

(NASA-CR-127811) NATURAL RESOURCE N72-29296  
INFORMATION SYSTEM. VOLUME 2: SYSTEM  
OPERATING PROCEDURES AND INSTRUCTIONS  
Final Report (Boeing Co., Seattle, Wash.) Unclas  
Apr. 1972 57 p CSCL 08G H2/13 36767

## ACKNOWLEDGEMENTS

## NATURAL RESOURCE INFORMATION SYSTEM

This was developed as a result of the combined efforts of the technical monitors of BIA and BLM, the environmental sciences staff of the Aerospace Group of The Boeing Company, graduate students from the University of Washington, and the Systems and Operations Research staff of Boeing Computer Services, Inc.

In the execution of Volume II we are indebted to Fred Kernbach, Steve Scott and Charlotte Walsh for their intelligent and tireless team work in constructing the software and data base.

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## 1.0 INTRODUCTION AND SUMMARY

### 1.1 Introduction

Volume II of the final reports on Bureau of Indian Affairs contract No. K 51C14200459 covers System Operating Procedures and Instructions, and is keyed primarily to computer and programming staffs. Volume I is keyed primarily to BIA and BLM land use planning staffs.

This volume provides a total computer software system description, covering the items set out in the table of contents. Used in conjunction with Volume I, the reader will have full coverage of the work accomplished.

### 1.2 Summary of Required System Features

Task 2.1 of the contract specified the following system features:

- a) Simple file design allowing ease of data entry and recall, as well as ease of updating the files as new information becomes available.
- b) Programming language compatible with existing BIA/BLM facilities (FORTRAN and/or COBOL).
- c) Use of UTM system for geographic grid location with provision for acceptance and conversion of data in State Plane Coordinate and United States Public Land Survey systems.
- d) Provision for variable size areal elements to allow flexibility in tabular and graphic output.
- e) Provision for inputting data on variable size areal elements to accommodate coarse analysis of large areas or detailed analysis of small areas.
- f) Tabular and graphic output of analyzed data keyed to the geographic grid system.
- g) Ability to list a library description and give the physical location of all data pertinent to the area.
- h) Provision to accommodate growth of files as new data needs or capabilities are identified in the future.
- i) Adaptability to various classes of terrain that exist in different parts of the nation.

The system was designed and the software constructed so as to meet these requirements. Although not specifically required in items d) and e) above, a polygon approach to "variable size areal elements" was selected "to accommodate coarse analysis of large areas or detailed analysis of small areas" rather than a cellular approach. This was done because the polygon method was considered more economical to operate for the same level of informational accuracy, and also is capable of higher levels of precision wherever this is desired. The software developed under this contract is capable of transforming a "polygon" data base to a "cellular" data base. A cellular data base can also be transformed to a polygon data base providing every cell has only one level of an attribute.

During this contract Reference 9 was available and the experience gained in PIOS (Polygon Information Overlay System) was considered in the development of some of the required software. Improved techniques and in some cases different techniques were possible and some problems could be avoided or solved.

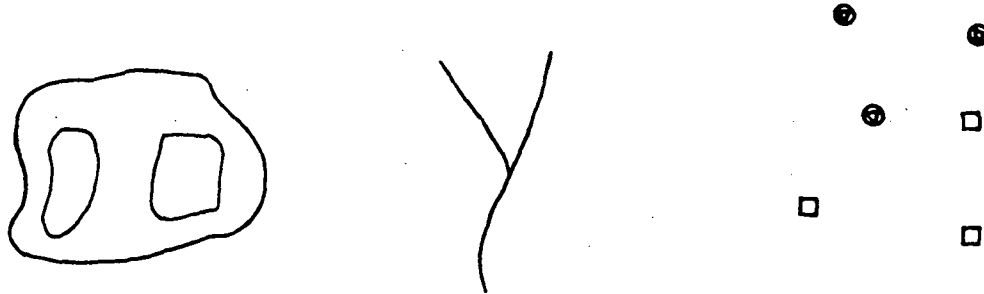
The approach to file design requirement a) above is provided in Volume I, Section 3.4 File Design and Volume II, Section 2.3 Computer File Design. Updating is performed by the EDITOR module. The scientific nature of the software dictated using FORTRAN IV Version III programming language, and the size of the programming modules dictates a medium-to-large computer for efficiency of operation (CDC or IBM). Data may be input in geographic or UTM coordinates, but geographic coordinates are converted to UTM before creating the data files. Other transformations can be accepted by the software system, in accordance with requirement c). Volume I, Section 3.5 Input Requirements covers this fully. Requirement f) is met since all graphic output (derived map overlays) contain the UTM grid at any desired spacing. Tabular output is keyed to annotated polygon numbers on the output overlays. Attribute data may be optionally printed in the polygons, or next to the linear and point features. Requirement g) is met by the ability to list for any specified geographic area all data available for the area, its origin, and date of origin. This requirement is covered in Volume II, Sections 2.1 and 2.2.5.

Growth requirements h) are entirely up to the users, and are only limited by the amount of resources devoted to storage of data. Adaptability requirements i) can be readily met as long as the type of information desired to be utilized can be converted to overlays representing this information as polygonal, linear or point features with associated tabular attribute data.

### 1.3 Summary of Computer System Capabilities

The Natural Resources Information System was designed to be adaptable to a wide variety of applications. The user controls the type of data that is stored, retrieved, processed or displayed. An overall flow chart of the system is shown in Figure 1.1. A diagram of the overlay structure is given in Figure 1.2. The following list summarizes the system capabilities available to the user:

- Digitize geographic feature data from maps, including polygons, linear features, or points. Polygons may contain inner holes not part of the outer area with no connection necessary between inner and outer areas.



