ISBN 0-919088-13-9

23-B

CANADIAN INSTITUTE OF SURVEYING
CENTENNIAL CONVENTION

Ottawa, Canada
April 19-23, 1982

In Cooperation with the

INTERNATIONAL FEDERATION OF LAND SURVEYORS (FIG)
INTERNATIONAL ASSOCIATION OF GEODESY (IAG)
INTERNATIONAL CARTOGRAPHIC ASSOCIATION (ICA)
INTERNATIONAL SOCIETY FOR PHOTOGRAMMETRY AND (ISPRS) REMOTE SENSING

ASSOCIATION CANADIENNE DES SCIENCES GÉODÉSIQUES
CONGRÈS DU CENTENAIRE

Ottawa, Canada
du 19 au 23 avril 1982

Avec la participation de

LA FÉDÉRATION INTERNATIONALE DES GÉOMÈTRES (FIG)
L'ASSOCIATION INTERNATIONALE DE GÉODÉSIE (AIG)
L'ASSOCIATION CARTOGRAPHIQUE INTERNATIONALE (ACI)
LA SOCIÉTÉ INTERNATIONALE DE PHOTOGRAMMÉTRIE ET (SIPT) DE TÉLÉDÉTECTION

A MAPPING AND RESOURCE ANALYSIS SYSTEM (MARS) AT THE NORTHERN FOREST RESEARCH CENTRE*

by

C.L. KIRBY AND W. CHOW

ABSTRACT

This paper describes the Mapping and Resources Analysis System (MARS) operate by the Northern Forest Research Centre (NoFRC) of the Canadian Forestry Service in Edmonton, Alberta. MARS includes the Systemhouse Limited RAMS system, with additional software to convert polygon map information to a grid cell data base and to interact to a gird cell data base and to interact with a mapping program called GIMMS. The project was funded through the federal ENFOR program to: 1) demonstrate how forest inventories bay be converted to biomass estimates; and 2) have these inventories displayed to facilitate forest management. MARS is capable of integrating map and satellite information for the updating of maps with regard to changes cuased by forest fire, clear cutting, insect and disease damage, and chemical or other disturbances.

SOMMAIRE

Cette communication décrit le système d'analyse des ressources et de la cartographie (MARS) mis en vigueur par le Centre de recherche sur la forêt boréale du service canadien des forêts à Edmonton (Alberta). MARS comprend le système RAMS du Systemhouse Limited avec un logiciel supplémentaire qui permet de convertir l'information cartographique polygone en une base de données et de dialoguer avec un programme cartographique appelé GIMMS. Le projet fut fondé par le programme fédéral ENFOR (Énergie de la forêt) afin de: 1) démontrer comment les inventaires forestiers peuvent être convertis en prévisions de la biomasse, et 2) visualiser ces inventaires pour faciliter la gestion forestière. MARS est capable d'intégrer les informations cartographiques et spatiales pour permettre la mise à jour des cartes en tenant compte des changements causés par les incendies en forêts, de la coupe des arbres, des dégâts causés par les insectes ou les maladies et toutes les perturbations chimiques et autres.

A MAPPING AND RESOURCE ANALYSIS SYSTEM (MARS)
AT THE NORTHERN FOREST RESEARCH CENTRE

by

C.L. Kirby[1] and W. Chow[2]

1.0 INTRODUCTION

This paper describes the Mapping and Resource Analysis System (MARS) operated by the Northern Forest Research Centre (NoFRC) in Edmonton, Alberta. It describes the hardware and software employed by the system and presents some of the output capabilities. MARS includes the Systemhouse Limited RAMS system integrated with the NoFRC PDP11/60 minicomputer system, with additional software for changing polygon data to a grid cell data base for integrating multiple maps and satellite information for a given area. In addition, polygon map data bases established for a mapping program called GIMMS (Waugh and Taylor, 1976) may be changed so that they are compatible with MARS or so that MARS map data files may be made compatible with GIMMS files.

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2.0 BACKGROUND

A federal goverment program (ENFOR) to evaluate the potential of ene from the forest has provided funds for obtaihing the MARS system NoFRC. The objectives for the NoFRC ENFOR project are as follows:

1. to provide a pilot study of a computerized interacti information system for biomass inventories suitable for provincial nee and compatible with national systems.

