Pacific Forest Research Centre

Yukon RRAMS

An information retrieval system for renewable resource and management statistics

Y. Jim Lee, D. Hunt and T.G. Honer

Environment Canada
Forestry Service

Environnement Canada
Service des Forêts

ABSTRACT

The Yukon Information Retrieval System, designed for use by various levels of decision-makers in the field of forestry and environmental management, allows for easy modification and addition of resource data input. It is capable of interactively retrieving, displaying and tabulating available resource data for a given location.

The resource data information inputs are based on a "cell" (grid) orientated system. The record for each "cell" contains data for a ¼ Universal Transverse Mercator (UTM) grid (2500 ha), expressed in percentage or some other units. Current forestry information is mainly based on a forest resource study by C.H. Gairns, the only up-to-date information for the Yukon Territory. Other data files, such as wildlife, land use, weather, hydrology, etc., can also be implemented.

The computer package has been written entirely in FORTRAN IV on the Pacific Forest Research Centre (PFRC) PDP-11/45 inhouse computer running under the RSX-11D operating system. It can be accessed from remote computer terminals and can also be adapted to a more elaborate and expensive computer, if necessary.

With the facility for monitoring and updating data on changing management activities, this system provides the PFRC and The Canadian Forestry Service with efficient and up-to-date resource information for research and policy decision-making.

RÉSUMÉ

Le Système de recherche documentaire du Yukon, destiné aux cadres de divers niveaux en foresterie et en gestion de l'environnement permet de modifier ou ajouter facilement des données d'entrée sur les resources. Il peut extraire, afficher et tabuler interactivement les données disponibles sur les ressources d'un lieu dit.

Les entrées de données d'information ont pour fondement un système qui s'oriente sur des "cellules" (une grille) de mémoire. L'enregistrement dans chaque "cellule" contient des données classées selon une grille ou quadrillage Mercator transverse universel ("UTM") au quart (2500 ha) et exprimées en pourcentages ou autres unités. Nos informations actuelles sont fondées surtout sur une étude de ressources forestières par C.H. Gairns, et ce sont les seules qui couvrent récemment le Yukon. On peut aussi mettre en oeuvre de la même façon les données sur la faune, les terres, la météorologie, l'hydrologie, etc.

Le programme-produit par ordinateur fut écrit entièrement en FORTRAN IV avec l'ordinateur PDP-11/45 au Centre de recherches forestières du Pacifique et il fonctionne selon le système RSX-11D d'opération. On peut accéder à un tel programme depuis des terminals d'ordinateur satellites et on peut aussi l'adapter à un ordinateur plus élaboré et plus dispendieux, si nécessaire.

INTRODUCTION

Resource managers require basic information and inventory data for environmental planning and management. With increasing demands being made on the Yukon Territory by resource users, it is desirable that existing ecological information relating to the renewable natural resources be organized to permit immediate access and retrieval for planning purposes.

A project was initiated in 1975 to review existing information and, through the application of LANDSAT imagery, to zone the Territory into broad ecological regions suitable for resource planning and management (Oswald and Senyk 1977). An integral part of this project was the development of an information retrieval system for renewable resource and management statistics (Yukon RRAMS).

Before detailed systems design work commenced, several criteria were established to guide its development. Since it would initially be used to assess the status of the forest resource for braod management and research purposes, it had to be relatively simple, fast and inexpensive. Because it would be used by management personnel having a minimum of experience with related computer equipment, it had to be elementary in design and operation, and easy to up-date. In addition, it had to operate on the in-house computer at PFRC in order to minimize cost, and be capable of displaying results in map form, and presenting tabular summaries in Canadian metric units.

The system was completed within an 8-month period and became operational in August 1976. The basic design was later adopted by the Forest Management Institute of Ottawa (Madill 1976) for the development of the National Forestry Statistics Program information retrieval system.

THE CONCEPTS

Resource statistics must relate to a land or area base. The number of cubic metres of timber on the land base and the extent of the timber's distribution over the land determine the long-term forest management strategy. Forest resource maps show the locations of merchantable timber stands and this mapped information may be presented for computer storage in cells or grids of fixed size, or in polygons of variable size. There are advantages to each approach (Schwarzbart et al. 1976; Piirvee 1975; Harding 1974; Thornburn et al. 1973). The general characteristics of the two storage systems are as follows:

Grid	Polygon
(1) Maps and data inputs are based on cells of equal area. Therefore, area summaries are precise.	(1) Maps and data inputs are based on polygons. Area summaries are the sums of individual polygons.
(2) Computer inputs are hand coded or automatically generated with the aid of an optical scanner from grid forms overlaid on the base map.	(2) Computer inputs are generated by manually digitizing the polygon boundaries from the base map to obtain numeric data; automatic scanners currently available require considerable manual preparation.
(3) Updating of data is simple and easy, because of direct access to cells in computer memory.	(3) Updating of data is difficult because polygon boundaries have to be redefined.
(4) Additional data files are easy to create and take up less memory space.	(4) Each additional data file requires digitizing polygon boundaries from each additional base map and takes up a great deal of memory space.

(Grid cont'd)	(Polygon cont'd)
(5) Software requirements are simple, straight forward and easy to understand.	(5) Software requirements are relatively complex and difficult to implement.
(6) Operation of the system is simple and fast.	(6) Operation of the system is difficult and relatively slow, and requires a substantial amount of training and technical support.
(7) Use of the system is relatively inexpensive.	(7) Use of the system is fairly expensive.