- Digitized data may be plotted with an exploded view option. This means that successive map features may be shifted by some user specified distance so that map feature boundaries may be checked for completeness.
- Input map reference points in latitude and longitude so that map features may be located precisely within any overall mapping system.
- Convert reference points and digitizer coordinates to Universal Transverse Mercator values, so that every map feature is expressed in UTM coordinates on the data file for subsequent processing and output.
- Eliminate unnecessary points from map feature data based on a user specified chord height tolerance. Figure 1.3 explains this weeding capability.

- Create land management data records that contain map feature data, identifiers, and attributes from the weeded digitized data and input cards. Refer to Section 2.3 for a definition of record structure.
- Add or modify attribute data in data records. This is done by card input only.
- Create data files with any number of related data records.
- Add, replace, or delete map feature data on existing data files. This may be done by redigitizing the updated map features, or by card input. Section 2.4 covers file update methods.
- List data records from existing data files.
- Intersect two data files and write resultant records on a new file. See Figure 1.4.
- Perform a complement or "not" operation with two data files and write output records on a new file. See Figure 1.4.
- Perform union operation on one or two data files and write output records on a new file. See Figure 1.4.
- Sort and/or copy data files by identifiers or attributes. This allows the user to extract that subset of the data file of interest to him.
- Inventory data files or subsets thereof by record identifier or by attribute number.
- Set area and linear tolerances for interaction of data files. This is necessary since input maps can be of differing scales.
- Plot data files or parts of data files at a user specified scale.
- Provide grid marks, for showing relationship to base maps. Spacing of grid marks must be specified by user.
- Provide sheet labels, or map feature labels on the plot sheet, either from a user specified input, or obtained from the attribute data.
- Summarize map feature data from a data file, including computing areas and perimeters and listing descriptive properties.

- Compare map feature data from two files and print computed values of one file as a percentage of the values on the second file.
- Write fire and timber data files and produce the annual timber report.

Because of the modular nature of the software construction, additional features can be added without affecting the existing programs.

