an extended legend.

The map symbol for a Land System is set up in the following manner:

topographic expression	Mineral landforms / Soil Association(s)	Organic landforms / Soil Association(s)

The various components of the landscape in a particular Land System are described in terms of genetic landform, textural category of the surficial deposits, the kind of morphology and surface form, erosional modifier, slope and relief class, and soil association.

Map Symbol:



The soil association symbol directs the user to the expanded legend (Figure 4) which will provide information about the Land Region, parent material, the various soil subgroups belonging to the association, drainage, landscape position of the dominant member of the association, ice content and depth of thaw of permafrost, and the vegetation associated with the dominant soil subgroup.

CANADA LAND DATA SYSTEM (CLDS/CGIS) GRAPHICS SUBSYSTEM

The Canada Land Data System/CGIS was originally designed to handle all Canada Land Inventory data, which covers about 2.5 million km^2 of Canada's land mass. The storage of this massive data base was the first priority for the CLDS. At present, 98% of the CLI data is stored in the CLDS. The system is now expanding its services to a wider range of users and is storing a diversity of information. The CLDS was adapted to handle complex ecological data, to allow further expansion of the national data base to northern areas not covered by the CLI.

This demonstration makes use of the CLDS Graphics Subsystem, which allows the user to interact with the data base instantaneously. This system was modified to handle the large range of parameters associated with each of the NRIP map polygons.

The organization (i.e. map symbols and

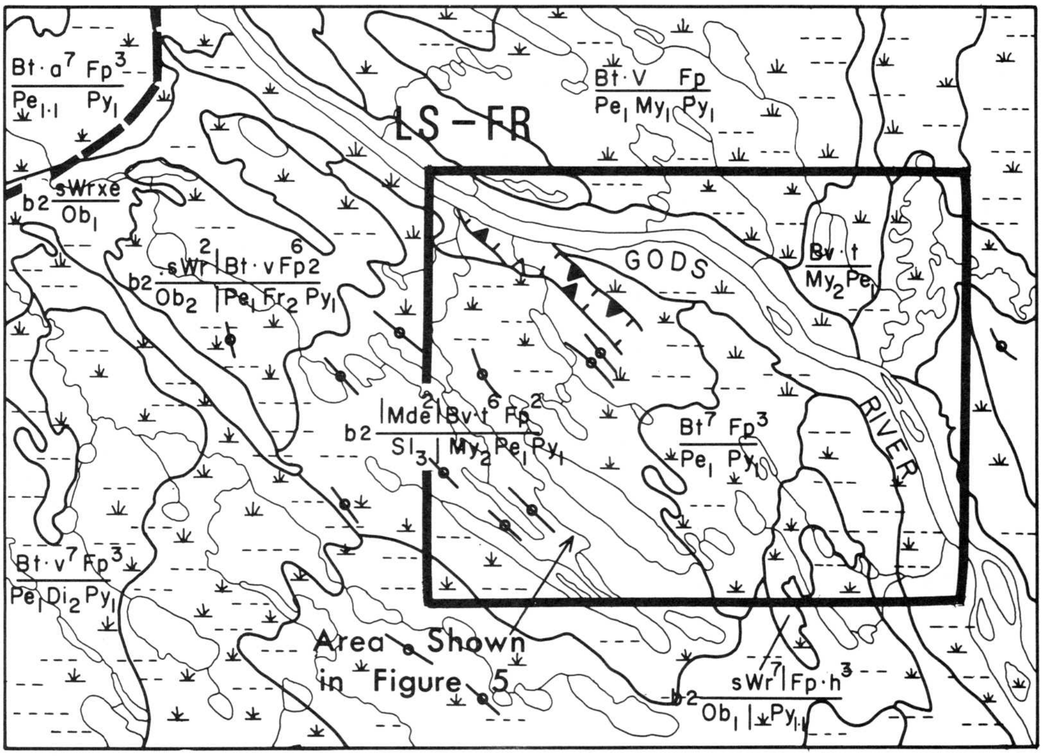


Figure 2: Portion of 1:125,000 scale biophysical map of the Hayes River area

Figure 3: Geomorphology Legend

GENETIC MINERAL LANDFORM CLASS

- A alluvial
- C colluvial
- E eolian
- G glacio-fluvial
- L glacio-lacustrine
- M morainal
- W marine
- U undifferentiated