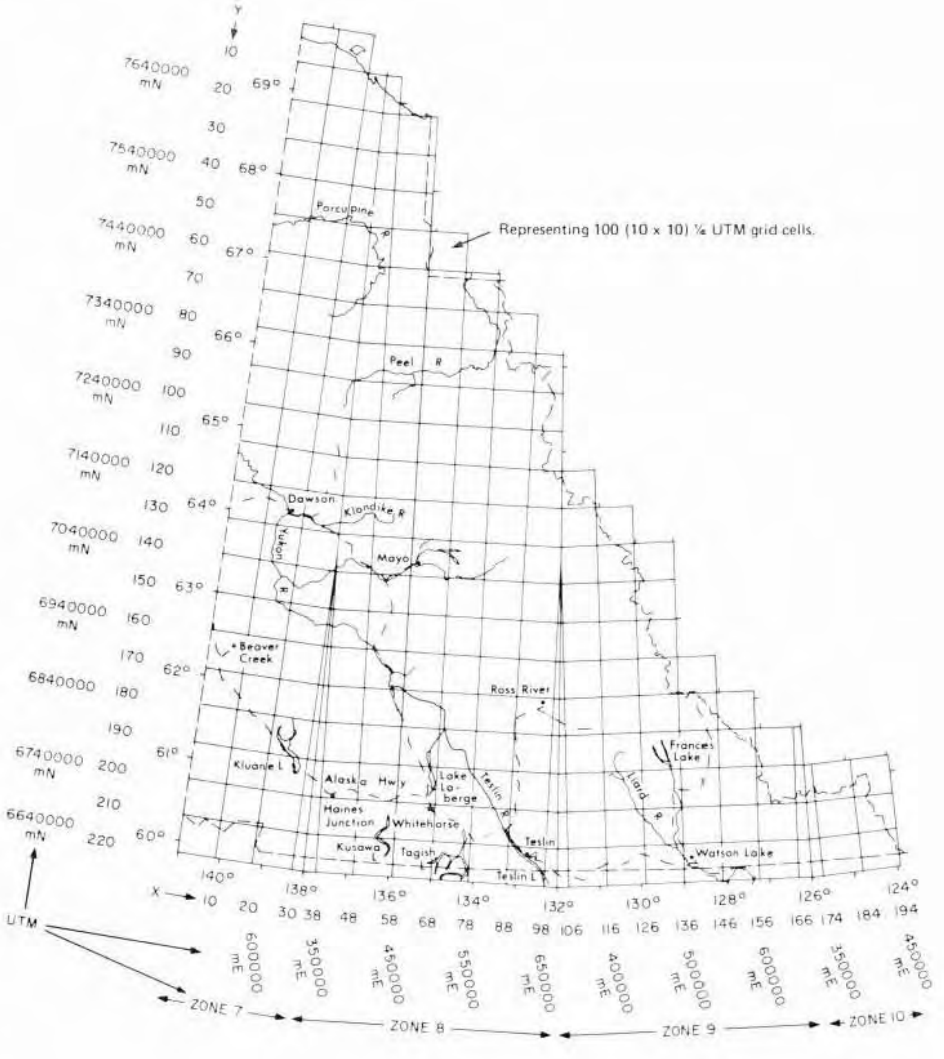

Figure 1. The ¼ UTM grid cells, expressed as X, Y coordinates, cover the Yukon Territory.