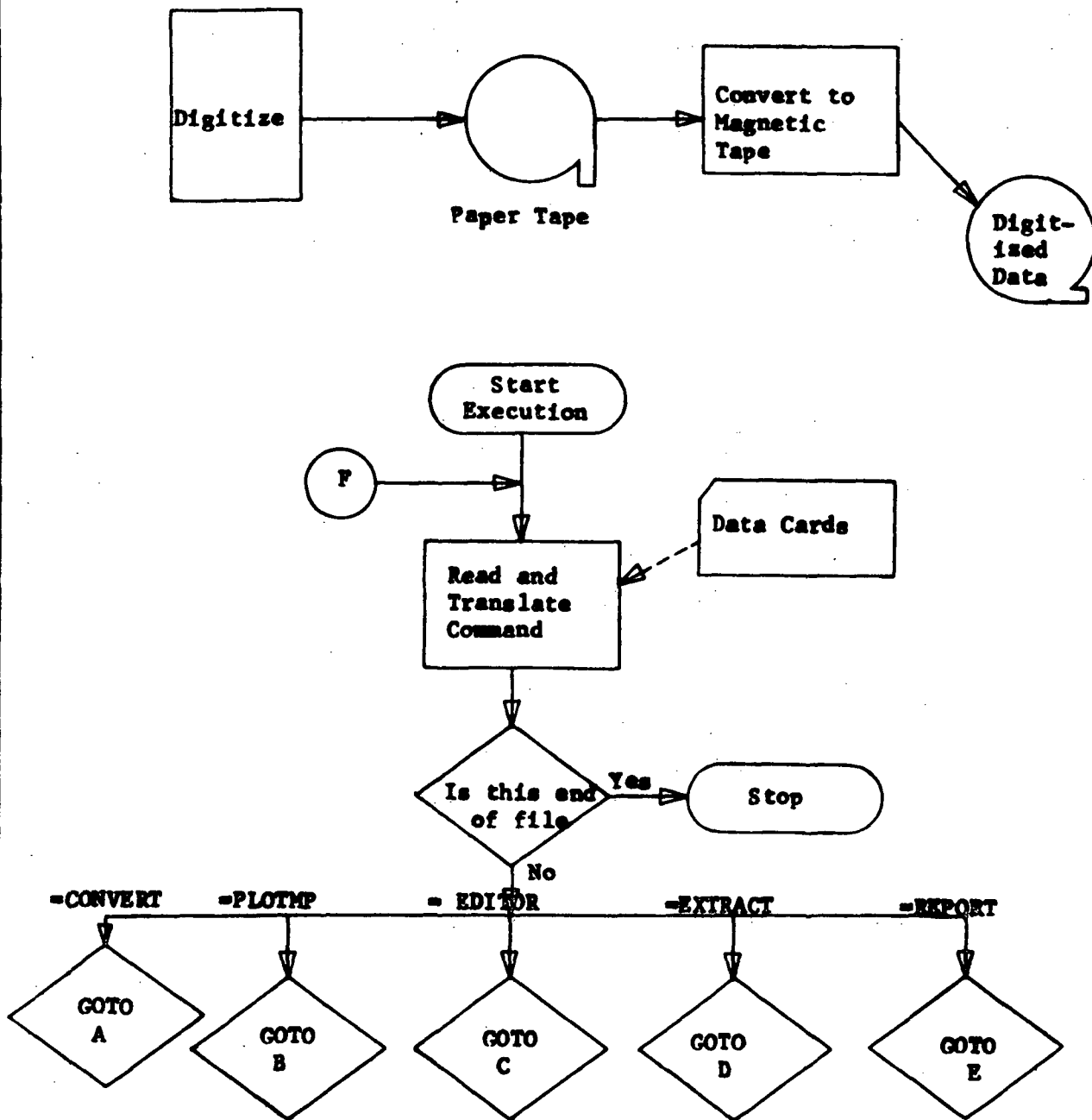
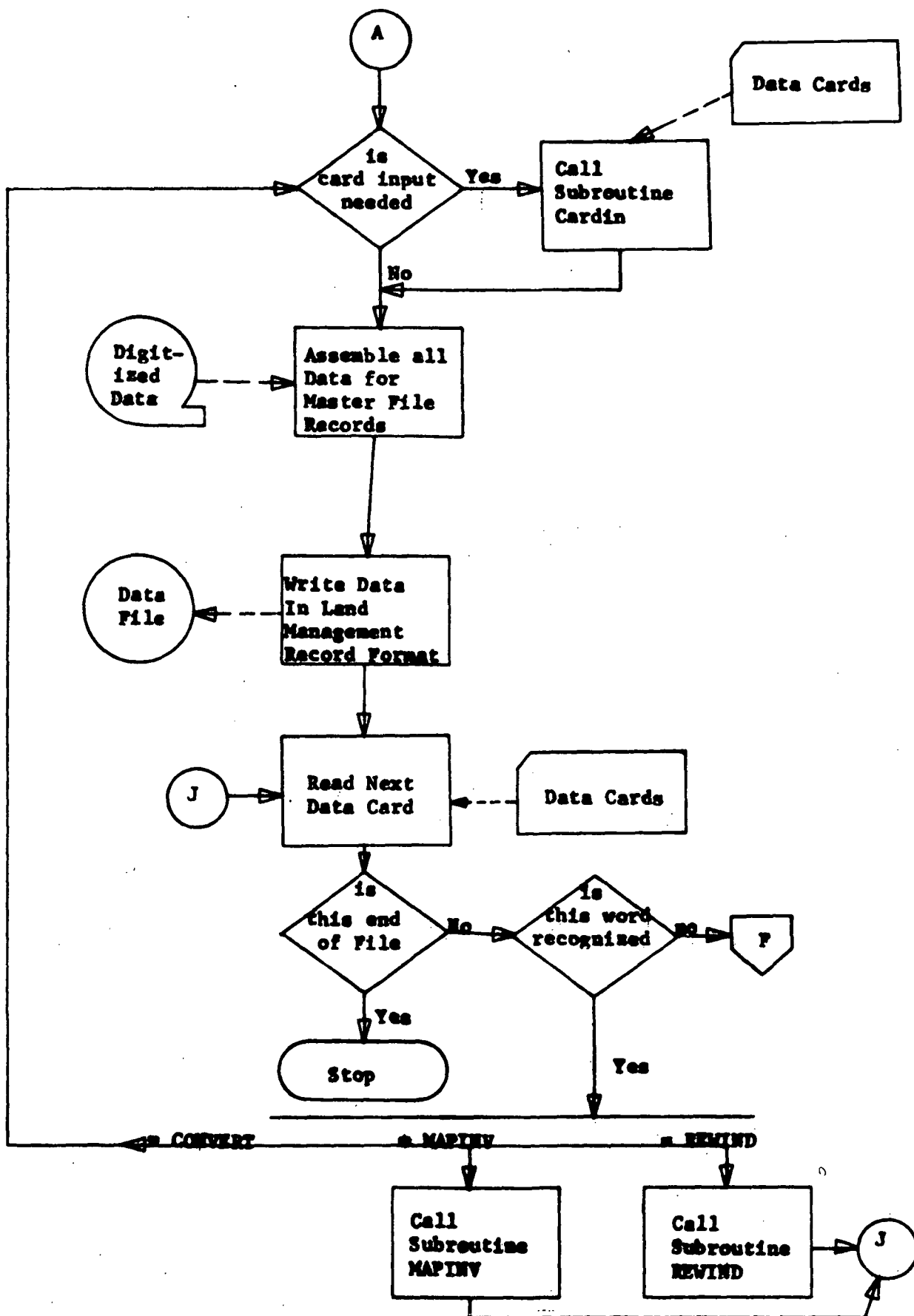