2. to provide an in-house biomass data base that may be us for economic studies using simulation modelling techniques.

3. to demonstrate the usefulness of Landsat in providing rap updating of conventional forest inventories.

4. to integrate information from multiple maps for a giv area; ie., biomass, productivity, ownership boundaries.

The first phase of the project provides much of the necessary hardwar and software to achieve these objectives.

A major problem with many forest inventories is that because of cos they are able to provide only forest statistics that are quite ofte ten, sometimes twenty or more, years old. The MARS system at NoFR represents an attempt to integrate information from satellites an forest inventory maps. It will permit the updating of map informatio that has been altered because of changes brought about by fire, insect and disease damage, cutting, and chemical or other disturbances in the forest. Research and development that assists the provinces in providing timely and economical forest inventories is a contribution towards improving the Canadian Forest Resources Data Program as well as towards improving estimates of forest biomass which are also based on provincial forest inventory statistics.

3.0 MARS

3.1 Hardware

A schematic diagram of the hardware for MARS is presented in Figure 1. A photograph of the work station is presented in Figure 2. The hardware comprises:

- HP 1000 Model 40 Series E with 256K bytes of standard memory
- Fixed 10 mb disk drive
- Removable 10 mb disk drive
- Fast Fortran processor
- HP 2645 console
- HP 2621A terminal at mapping station
- 6211 Ramtek color display (480 x 640 resolution with 16 colors)
- 4100 Ramtek color printer plotter
- 16 bit parallel link between PDP11/60 and HP 1000
- Altek 34-2-BL digitizing table with SHL microprocessor. Absolute accuracy of the table is plus or minus .076 mm and the resolution is .025 mm.

3.2 Software

The MARS system has the following software facilities that may be used to produce polygon maps with shading that is dependent upon polygon attributes. In addition, linear measurements of features and area measurements of each polygon are calculated and stored along with the attributes for tabular outputs. Programs for computer mapping include the following:

- Map registration
- Workstation settings
- Features
- System database
- Digitizing features
- Editing features
- Text
- Polygons
- Graphics operations
- Display facilities
- Polygon to grid
- Grid merge
- Grid display
- Grid count

3.2.1 Map Registration

Facilities for initializing map files, and registering maps to kn geographic control are provided.

- Initialize files to receive data
- Open previously initialized files
- Register maps so that the system automatically calculates a tranformation from the digitizing table to UTM coordinates
- Define map origin
- Define control points
- Verifying residuals between known control points and digitized control points.

3.2.2 Workstation Settings

The operator may control the quality of data digitized on the table.

Sample Interval

The time interval between successive samples of the table or display cursor is set at 25 times per second.

Minimum Travel

When the cursor button is activated, but held fixed in one location, redundant data will not be stored in the system. Points will not be stored unless a minimum distance is travelled by the cursor. Minimum travel may be set by the operator.

Maximum Travel

If the operator moves the cursor more than a maximum distance within a given time interval, then an error condition will be automatically signalled by the system. Maximum travel may be set by the operator.

Range

The operator will use the cursor to locate on the table and display features previously digitized, so that they may be displayed or operated on. Range is used to locate features within an operator specified tolerance of a digitized point.

3.2.3 Features

The system will recognize the following feature types:

Single point	-	e.g., survey monuments
Multipoint	-	e.g., transmission lines
Continuous	-	e.g., curvalinear lines
Text	-	e.g., place names
Polygons	-	e.g., geostatistical areas
Polygon attributes	-	240 characters

3.2.4 System Database

The system database has been designed to store all feature types, enabl the formation of polygons with associated attributes, and produce shade polygon maps. The database includes:

- An index that stores a descriptive record of each feature.
- A data file that stores the coordinate data for features.

These files are interrelated through a system of pointers, so that file may be searched quickly and efficiently.

The database is created automatically by the system as the operato works.

3.2.5 Digitizing Features

A set of commands is provided for digitizing points and lines. Provision has been made for the feature coding of all graphic entities. Facilities include:

- Feature entry
- Automatic repeat for entry of a feature of the same code as that previously digitized
- Attach features together
- Mode change so that one feature may contain curvilinear sections defined by continuous digitizing and straight line sections defined by start and end points

3.2.6 Editing Features

A set of commands is provided for editing features:

- Feature restart
- Remove points on a multipoint feature
- Back-up on a feature
- Change a mid-section of a feature
- Delete features
- Join features
- Split features

3.2.7 Text

Facilities are included for entering, modifying, and drawing text.