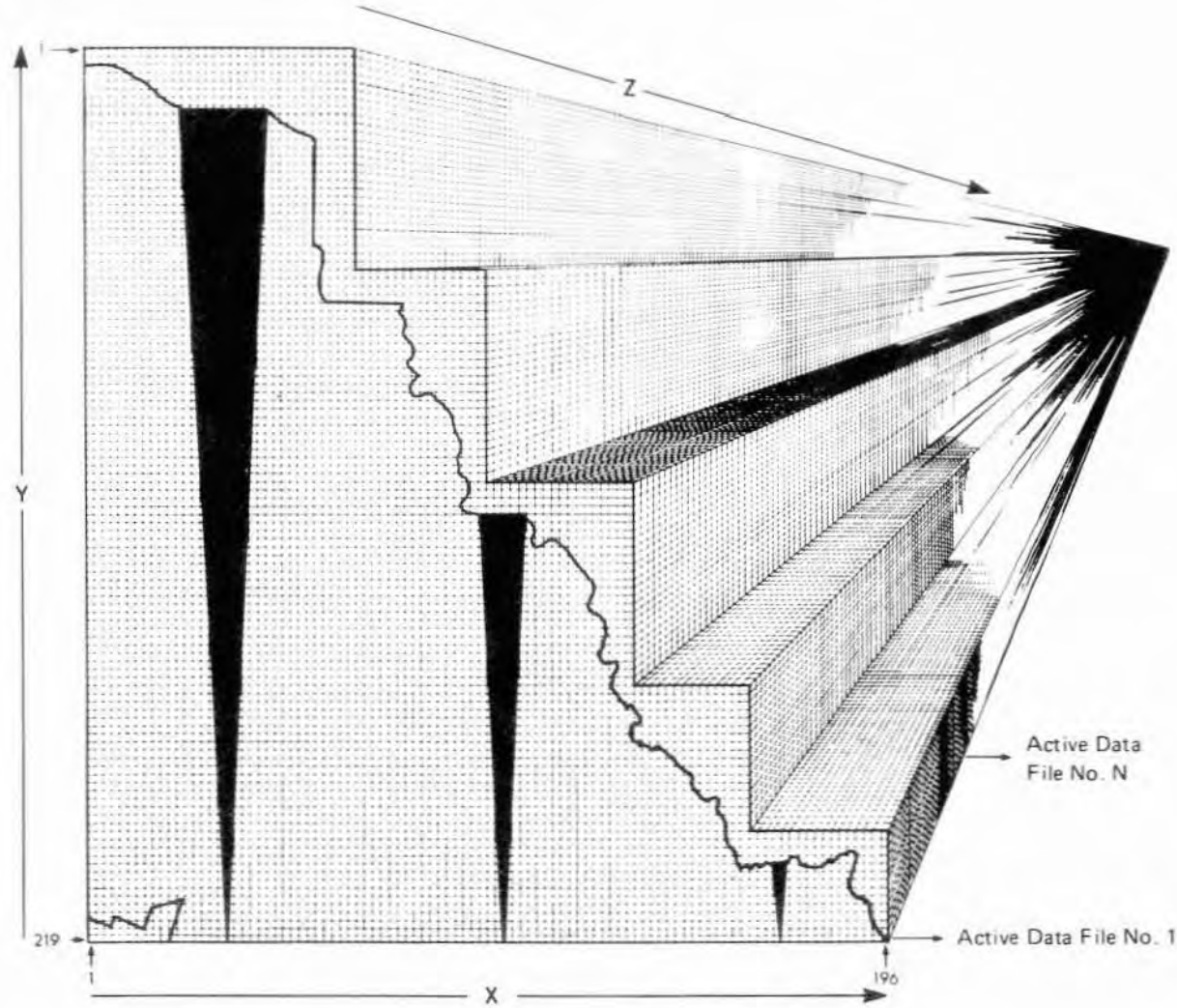

Figure 2. Schematic diagram of the Yukon Information Retrieval System Data Storage.

In accordance with the established criteria for development of the system, preference was given to a data base using a grid "cell" as the basic unit of information. The data inputs are specific to each cell of the grid. The record for each cell contains data for a grid of 2500 hectares (¼ Universal Transverse Medicator - UTM), expressed in percentage or some other units. Each of these cell units represents an exact area (2500 ha) or a portion of it along the convergent line from the equator to the north pole. The cells cover the entire Yukon Territory and form the basis for a retrieval system designed to provide an overview of the Territory (Figure 1).

The data bank configuration can be expressed as a conceptual approach to storing and retrieving information about an area of interest within the Territory. It can be viewed as a three-dimensional array of data points (Figure 2), each designated by an X, Y coordinate, representing the northwest corner of a ¼ UTM grid. The Z coordinate represents the facility for numerous "active data files" of discrete information in the data bank, such as data about vegetative types, tenure of productive forest land, fire danger ratings, fire history, cutover areas, regeneration, land use activities, recreation, wildlife, weather, hydrology, mineral deposits, etc. The amount of active data-file information that can be stored for each cell on the X and Y coordinates is virtually unlimited. Data files can be eliminated or updated at any time.

Current forestry information is mainly based on a forest resource study (Gairns 1968), a biophys-

ical study (Oswald and Senyk 1977), and information provided by the Yukon Lands and Forest Service. The current forestry file is capable of producing tabular summaries of area and timber volume by ecoregion or management unit for six land classes, including productive and nonproductive forest. Other data files are being developed.

THE SYSTEM

Yukon RRAMS is a highly interactive system capable of storing, retrieving, displaying and tabulating resource data. Although the current report generating routines have fixed selection criteria, new criteria can be added with minor software changes. Such a change may require tabulation of only those areas containing a fixed proportion of a characteristic or a range of values, and it has been found that this can be implemented within a day. The lineprinter mapping feature is currently capable of interactively producing distribution maps based on user selection of the percentage of any cover type in each cell. The system has been written entirely in FORTRAN IV and is currently operating on a PDP 11/45 minicomputer under the RSX-11D operating system. Total memory requirements without overlaying are less than 32 K words (16 bit words). It is a disk based system that takes advantage of direct access files and index files to provide the quick conversational response necessary for interactive use. In addition to the main interactive system, there is a currently offline graphics subsystem capable of generating color maps on either film or television screens. At present, the basic hardware requirements in addition to the minicomputer are a disk drive for storage of files, a line printer for printing of reports, a terminal and a magnetic tape drive for storage of graphics files.

A general flow chart of the system is shown in Figure 3. The three basic file types essential to the system are:

(1) Disk INDEX File: Contains a description of each Active Data File, including a general file description, number of "fields" or observations per 'cell', descriptions of these "fields", and designated options for the systems mapping facility. This file is made available to the user when running the system.

(2) Active Data Files (ADF): Currently, only the forestry file is available and tabular outputs are specific to it, but the basic retrieval logic and mapping option are suitable for new files. Any number of active data files can be generated and maintained by the system.

(3) Geographic Description File (GDF): When retrieving information based on X and Y coordinates, this file minimizes the time required to access the active data file. It is essentially an index for the ADF.

The system can easily be updated by implementing the following:

(1) Revise existing data.

(2) Add new active data files to the system.

(3) Add options and general purpose routines to the modular structure of the system.

(4) Enlarge the system to cover small management areas where detailed data are required with a smaller cell unit.

SOME OPERATING EXAMPLES

When a user begins a session, he is informed which active data files are available and is provided a description of each. An outline of the management boundaries of the Yukon Territory is available on the line printer or the terminal to assist the user in defining the X, Y coordinates of a subarea from which the user wishes to retrieve information. The shape of the subarea is limited to that of a square or rectangle. However, an irregular shape of subarea can be achieved by retrieving up to 20 subareas at any one time. When the subareas are satisfactorily defined, outputs and options are listed and the user may request the printing of various tables and maps redefine subareas, return to the introductory stage of the system, or end the session.