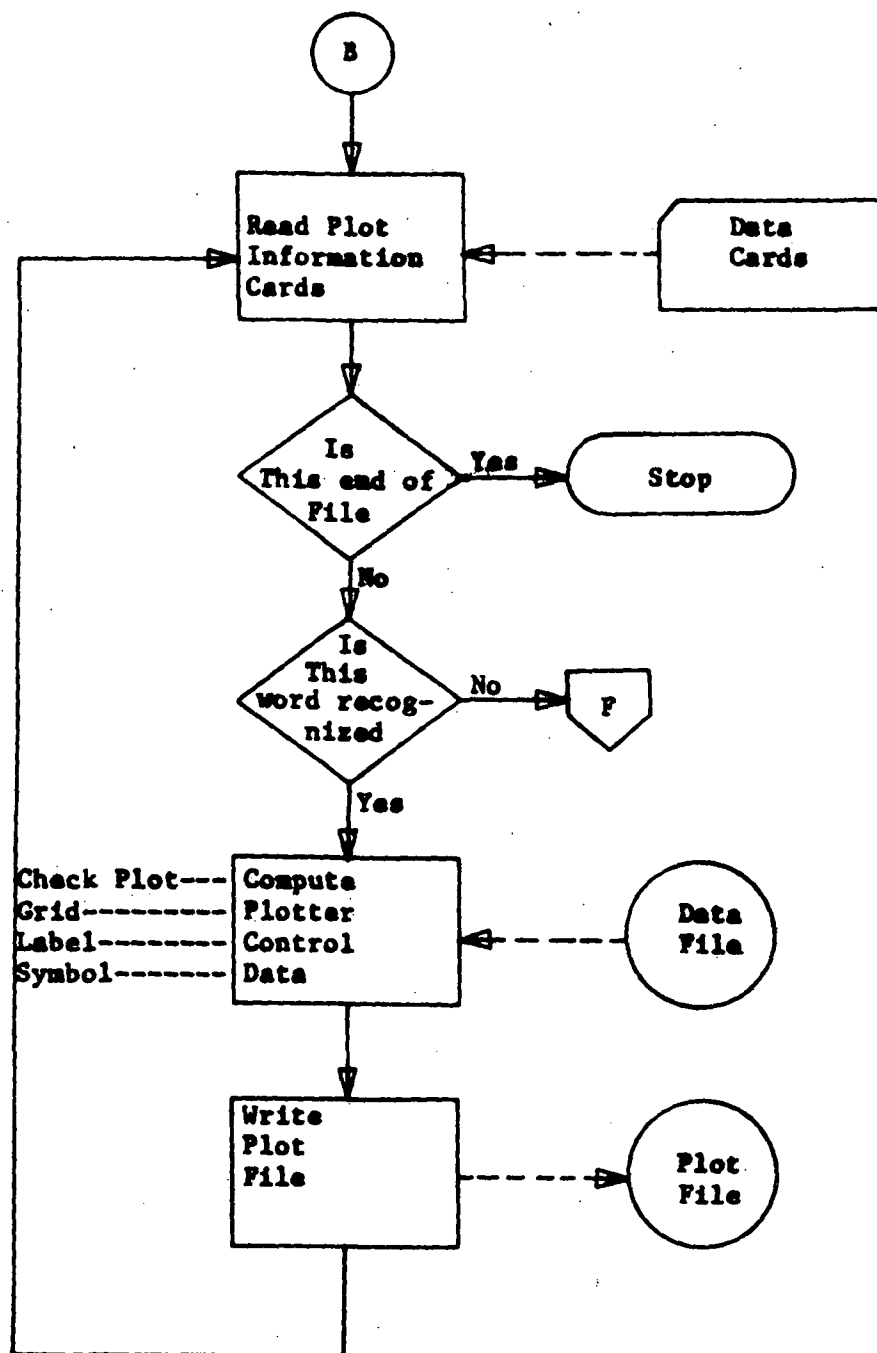