BEDROCK CLASS

- aR bedrock, acidic
- bR bedrock, basic
- cR bedrock, carbonatic
- uR bedrock, undifferentiated

MORPHOLOGY AND SURFACE FORM CATEGORY

(placed after landform class)

- p plain
- h hummocky
- u undulating
- m rolling
- d drumlinized
- k kettled
- r ridged
- t terraced
- a apron
- Δ delta
- f fan
- b blanket
- v veneer

TEXTURAL CATEGORY (placed before landform class)

- c clayey
- l loamy
- s sandy
- f fragmental (gravelly, cobbly or bouldery)
- -s skeletal (used in combination with clayey, loamy or sandy)

EROSIONAL MODIFIER (placed after morphology & surface form category)

- c channeled
- e eroded
- i dissected
- l deflated
- w washed

GENETIC ORGANIC LANDFORM CLASS AND CATEGORY

B Bog

- a palsa
- b bowl bog
- f flat bog
- l blanket bog
- m peat mound
- p bog plateau
- t peat plateau
- v bog veneer
- y polygonal peat plateau

F Fen

- c collapse scar
- f floating fen
- h horizontal fen
- l sloping fen
- m minerotrophic palsa
- p patterned fen

S Swamp

RELIEF CLASS (meters)		SLOPE CLASS degrees		%
a	0- 2	1	0- 2	0- 5
b	3- 5	2	3- 7.5	6-15
c	6-20	3	8-15	16-30
d	21-50	4	16-30	31-60
e	51-100	5	>30	>60
f	>100	6	complex	

BIO-PHYSICAL BOUNDARIES

- Land Region (heavy solid line)
- Land District (dashed line)
- Land System (thin solid line)

LS-FR

NOTES:
1. See text for explanation of Map Symbol
2. See Table 1 for soil and vegetation
3. See Appendix III for definition of terms

Figure 4: Portion of the extended legend, Hayes River Map area, 54C Manitoba

LEGEND FOR SOIL AND VEGETATION

Soil Association Symbol	Soil Association Name	Land Region	Parent Material	Map Unit Symbol	Soil and Drainage[4] Dominant Subgroup[1]	Soil and Drainage[4] Significant Subgroup Inclusions[2]	Landscape Position[3]	Ice Content and Depth of Thaw[3]	Dominant Vegetation[3,5]
Di	Deer Island	LS	Shallow (40-160 cm) deposits of mesic to humic forest peat with alternating subdominant layers of fibric sphagnum peat and/or mesic fen peat underlain by medium to fine textured marine sediments.	Di_1	Terric Mesic Organo Cryosol (i-p)		Raised peat plateaus and palsas	High; 50 cm	bS-Er-Li-Fm bS-Er-Sp-Fm
				Di_2	Terric Mesisol (p)	Terric Mesic Organo Cryosol (p-i)	Gently sloping areas with shallow channels, runnels and depressions	Moderate; 50 cm to 100+ cm	bS-Sp-Er bS-Fm-Er-Li
Pe	Pemichagamau	LS	Deep (>160 cm) deposits of mesic to humic forest peat	Pe_1	Mesic Organo Cryosol (i-p)	Typic Mesisol	Raised peat plateaus and palsas	High; 50 cm	bS-Er-Li-Fm bS-Er-Sp
Py	Pennycutaway	LS	Deep (>160 cm) deposits of mesic fen peat or very thin (15-60 cm) discontinuous fibric sphagnum peat overlying fen peat.	Py_1	Typic Mesisol (v)	Typic Mesisol, sphagnic phase (v)	Level to depressional fens, water track fens	Non-frozen	Cx-Dp-Co
				Py_2	Typic Mesisol, sphagnic phase (v)	Typic Mesisol (v)	Level to depressional fens	Non-frozen	tL-Cx-Dp-Sp
Sl	Strobus Lake	LS	Very strongly calcareous, medium to moderately fine textured stony till.	Sl_1	Degraded Eutric Brunisol (w)	Orthic Grey Luvisol (w) Gleyed Degraded Eutric Brunisol (i)	Apex and upper slopes	Non-frozen	bS-(jP-tA)-Fm-Al
				Sl_2	Gleyed Degraded Eutric Brunisol (i)	Rego Gleysol, peaty phase (p) Gleysolic Static Cryosol, peaty ph. (p)	Mid to lower slope	None to moderate; 50 cm to 100+ cm	bS-Fm-Er-Al
				Sl_3	Rego Gleysol, peaty phase (p)	Gleysolic Static Cryosol, peaty ph. (p)	Depressional to level	None to high; 50 cm to 100+ cm	bS-Sp-Er-Fm