For example, a request was received from operating personnel of the Yukon Lands and Forest Service to determine timber areas and volumes for four areas, as a preliminary overview prior to undertaking additional inventories. Locations of data were specified as follows:

subarea 1 coordinates X = 110 to 137, Y = 196 to 217
subarea 2 coordinates X = 32 to 54, Y = 95 to 108
subarea 3 coordinates X = 33 to 42, Y = 168 to 185
subarea 4 coordinates X = 90 to 105, Y = 128 to 148

and Figure 4 shows the areas of interest located on the computer map. Table 1 shows the area in hectares

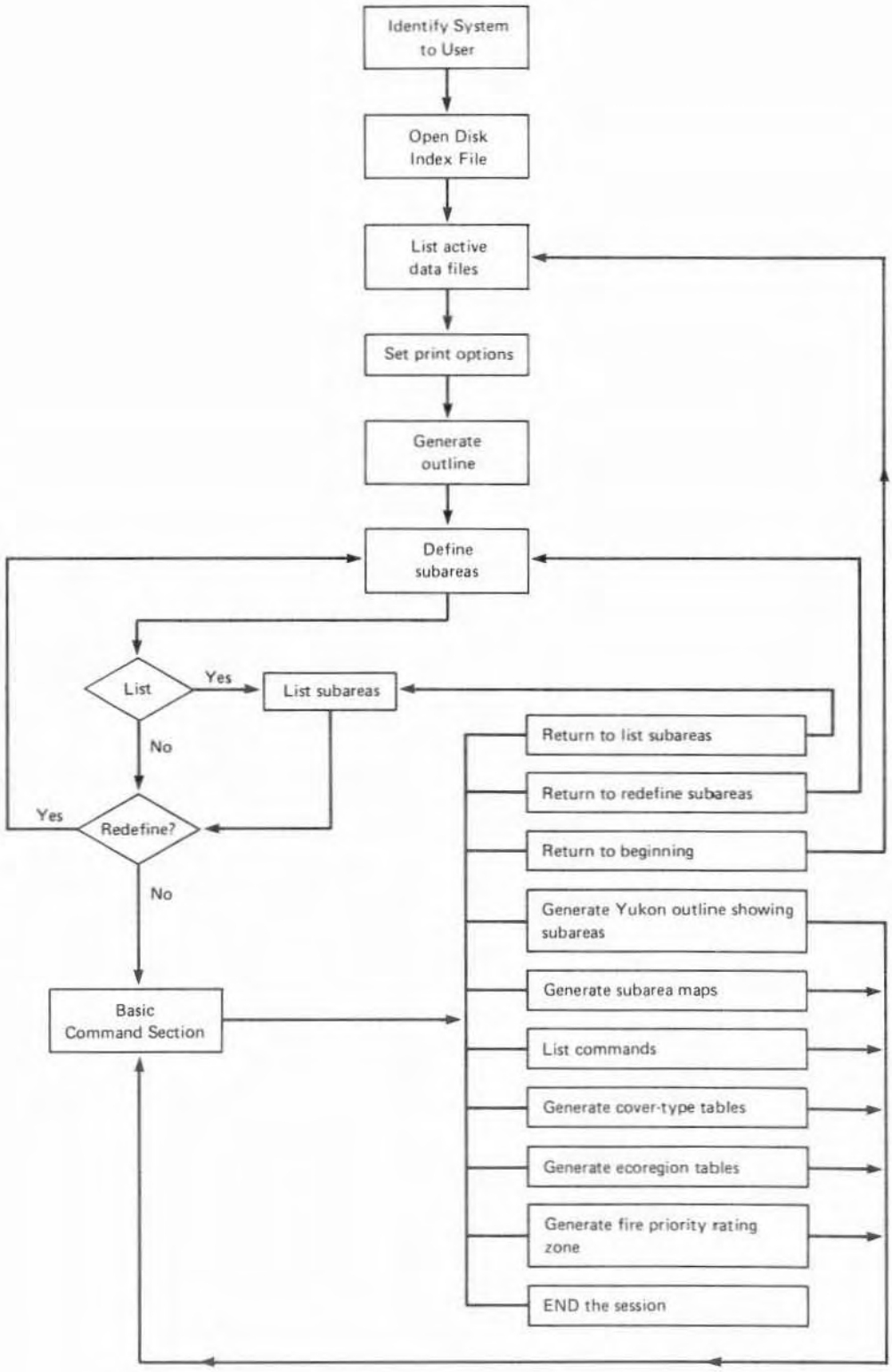

Figure 3. General flowchart of the Yukon Information Retrieval System.