- Enter text string
- Specify text angle
- Replace text--for error correction

3.2.8 Polygons

Polygons are formed as follows:

- Digitizing each boundary in the polygon network
- Defining a polygon by pointing in sequence to all the boundaries of a given polygon
- Entering the polygon attributes, to a maximum of 240 alphanumeric characters per polygon

The area of the polygon and the length of the perimeter are calculated by the system.

3.2.9 Graphics Operations

A set of operator commands is provided for control of the graphics display:

- Echo on the display while digitizing
- Window to a selected area
- Move the window
- Draw operator selected features by layer or groups of layers

3.2.10 Display facilities

This Thematic Mapping Program contains powerful and flexible display facilities for shading and plotting polygons and text. Facilities are provided for:

- Polygon coloring
- Operator selection of patterns
- Coloring a function of polygon attributes
- A numeric and alphabetic character set defined by 100 x 100 dot matrices
- A symbol set defined by 100 x 100 dot matrices
- Hardware generated line symbolism related to feature type coding

- Plotting the graphics display on the matrix printer plotter to create a hardcopy, including characters, symbols, line types and shaded polygons

[The following six software modules were developed at the specific request of NoFRC. The software with the exception of the device drivers is in Fortran.]

3.2.11 Polygon to Grid

The polygon to grid is a batch program that converts polygon structured data to a grid form. The user may specify the grid interval, so that compatibility to other data, including Landsat, may be achieved.

3.2.12 Grid Merge

The grid merge is a batch program that may be used to concatenate compatible grid data sets. For example, a polygon derived grid may be merged with a Landsat classified image.

3.2.13 Grid Display

Grid display provides the facilities to produce thematic grid maps displayed on the Ramtek 6211 graphics display. The user may assign selected shading patterns according to the attribute value.

3.2.14 Grid Count

Grid count provides the facility to count the number of cells for the various classes according to the attribute value.

3.2.15 HP 1000-PDP11/60 16 Bit Parallel Link

This link between the two computing systems makes it possible to do image processing on the PDP11/60 and have the classification output on the HP 1000 system to obtain color display and hardcopy. In addition, a digitized map from the MARS system may be placed on magnetic tape using the tape drive of the PDP11/60 system.

3.2.16 GIMMS to MARS and MARS to GIMMS Conversion Programs

The digitized map formats of these two mapping systems are not compatible. GIMMS is a mapping system available at many universities and is used by Statistics Canada and the Canadian Forest Resources Data Program. To be compatible with GIMMS, these conversion programs are required. It is desirable for all computer mapping programs to have a common input format such as indicated by Goodenough et al., 1980. Digitized maps are a resource that should be shared.

4.0 MARS OUTPUT

After two days of training tests of the system were carried out. Test material included the following:

1. A test map which was supplied by the Alberta Forest Service and which was a recent Phase III inventory map at a scale of 1:15,000 containing approximately 800 forest types;

2. A classified portion of a DICS tape of the Fort Smith area of the Northwest Territories;

3. A small test map where the area of each polygon was accurately known.

4.1 Alberta Phase III Test Map

Approximately 40 hours were required to digitize this map for the MARS system. The procedures developed by Systemhouse are comprehensive. Systemhouse anticipates that there will be improvements of the digitizing procedures in future versions of the software. Approximately 80% of the cost of computer mapping is incurred in the digitizing process.

The size and resolution of the Ramtek screen and printer plotter is sufficient for displaying only a portion of the map according to classification criteria which are defined by the operator. An example of the Ramtek output is given in Figure 3.

Improved map output can be obtained using an HP 7580A plotter. An example of the output produced on a unit provided by Systemhouse for this test is shown in Figure 4. The Alberta test map (10 x 10 km) was produced on one sheet at a scale of 1:20,000. If the map were produced at a scale of 1:15,000, it would have to be done in two sections. The production of the whole test map took approximately two hours.

The grid overlay aspect was tested by producing a second map which divided the test map into four sections. The polygon to grid and grid merge routines took approximately one half hour for a portion of the test map. The grid output from the two maps was overlaid and was visually correct.