Notes:
1. Dominant subgroup comprises more than 40 percent of soil association.
2. Significant subgroup inclusions are 20 to 40 percent of soil association. Minor subgroups are listed in order of dominance.
3. Landscape position, ice content, depth of thaw and dominant vegetation refer to the dominant subgroup.
4. Drainage classification
   - e - excessively drained
   - w - well drained
   - i - imperfectly drained
   - p - poorly drained
   - v - very poorly drained
5. Vegetation: species abbreviation
   - Dp - Drepanocladus
   - bS - black spruce (Picea mariana)
   - wS - white spruce (Picea glauca)
   - wB - white birch (Betula papyrifera)
   - Bi - dwarf birch (Betula glandulosa)
   - tL - tamarack (Larix laricina)
   - Wi - willow (Salix sp.)
   - Al - alder (Alnus sp.)
   - tA - trembling aspen (Populus tremuloides)
   - bPo - black poplar (Populus balsamifera)
   - Cx - Sedge (Carex sp.)
   - Co - Cottongrass (Eriophorum sp.)
   - Li - Lichen (Cladonia sp.)
   - Sp - Sphagnum (Sphagnum sp.)
   - Er - Ericareae (Ledum, Chamaedaphne, Kalmia, etc.)
   - Fm - Feathermosses
   - jP - Jack Pine (Pinus banksiana)

extended legend) of the NRIP data was not designed with computer data handling in mind, and this complicated the procedures for handling and retrieving. Each map polygon or point of information in the biophysical data base is characterized by environmental parameters in the map symbol as well as by the extended legend. Approximated climatic information (Ecoregions) and land information are stored in map symbols while vegetation information is stored in the extended legend. To handle this data, CLDS staff developed a software package that allows the characterization of each map polygon by a series of 15 variables. Each of the variables may have a maximum of 50 values. This means that a maximum of 750 environmental parameters can be handled for each polygon. The following variables are used in this demonstration:

- SHORELINE
- REGION
- DISTRICT
- RELIEF
- SLOPE
- TEXTURAL CATEGORY OR ORGANIC LANDFORM
- GENETIC MINERAL CLASS
- MORPHOLOGY & SURFACE FORM
- EROSIONAL MODIFIER
- MINERAL & ORGANIC PERCENTAGES
- DRAINAGE
- SOIL CLASS
- PERMAFROST
- VEGETATION

The values, in this case, are descriptions given in the legend (Figure 3 and Figure 4). For example, the genetic mineral landform class (GENCL) is described by A (alluvial), C (colluvial), etc. Permafrost is described by ice content and occurrence - H (high), M (moderate), and NF (non-frozen). Each value can be retrieved separately or in combinations with any other(s). The retrieved information is displayed as:

1. A summary report depicting, by variable value(s), the area of land which satisfies the selection criteria;

2. A map of the study area showing the polygons with the selected criteria.

The CLDS Graphics Subsystem is simple. A user, without previous experience can learn to retrieve data within a half hour. After logging onto the system, the following commands can be entered:

<u>LIST</u> lists the variables available in the data base.

<u>SELECT</u> selects polygons by classification (by variable and value specification) and produces a summary report.

<u>RESELECT</u> selects polygons by classification using different values for the variables processed in the last selection, and produces a Summary Report.

<u>PLOT</u> plots polygons selected by the last selection.