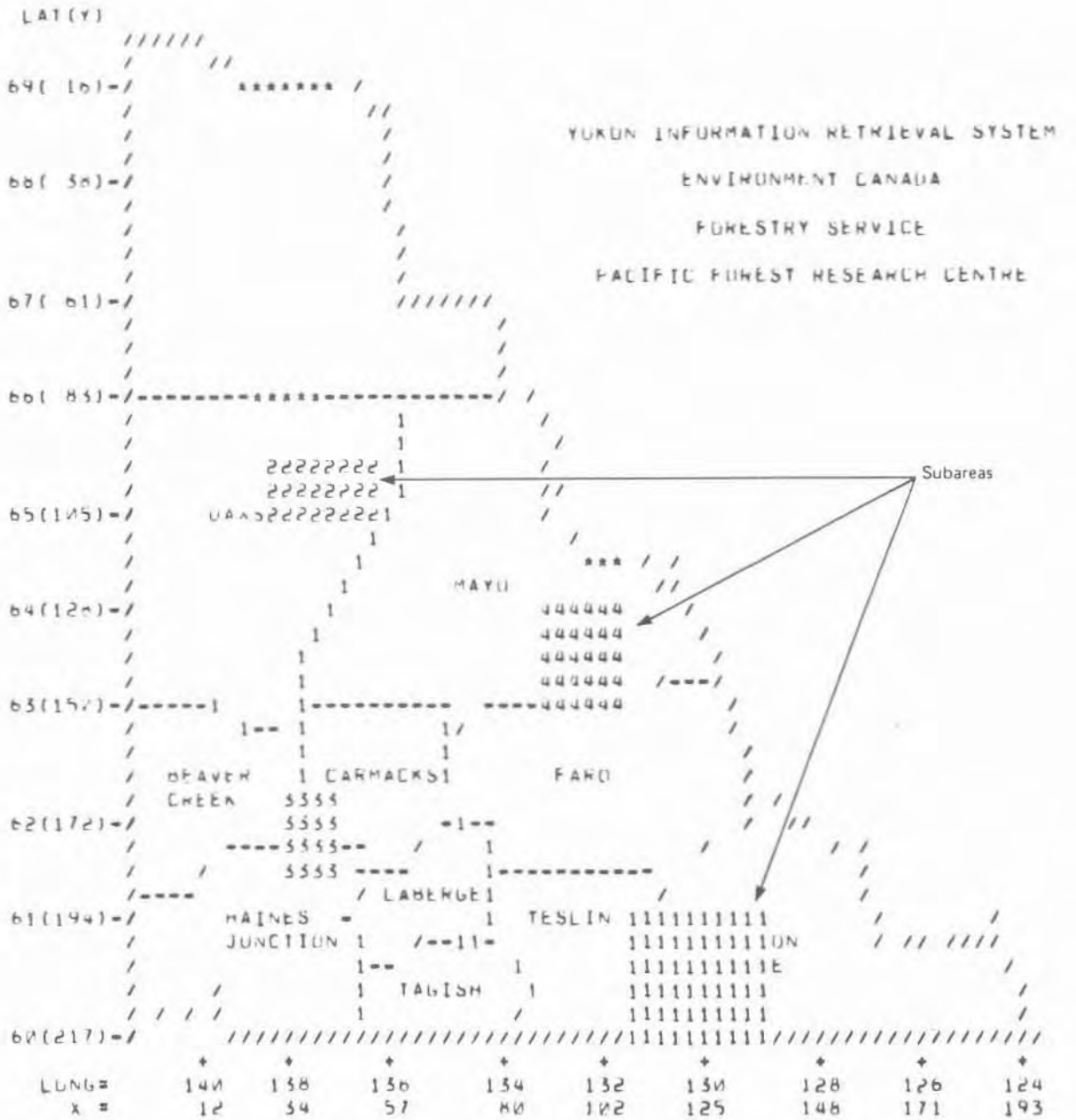

Figure 4. Yukon outline, showing subareas that have been defined.

and acres by vegetation type and management unit for subarea 1. Since the subarea of interest spans the administrative districts of Teslin and Watson Lake, the areas within each are presented and the totals for the subarea are also provided. Timber volumes of softwoods and hardwoods in cubic metres and cubic feet are also presented for subarea 1 by vegetation type and administrative district (Table 2). Similar tables are printed for subareas 2 to 4, but have been omitted from the presentation. A total summary of all subareas is shown in Tables 3 and 4.

Each subarea was composed of the following number of cells:

subarea 1:	616 (28 x 22) cells
subarea 2:	322 (23 x 14) cells
subarea 3:	180 (10 x 18) cells
subarea 4:	336 (16 x 21) cells

The total time required to input, compute and print the results is about 6½ minutes. This included the time required in retrieving the four subareas, printing the map of the Yukon showing the subareas,

TYPE	RESOURCES MANAGEMENT AREAS IN THOUSANDS OF HECTARES /THOUSANDS OF ACRES/										
	DAWSON	MAYO	BEAVER CREEK	LARMACKS	FARO	HAINES JUNCTION	LABERGE	TAGISH	TESLIN	WATSON LAKE	*TOTAL*
SOFTWOOD= ALLUVIAL	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.3 / 0.7	30.1 / 74.4	30.4 / 75.1
SOFTWOOD= UPLAND	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	8.5 / 21.0	574.3 / 1419.2	582.8 / 1440.2
HARDWOOD	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.1 / 0.3	0.1 / 0.3
PRODUCTIVE AREA	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	8.8 / 21.7	604.6 / 1493.9	613.4 / 1515.6
BURNS	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	7.8 / 19.2	91.7 / 226.5	99.4 / 245.6
WATER	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	1.0 / 2.4	14.1 / 34.8	15.1 / 37.2
OTHER	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	252.5 / 623.9	559.7 / 1383.0	812.2 / 2007.0
TOTAL	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	270.0 / 667.2	1270.0 / 3138.2	1540.0 / 3805.4

NORTHERN AREA (THOUSANDS OF HECTARES)= 0.000

Table 1. Forest resources area summary by management units for subarea 1.