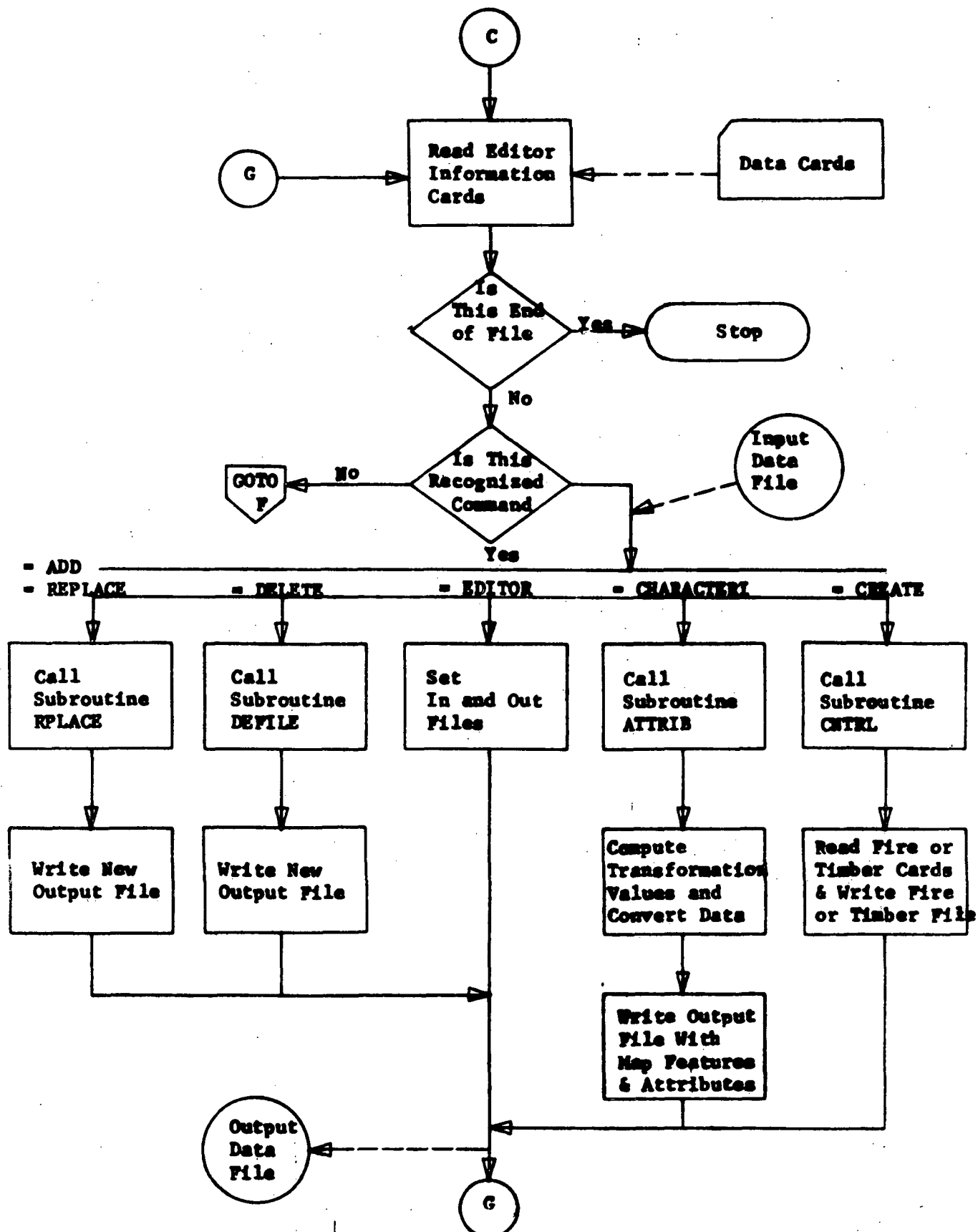
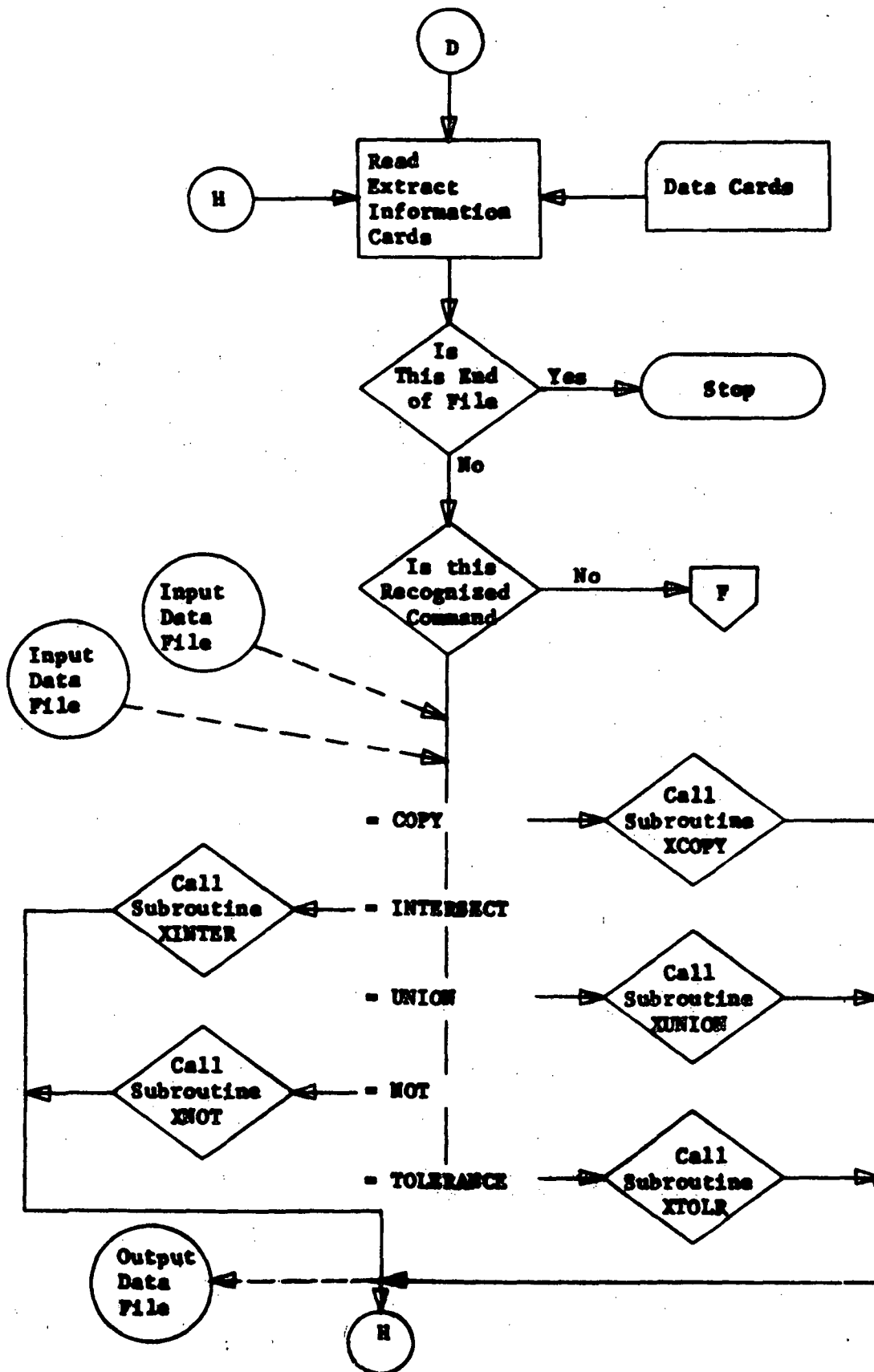