<u>SAVEC</u> saves the origin and scale of the last plot blow-up (minimum and maximum X and Y coordinates of the blow-up) so that plots of subsequent selections and/or reselections will be confined to that portion of the study area delimited by the SAVEC command.

<u>DELETEC</u> restores the original scale for plotting the entire study area (i.e. it cancels the effects of the SAVEC command).

<u>SCALE</u> permits the specification of the scale desired on the paper copy of a screen image produced by the hard copy copy unit connected to the Tektronix CRT (Cathode Ray Tube).

<u>NOSCALE</u> restores the scale to that of either the original data base or the scale of the last map plotted, if in plot mode.

<u>SUPMSG</u> suppresses some prompting messages.

<u>MSG</u> restores prompting messages suppressed by SUPMSG command.

<u>STRLEN</u> changes the length of line displayed at the terminal.

<u>STOP</u> stops the interactive computer program.

The LIST command provides the list of the variables that can be used for retrieval:

```
ENTER COMMAND
LIST
VARIABLES AVAILABLE IN THIS DATA BASE
SHRLN - SHORELINE                               1    3
REGNX - REGION                                  2    5
DSTRX - DISTRICT                                2    9
RELXX - RELIEF                                  1    6
SLOPE - SLOPE                                   1    6
TEXOR - TEXTURAL CATEGORY OR ORGANIC LANDFORM   2   21
MINLD - GENETIC MINERAL CLASS                   2    8
MORPH - MORPHOLOGY & SURFACE FORM               2   50
EROSX - EROSIONAL MODIFIER                      2    5
PCNTX - MINERAL & ORGANIC PERCENTAGES           1   10
DRAIN - DRAINAGE                                2   10
SOILX - SOIL CLASSIFICATION                     4   40
PERMF - PERMAFROST                              3   10
VEGET - VEGETATION                              8   50
SPARE -                                         3    1
MAX NUMBER OF VALUES PER VARIABLE        50
SCALE OF INPUT DATA BASE IS 1 : 125,000
ENTER COMMAND
S
```

Each of the variables, either single or in combination with others, can be used for retrieval. By using single parameters like sand (s) or gravel (f), from the variable TEXOR potential areas with aggregate materials can be identified (Figure 5). The distribution of areas with sensitive surface layers due to permafrost (Figure 6) can be obtained as follows:

1) select input value B (bog) from TEXOR
2) select input value P (permafrost) from PERMF
3) select 6,7,8,9 (more than 60%) from PCNTX.

Values and variables may be combined into land capability maps. For example, per definition, similar forest sites within a Land Region will have similar forest productivity. Field data may have shown that class 5 forest capability will occur on well to moderately well-drained clay and loam materials, in the high boreal Land Region.

By specifying the variables:

Land Region concerned - REGNX
Textural Category - TEXOR
Drainage Condition - DRAIN

and entering for each the corresponding values-HB (High Boreal), C (Clay), L (Loam), W (Well drained), and M (Moderately drained), a map and area statistics can be made which shows the distribution of class 5 forest capability is the study area (Figure 7).

Given the number of variables (15) and values (50), a very large number of retrievals is possible. This gives great flexibility to a planner or manager using ecological land survey information. Ecological Land Surveys and land data systems like the CLDS can improve each others efficiency. The computer allows easy evaluation and mapping of complex and difficult to interpret map symbols and legends. The Ecological Land Survey provides a simpler geographic data base, fewer overlays and reduces computation time.

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```
                  SUMMARY OF AREAS SELECTED
        SELECTION  3                 NOV. 29/78     PAGE     1
VARIABLE : TEXOR
VALUE                   ACRES      HECTARES   %SEL AREA    %STUDY AREA
S                    25,334.9      10,260.6     100.0            1.6