RESOURCES MANAGEMENT AREAS		VOLUME IN THOUSANDS OF CUBIC METRES (THOUSANDS OF CUBIC FEET)					
		SOFTWOOD-ALLUVIAL		SOFTWOOD-UPLAND		HARDWOOD	*TOTAL*
DAWSON	S:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
	M:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
MAYO	S:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
	M:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
BEAVER CREEK	S:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
	M:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
CARMACKS	S:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
	M:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
FARO	S:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
	M:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
HAINES JUNCTION	S:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
	M:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
LABERGE	S:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
	M:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
TAGISH	S:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
	M:	0.(0.)		0.(0.)		0.(0.)	0.(0.)
TESLIN	S:	35.(1249.)		257.(9092.)		0.(0.)	293.(10341.)
	M:	3.(96.)		15.(543.)		0.(0.)	18.(639.)
WATSON LAKE	S:	5003.(176686.)		30030.(1060485.)		2.(85.)	35035.(1237257.)
	M:	837.(29551.)		2143.(75689.)		13.(444.)	2993.(105684.)
TOTAL	S:	5039.(177935.)		30287.(1069577.)		2.(85.)	35328.(1247598.)
	M:	840.(29647.)		2159.(76232.)		13.(444.)	3011.(106323.)

Table 2. Forest resources volume summary by management units for subarea 1.

RESOURCES MANAGEMENT AREAS IN THOUSANDS OF HECTARES /THOUSANDS OF ACRES/

TYPE	DAWSON	MAYO	BEAVER CREEK	CARMACKS	FARO	MAINES JUNCTION	LAKEBGE	TAGISH	TESLIN	WATSON LAKE	*TOTAL*
SOFTWOOD=	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.5	50.1	31.8
ALLUVIAL	0.0 /	3.4 /	0.0 /	0.0 /	0.0 /	0.0 /	0.0 /	0.0 /	0.7 /	74.4 /	78.5 /
SOFTWOOD=	0.0	53.6	0.0	2.1	0.0	3.3	0.0	0.0	8.5	574.3	641.8
UPLAND	0.0 /	132.4 /	0.0 /	5.2 /	0.0 /	8.2 /	0.0 /	0.0 /	21.0 /	1419.2 /	1585.9 /
HARDWOOD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
	0.0 /	0.0 /	0.0 /	0.0 /	0.0 /	0.0 /	0.0 /	0.0 /	0.0 /	0.3 /	0.3 /
PRODUCTIVE	0.0	55.0	0.0	2.1	0.0	3.3	0.0	0.0	8.8	644.6	673.7
AREA	0.0 /	135.8 /	0.0 /	5.2 /	0.0 /	8.2 /	0.0 /	0.0 /	21.7 /	1493.9 /	1664.8 /
BURNS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	91.7	99.4
	0.0 /	0.0 /	0.0 /	0.0 /	0.0 /	0.0 /	0.0 /	0.0 /	19.2 /	226.5 /	245.8 /
WATER	0.2	4.4	0.0	0.0	0.0	2.0	0.0	0.0	1.0	14.1	21.6
	0.5 /	10.9 /	0.0 /	0.0 /	0.0 /	4.8 /	0.0 /	0.0 /	2.4 /	34.8 /	53.4 /
OTHER	491.2	400.8	0.0	154.2	0.0	87.3	0.0	0.0	252.5	559.7	1945.4
	1213.2 /	990.3 /	0.0 /	381.0 /	0.0 /	215.7 /	0.0 /	0.0 /	623.9 /	1383.0 /	4807.1 /
TOTAL	491.2	460.1	0.0	156.3	0.0	92.6	0.0	0.0	270.0	1270.2	2740.2
	1213.7 /	1137.0 /	0.0 /	386.2 /	0.0 /	228.7 /	0.0 /	0.0 /	667.2 /	3158.2 /	6777.9 /

NORTHERN AREA (THOUSANDS OF HECTARES)= 8572.876

Table 3. Forest resources area summary by management units for all 4 subareas.

RESOURCES MANAGEMENT AREAS		VOLUME IN THOUSANDS OF CUBIC METRES (THOUSANDS OF CUBIC FEET)							
		SOFTWOOD-ALUVIAL		SOFTWOOD-UPLAND		HARDWOOD		*TOTAL*	
DAWSON	S:	0.(	0.):	0.(	0.):	0.(	0.):	0.(	0.):
	M:	0.(	0.):	0.(	0.):	0.(	0.):	0.(	0.):
MAYO	S:	157.(	5548.):	1245.(	43960.):	0.(	0.):	1402.(	49508.):
	M:	50.(	1760.):	735.(	25970.):	0.(	0.):	785.(	27729.):
BEAVER CREEK	S:	0.(	0.):	0.(	0.):	0.(	0.):	0.(	0.):
	M:	0.(	0.):	0.(	0.):	0.(	0.):	0.(	0.):
CANMACKS	S:	0.(	0.):	54.(	1890.):	0.(	0.):	54.(	1890.):
	M:	0.(	0.):	18.(	651.):	0.(	0.):	18.(	651.):
FARO	S:	0.(	0.):	0.(	0.):	0.(	0.):	0.(	0.):
	M:	0.(	0.):	0.(	0.):	0.(	0.):	0.(	0.):
HAINES JUNCTION	S:	0.(	0.):	94.(	3318.):	0.(	0.):	94.(	3318.):
	M:	0.(	0.):	18.(	618.):	0.(	0.):	18.(	618.):
LAKEHOE	S:	0.(	0.):	0.(	0.):	0.(	0.):	0.(	0.):
	M:	0.(	0.):	0.(	0.):	0.(	0.):	0.(	0.):
TAGISH	S:	0.(	0.):	0.(	0.):	0.(	0.):	0.(	0.):
	M:	0.(	0.):	0.(	0.):	0.(	0.):	0.(	0.):
TESLIN	S:	55.(	1249.):	257.(	9092.):	0.(	0.):	293.(	10341.):
	M:	3.(	96.):	15.(	545.):	0.(	0.):	18.(	659.):
WATSON LAKE	S:	5003.(	176683.):	31029.(	1096464.):	2.(	85.):	35934.(	1273232.):
	M:	837.(	29551.):	2143.(	75687.):	13.(	444.):	2993.(	105682.):
TOTAL	S:	5196.(	183480.):	31679.(	1119723.):	2.(	85.):	36877.(	1302289.):
	M:	889.(	31406.):	2930.(	103468.):	13.(	444.):	3832.(	135519.):

Table 4. Forest resources volume summary by management units for all 4 subareas.