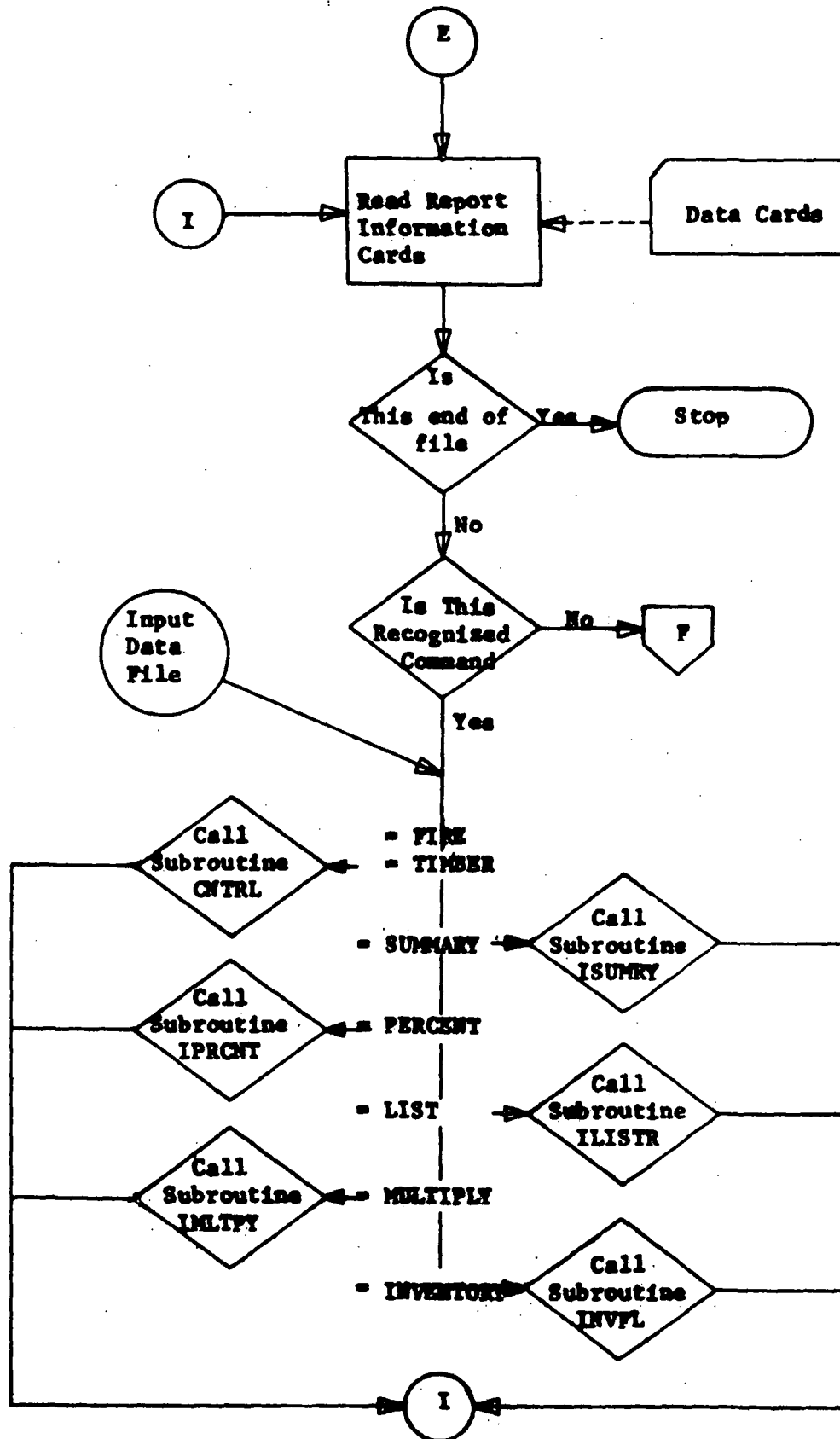
Figure 1.1

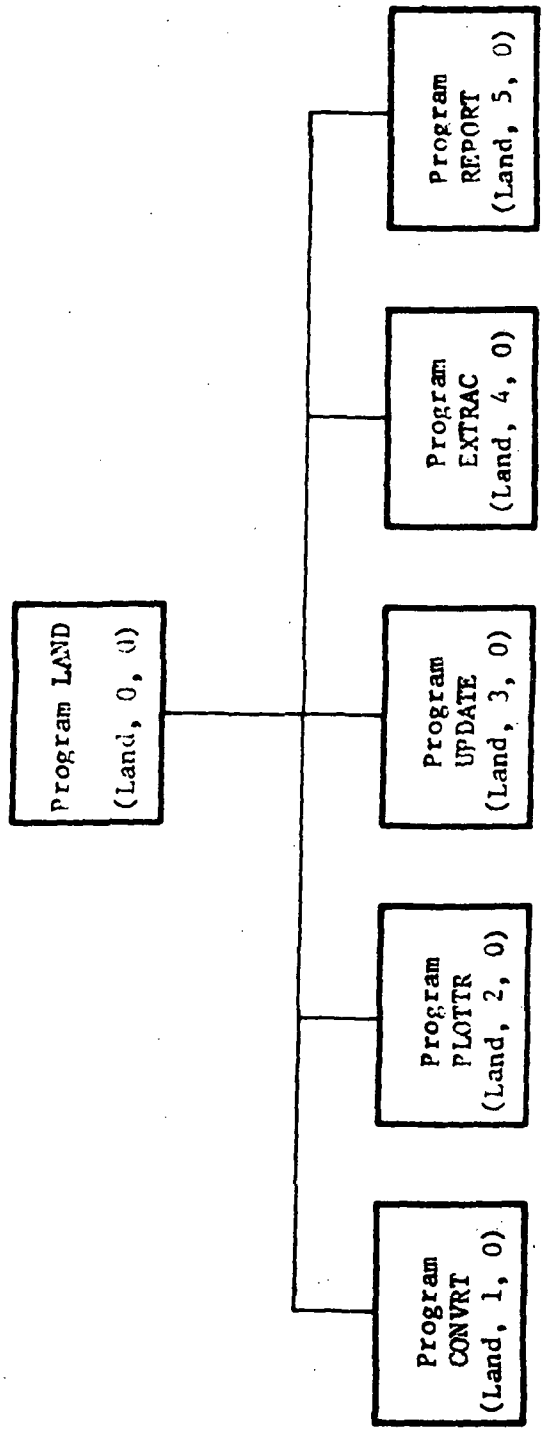






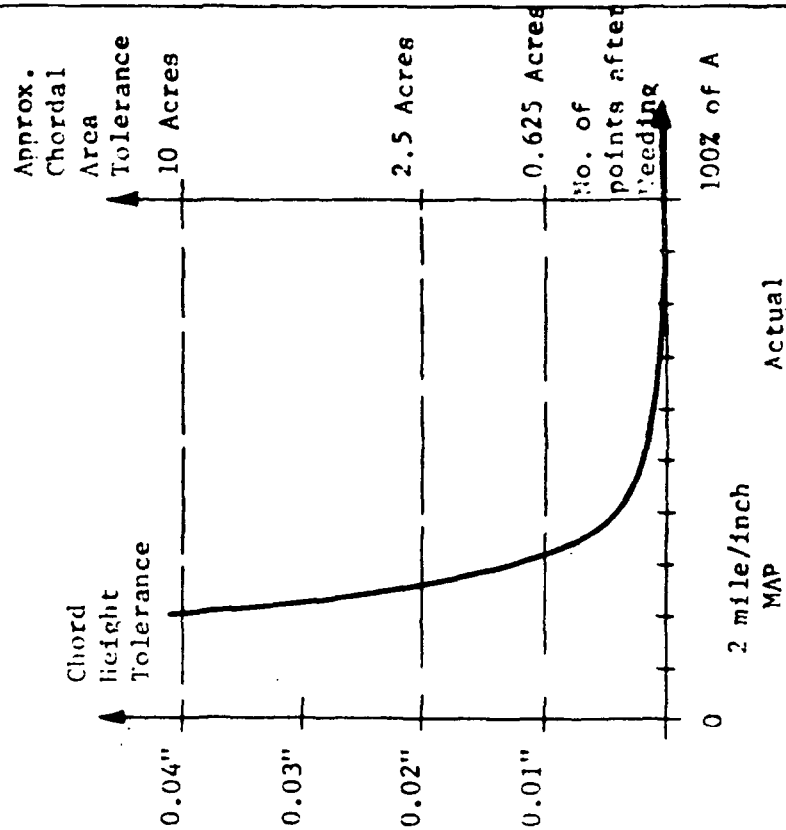
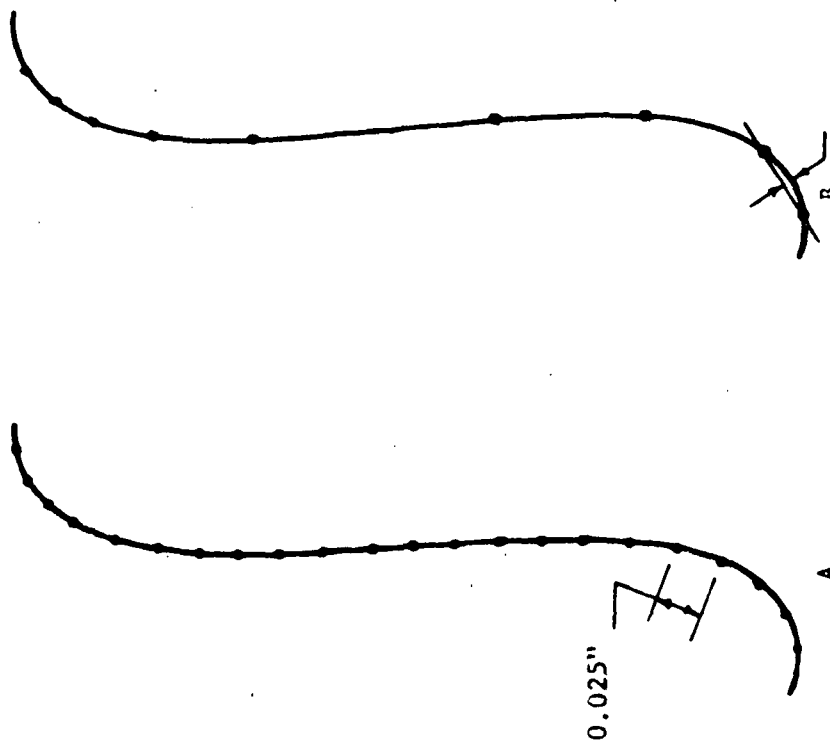






Program CONVRT

Figure 1.2 Overlay Structure



Actual

Chord Height Tolerance = 0.038"

400 ft.

Chordal Area - - - - - &lt; 10 Acres

Reducing CHT Requires more points to be retained.

Most Processing was done with CHT = 0.009"

Figure 1.3 WEEDING PROCESS. The original line can be digitized according to 3 options: - (1) Evenly spaced points (2) Area tolerance, (3) Angular tolerance, where the latter options perform selective weeding by the digitized software. Line (A) shows option (1) with spacing at the most commonly used value. Further weeding is done by software in the file building process to reduce the number of points to be stored. This process uses a chord height tolerance method which also guarantees area tolerance requirements (B).