TOTAL SELECTED       25,334.9      10,260.6

TOTAL STUDY AREA  1,573,878.5     637,420.8
ENTER COMMAND

PLOT  3  APPX SCALE - SCREEN 1 :    416,199  PAPER COPY 1 :    618,354
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Figure 5: Distribution of areas with potential of aggregate materials.

```
                  SUMMARY OF AREAS SELECTED
        SELECTION  9                 APR. 02/78     PAGE     1
VARIABLE : TEXOR
VALUE                   ACRES      HECTARES   %SEL AREA    %STUDY AREA
BV                    7,356.2       2,979.2       5.4            0.4
BT                  128,739.7      52,139.5      94.5            7.5
VARIABLE : PCNTX
VALUE                   ACRES      HECTARES   %SEL AREA    %STUDY AREA
6                    50,989.5      20,650.7      37.4            3.0
7                    57,019.9      23,093.0      41.8            3.3
8                    25,935.2      10,503.7      19.0            1.5
                      2,151.2         871.2       1.5            0.1
VARIABLE : PERMF
VALUE                   ACRES      HECTARES   %SEL AREA    %STUDY AREA
PMH                   8,485.3       3,436.5       6.2            0.5
PH                  124,620.6      50,471.3      91.5            7.3
PLM                   2,989.9       1,210.9       2.1            0.1
VARIABLE : VEGET
VALUE                   ACRES      HECTARES   %SEL AREA    %STUDY AREA
BSLGRCLI              4,119.0       1,668.2       3.0            0.2
BSLGLDVC            124,620.6      50,471.3      91.5            7.3
BSLGLDOX              4,366.2       1,768.3       3.2            0.2
BSLGVCOX              2,989.9       1,210.9       2.1            0.1

TOTAL SELECTED      136,095.9      55,118.8

TOTAL STUDY AREA  1,694,593.0     686,310.1
ENTER COMMAND

PLOT  9  APPX SCALE - SCREEN 1 :    416,199  PAPER COPY 1 :    662,964
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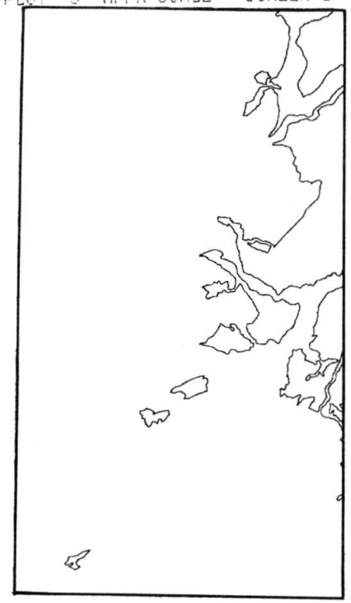

Figure 6: Distribution of areas with permafrost

```
INPUT VALUE(S) TO BE SELECTED FROM : REGNX
HB
HB
INPUT VALUE(S) TO BE SELECTED FROM : TEXOR
C/L
C/L
INPUT VALUE(S) TO BE SELECTED FROM : PCNTX
6/7/8/9/$
6/7/8/9/$
INPUT VALUE(S) TO BE SELECTED FROM : DRAIN
W/M
W/M
ARE THE VARIABLES ABOVE CORRECT AND COMPLETE? ANSWER (YES) OR NO

                  PRESS RETURN FOR SUMMARY REPORT

***                        SUMMARY OF AREAS SELECTED                          ***
***        SELECTION   8                 APR. 02/78     PAGE      1           ***
VARIABLE : REGNX
VALUE                    ACRES         HECTARES     %SEL AREA    %STUDY AREA
HB                    54,894.4         22,232.2       100.0          3.2
VARIABLE : TEXOR
VALUE                    ACRES         HECTARES     %SEL AREA    %STUDY AREA
L                     54,894.4         22,232.2       100.0          3.2
VARIABLE : PCNTX
VALUE                    ACRES         HECTARES     %SEL AREA    %STUDY AREA
6                     17,630.3          7,140.2        32.1          1.0
                      13,349.2          5,406.4        24.3          0.7
7                      8,484.3          3,436.1        15.4          0.5
8                     15,430.4          6,249.3        28.1          0.9
VARIABLE : DRAIN
VALUE                    ACRES         HECTARES     %SEL AREA    %STUDY AREA
W                     53,365.3         21,612.9        97.2          3.1
M                      1,529.1            619.2         2.7          0.0