Figure 5. Graphic map output of subarea No. 1.

the digital display map of each subarea showing the major classification of each cell (Figure 5), and printing the 10 summary tables. The majority of time was actually consumed in keying in the four subarea X, Y coordinates and the printing of the outputs.

At the moment, the application of this system is as follows:

(1) To provide annual up-to-date forestry statistics for the Yukon Territory for reporting by Statistics Canada (Lee 1977).

(2) To find out quickly where, what and how much current forestry resources exist in any locality at any time in the Yukon Territory, using the subarea retrieving process.

(3) To assist in finding out how large an area is required to sustain a certain forestry industrial development or a sustained yield unit, using the subarea retrieving process.

(4) To retrieve information quickly through a computer terminal for deciding whether a certain forest fire in a certain locality is worth fighting, using the fire suppression priority zone.

(5) To retrieve fire rating information quickly through a computer terminal.

GRAPHICS SUBSYSTEM

The graphics subsystem is capable of producing color images. In order to minimize the costs of producing such images, available facilities such as pen plotters and video outputs were evaluated. The facilities chosen related directly to LANDSAT image analysis systems and their associated input/

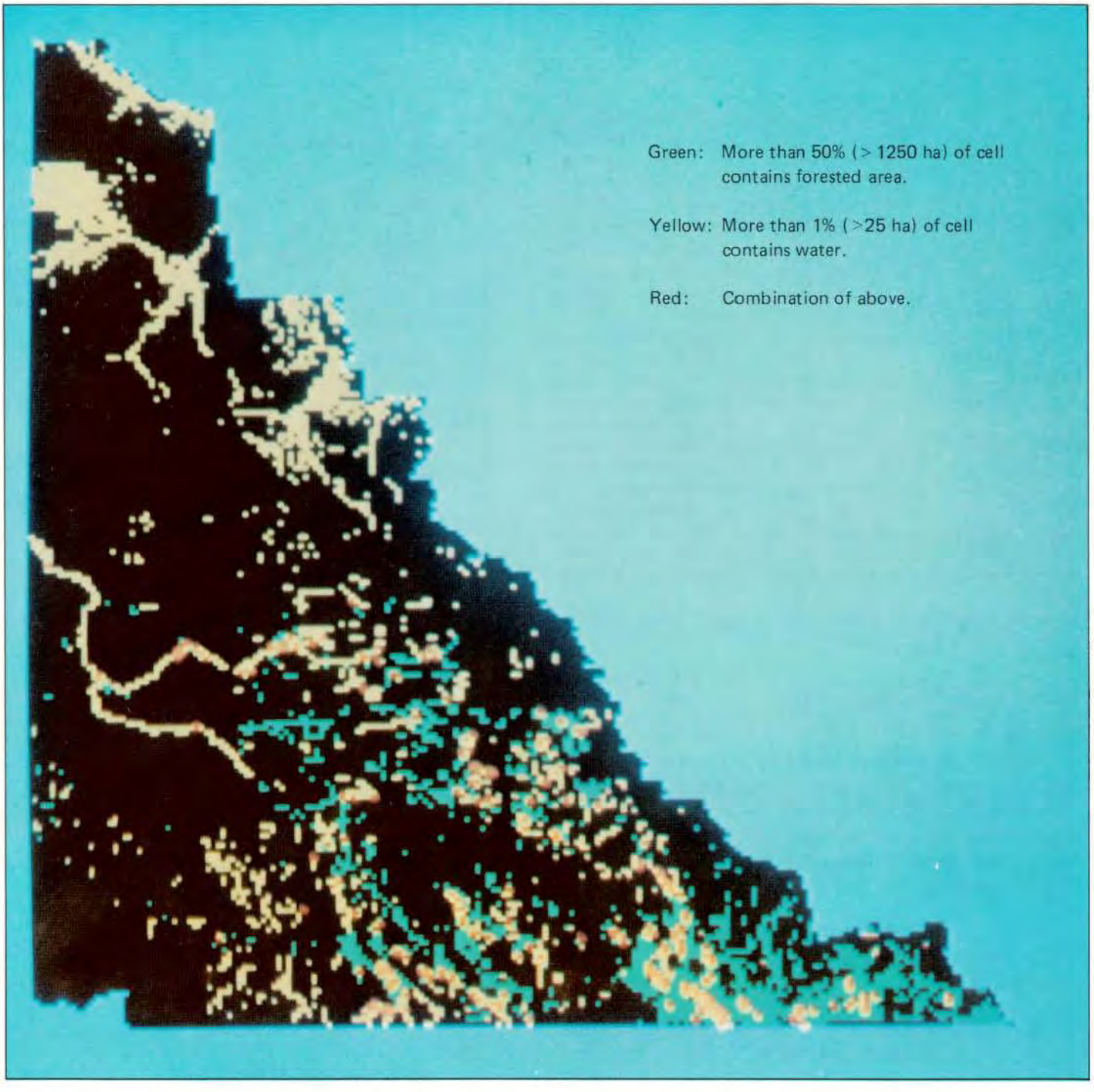

Figure 6. A graphic image of the Yukon Territory showing distribution of water and forest land.