4.2 Small Test Map with Known Polygon Areas

A small map approximately 20 x 20 cm with 33 polygons of known area with some island polygons was digitized by W. Chow and C.L. Kirby on the MARS

system. The areas determined by the MARS system were within one to two percent of those obtained by use of a planimeter, except for small areas such as oil well sites where larger errors were encountered. Differences between the two methods of area determination are attributable to scale and to the care taken in obtaining the measurements.

4.3 Satellite Image Analysis and Display

A portion of a satellite image on a DICS tape was classified on the PDP11/60 at NoFRC using the Goldberg-Schlein (1978) unsupervised classifier. This classifier was made available through Dr. P. Kourtz of Petawawa National Forestry Institute. It was installed on the PDP11/60 system by Messrs. B. Todd and B. Rossen also of the Petawawa National Forestry Institute (Todd and Rossen, 1981) (Rossen, 1981).

A 300 x 300 pixel area (15,000 x 15,000 m) was selected from a DICS tape of the Fort Smith area in the Northwest Territories. The area selected was classified into 17 themes on the PDP11/60. Some of the themes were combined into one class. The classification was stored and sorted to be compatible with the MARS mapping system using a program written by W. Chow (November, 1981). The classified image was displayed on the MARS system. The display of the classification on the color screen and the Ramtek printer plotter was of high quality at a scale of 1:100,000 approximately. Areas up to 1000 x 1000 pixels may be handled by the MARS system with the display at a correspondingly smaller scale. The classification of the DICS tapes for use on the MARS system may be done on any image analysis system as long as it produces a tape which may be read by the PDP11/60 at the Northern Forest Research Centre.

The assessment of the accuracy of the satellite image classification has been a tedious and time consuming task. With the polygon to grid and grid merge of MARS this task is now done much more efficiently. An example of the output showing the image classification with hardcopy from the Ramtek printer plotter is shown in Figure 5.

5.0 APPLICATIONS

The primary application of MARS is for the demonstration of computer mapping and data base management techniques for the estimation of biomass in Alberta, Saskatchewan, Manitoba and the Northwest Territories. Results from other ENFOR studies (biomass prediction equations, productivity) will be used to make biomass estimates and to assist in technology transfer--two major objectives of the ENFOR program. MARS places NoFRC in a position to do research and development in computer mapping and the integration of mapping with satellite image analysis.

Other applications and programs to which the MARS system will contribute are:

1. Regional maps and statistics of insect and disease losses integrating the use of satellite information such as are being developed by R. Hall[3] in his Master's program at The University of Alberta. He has shown areas of poplar defoliation in Alberta by using multidate satellite images;

2. Thematic maps and resource analyses for watershed research and planning;

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3. Forestry Officer, Remote Sensing Specialist, Northern Forest Research Centre, Canadian Forestry Service, Edmonton, Alberta.

3. Thematic maps and resource analyses of biophysical inventory programs. The overlay process will make it possible to integrate information on habitat and soils for determining optimum use of various areas;

4. Thematic maps and resource analysis for impact statements and route location for such areas as the Mackenzie Corridor;

5. Habitat maps for wildlife management.

6.0 CONCLUSION

The development in computer graphics is likely to be rapid during the next ten years. There will be considerable improvement in input procedures: Raster scanning methods may replace conventional digitizing; 32 bit computers will address megabytes of core memory; and improved output devices will provide higher resolution at more moderate cost. These hardware developments will require some changes in software.

The MARS system has powerful analysis capability for analysis of multiple maps of information pertaining to a specific area. The polygon to grid cell conversion of any desired size, and the grid overlay, display, and cell counting programs provided by Systemhouse make the system suitable for many resource analysis projects now and into the next ten years.