TOTAL SELECTED        54,894.4         22,232.2

TOTAL STUDY AREA   1,694,593.0        686,310.1
ENTER COMMAND
P

PLOT  8  APPX SCALE - SCREEN 1 :    416,199  PAPER COPY 1 :     662,964
```

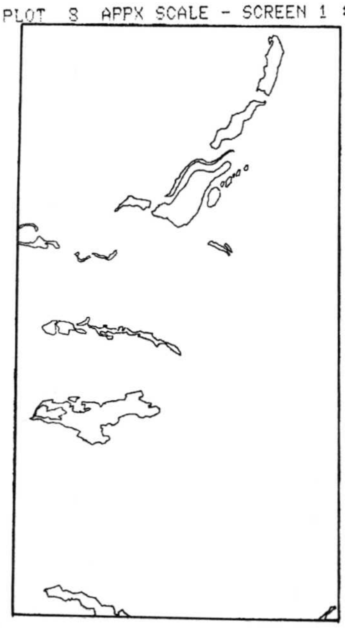

Figure 7: Distribution of areas with a dominance of class 5 forest productivity.

```
                              SUMMARY OF AREAS SELECTED
            SELECTION   6                           APR. 02/78    PAGE    1
VARIABLE : PCNTX
VALUE                     ACRES          HECTARES     %SEL AREA      %STUDY AREA
                       40,080.9          16,232.7        41.9             2.3
8                      55,510.4          22,481.7        58.0             3.2
VARIABLE : SOILX
VALUE                     ACRES          HECTARES     %SEL AREA      %STUDY AREA
 DEB                   23,297.0           9,435.2        24.3             1.3
TFOC                    2,391.2             968.4         2.5             0.1
  HM                    1,048.9             424.8         1.0             0.0
 OGL                   28,381.5          11,494.5        29.6             1.6
 TMF                    7,544.3           3,055.4         7.8             0.4
GDEB                    2,819.1           1,141.7         2.9             0.1
  TM                      689.7             279.3         0.7             0.0
 GCR                    3,724.1           1,508.2         3.8             0.2
 MOC                   25,695.2          10,406.5        26.8             1.5

TOTAL SELECTED         95,591.3          38,714.4

TOTAL STUDY AREA    1,694,593.0         686,310.1

ES
INPUT VALUE(S) TO BE SELECTED FROM : PCNTX
8/9/$
8/9/#
INPUT VALUE(S) TO BE SELECTED FROM : SOILX
B

***                           SUMMARY OF AREAS SELECTED                        ***
***         SELECTION   7                           APR. 02/78    PAGE    1    ***
VARIABLE : PCNTX
VALUE                     ACRES          HECTARES     %SEL AREA      %STUDY AREA
                       19,722.1           7,987.4        75.5             1.1
8                       6,393.9           2,589.5        24.4             0.3
VARIABLE : SOILX
VALUE                     ACRES          HECTARES     %SEL AREA      %STUDY AREA
 DEB                   23,297.0           9,435.2        89.2             1.3
GDEB                    2,819.1           1,141.7        10.7             0.1

TOTAL SELECTED         26,116.1          10,577.0

TOTAL STUDY AREA    1,694,593.0         686,310.1
ENTER COMMAND

PLOT  7  APPX SCALE - SCREEN 1 :     416,199  PAPER COPY 1 :     662,964
```

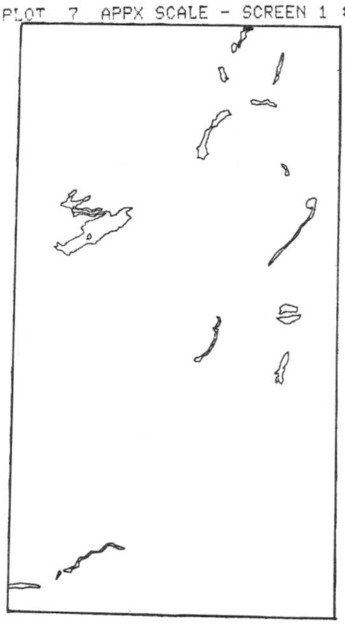

Figure 8: Distribution of brunisolic soils