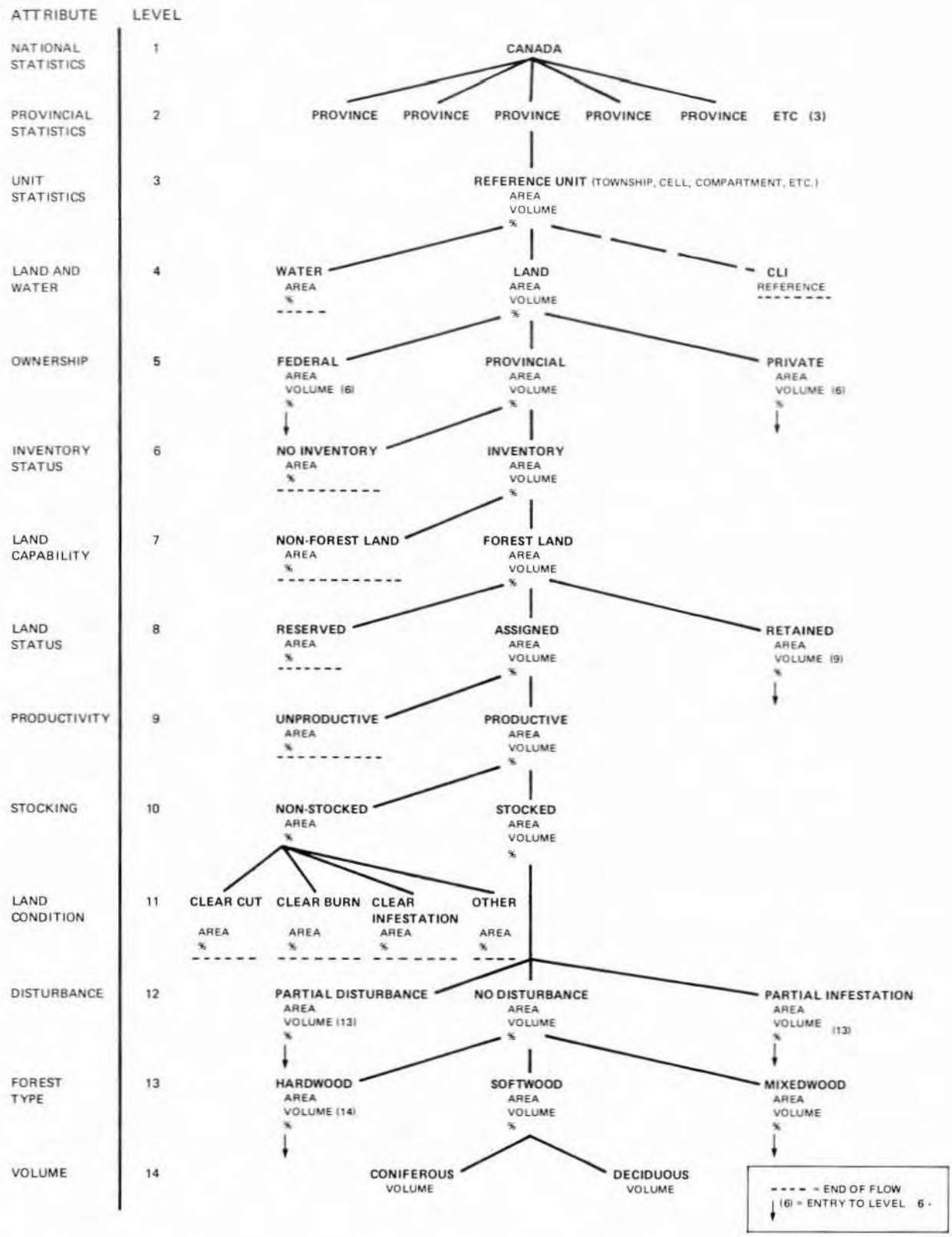

Figure 7. Proposed Canadian Forest Resource Data System.

output mediums. That is, in order to create a color image, Yukon RRAMS must output data in a Computer Compatible Tape format. This tape is then processed on a separate LANDSAT analysis system for image generation or on a film strip recorder. Costs of this process can be as low as $3 per image, not including minicomputer time.

Figure 6 shows a sample output map using this subsystem. It is anticipated that this compatibility with LANDSAT techniques will lead to the generation and updating of additional active data files (ADF's) using LANDSAT data.

FUTURE WORK

Yukon RRAMS is the vehicle used to store, retrieve and report on forest statistics for the Yukon Territory. The system organizes and contributes data to the National Forestry Data Program and assists in fulfilling the Canadian Forestry Service mandate in national forestry affairs.

At present, this system has demonstrated that broad resource information for the entire Yukon Territory can be retrieved almost instantly. The modular structure of the system makes it easy to add or subtract routines without affecting the entire operation. A subroutine will be added to the system in 1979 to output Yukon forestry statistics conforming with the proposed Canadian Forest Resource Data System (Figure 7). With facility for updating data on changing management activities, it is no longer a difficult task to monitor annual cut and burned-over areas, volume growth and depletion of the forest in the Territory.

Future work on remote sensing, through photo interpretation of aerial photos and LANDSAT imagery and multispectral analysis of LANDSAT digital tapes, is the major technical approach (Lee 1974, 1975, 1976) for gathering information on burned-over and cut-over areas, and regeneration for updating purposes. A forest fire history data file is being set up to monitor yearly burned-over areas and volume summary since 1968 to provide historical fire records for the Yukon Territory. A regeneration data file will also be set up to monitor regeneration conditions of areas burned or cut for updating productive forest land.

REFERENCES

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Canadian Forestry Service
Pacific Forest Research Centre
506 West Burnside Road
Victoria, B.C. V8Z 1M5

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