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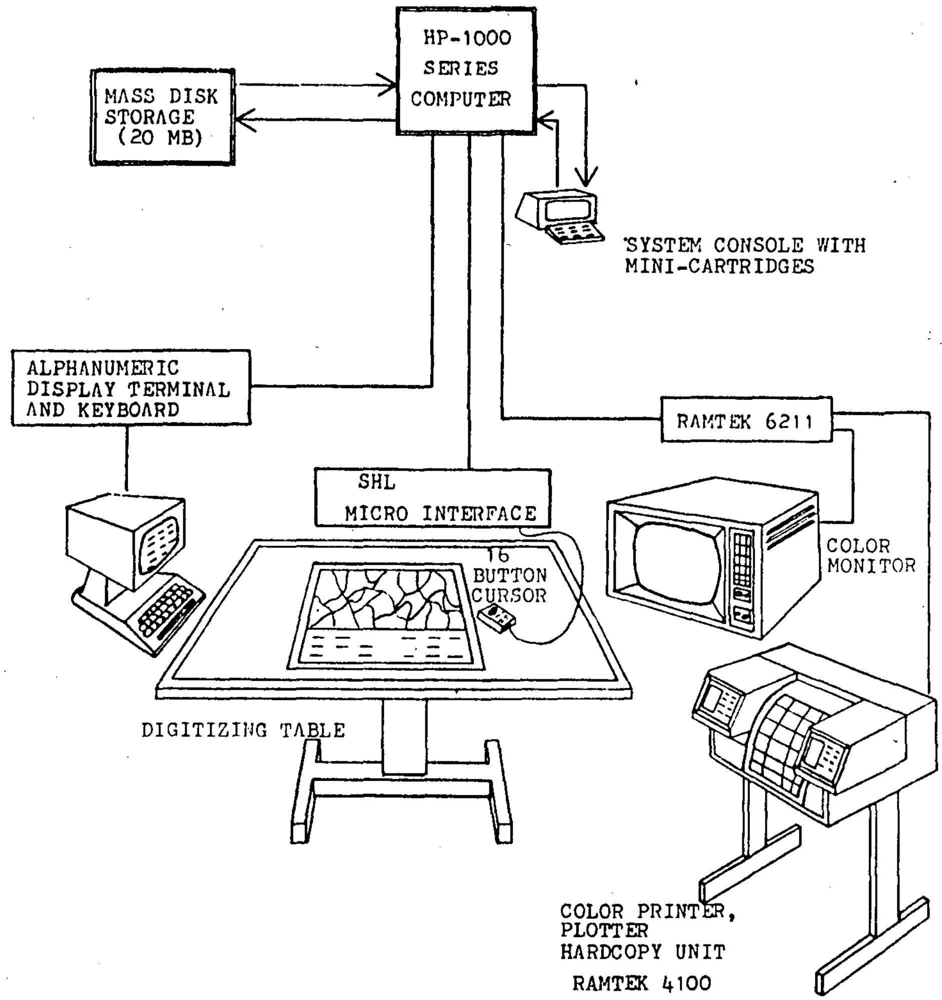

Figure 1. A schematic diagram of the mapping and resourse analysis system (MARS) to be installed at the Northern Forest Research Centre.

Figure 2. A photograph of the MARS workstation. from left to right: Ramtek 4100 color printer plotter, HP 2621A terminal, Ramtek 6211 color monitor, and Altek 34-2-BL digitizing table.

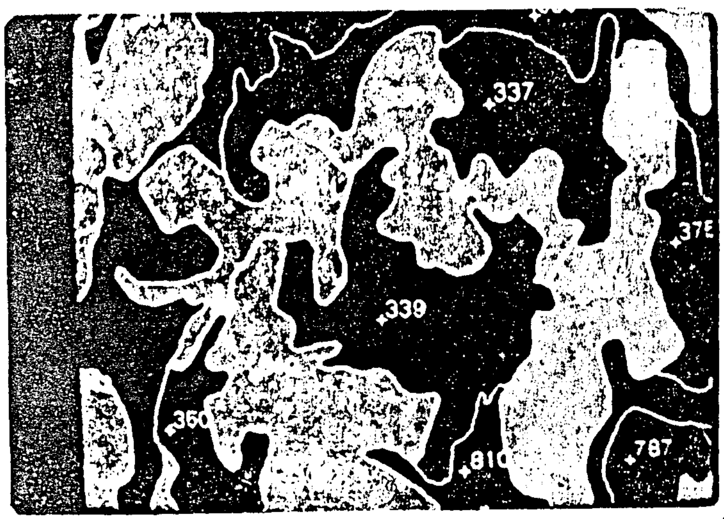

Figure 3. A portion of the Alberta test map showing type boundaries and polygon number with selected covertype attributes emphasized by color filling the polygons.

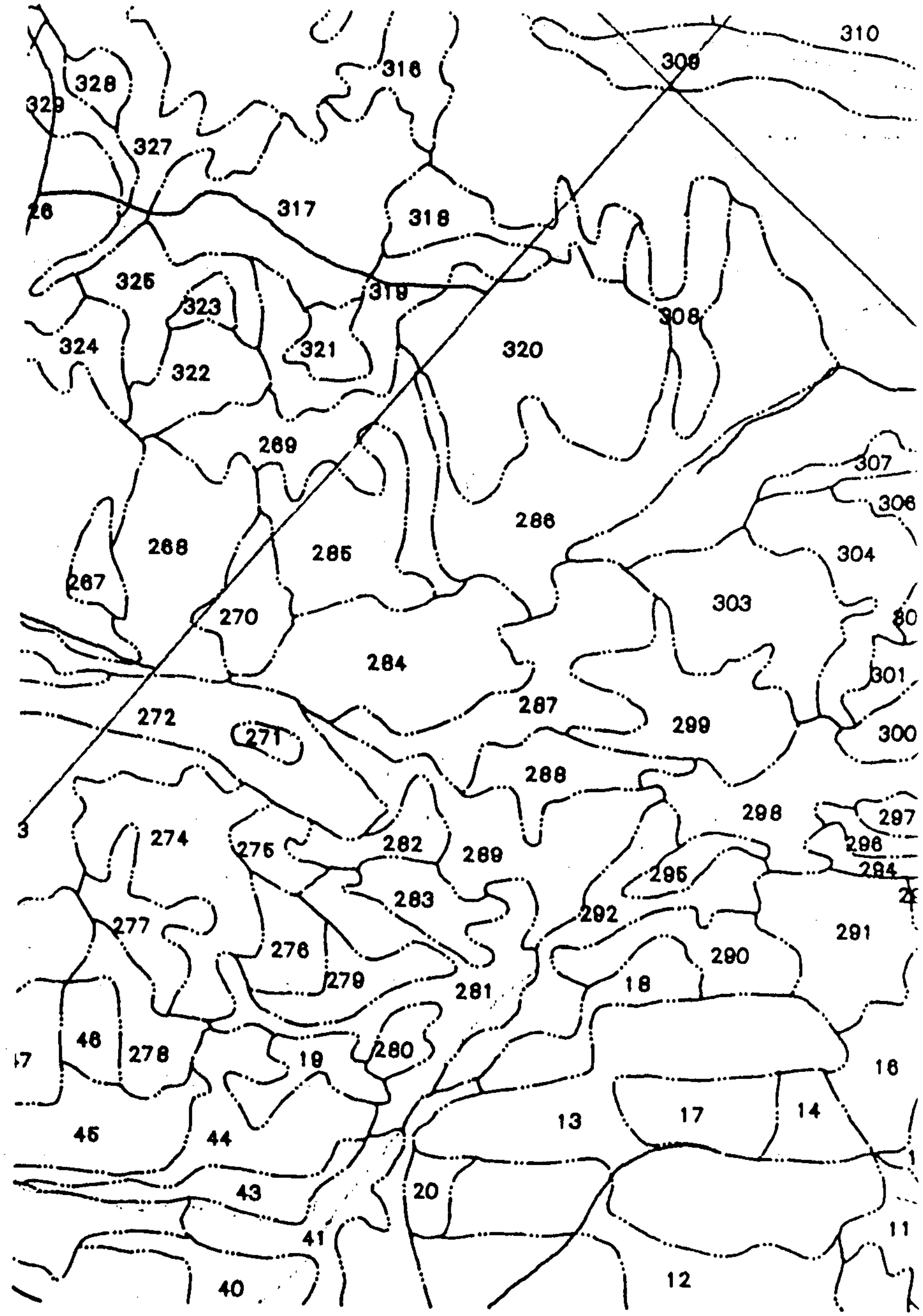

Figure 4. A portion of the Alberta Test Map produced on HP 7580A plotter at a scale of 1:15,000 with forest type boundaries and numbers in black, streams in blue, and seismic lines in red.

Figure 5. A print of a digital satellite image unsupervised classification done on the PDP11/60 at the Northern Forest Research Centre and displayed on the Ramtek 4100 of the MARS system.