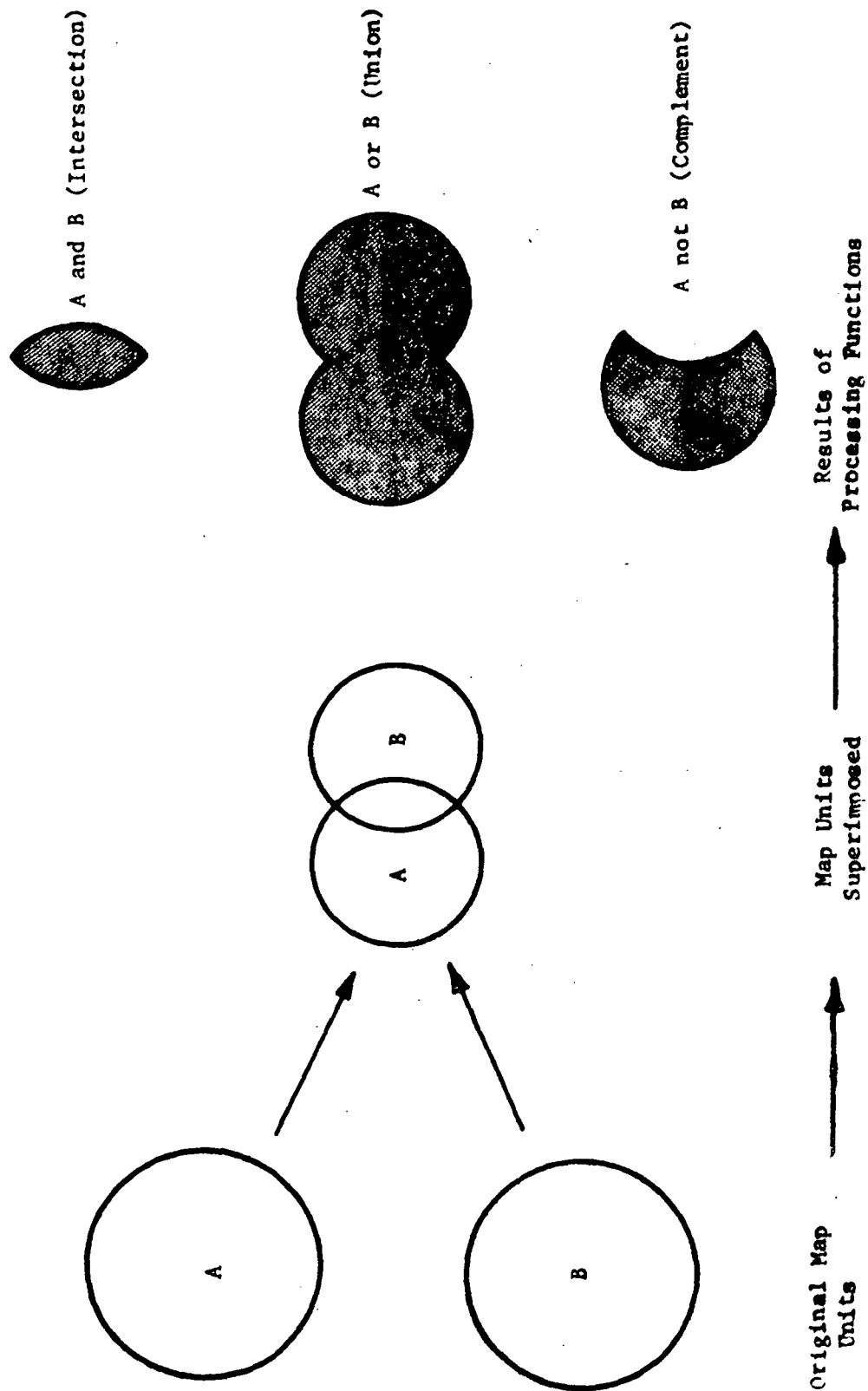


Figure 1.4 Basic Map Unit Processing Functions

## 2. COMPUTER PROGRAM DESCRIPTION

### 2.1 General Discussion

One of the main purposes of the Natural Resources Information System is to define geographic data in forms that can be processed and combined with other data. To allow for a wide variety of applications, geographic data can be defined in three forms: bounded areas, points connected by lines and discrete points. Bounded areas (or polygons) are defined by their vertices which are automatically ordered in a clockwise direction. These polygons may wholly contain other bounded areas which have no common boundaries with the outer region. Inner areas can be distinguished from the outer area because their vertices are automatically ordered in a counter clockwise direction. An outer region including its sub-regions, if any, is defined as one polygon set.

In addition to the geographic data defining the map feature, the data record may contain numeric or descriptive attributes for each map feature. This allows data files to be sorted by feature identifiers or by attribute numbers, as well as by geographic location. This means that land managers have the capability to scan files for data records containing certain attributes or groups of attributes. These records may be copied onto other data files and plotted or listed in detail on printed output. For example, from a timber map data file all the map features can be located that contain a certain species growing to a given height at maturity. From a soils type data file all those areas can be located that have a critical erosion hazard.

Another more powerful capability of the Natural Resources Information System is the ability to overlay map feature data from two or more data files. Polygon sets of one data file are compared with the sets from another; the comparison by set is more efficient than handling inner and outer areas separately. Selected data files or parts of files may be intersected to produce a new group of map features containing only those areas that are present on both files. New polygon sets are created in this process that contain attributes common to both data records. In this manner, for example, land managers could locate timber of a certain type that is growing on land with a specified slope condition, and obtain the acreage of these areas. In addition, linear features or discrete point data that is contained within polygon sets can be identified, lengths calculated or points counted.

Data files may also be combined to produce results that are a union of map feature data from both files. In this way polygon sets with common boundaries can be combined into

larger polygons with the common boundaries removed.

Data files may be compared in a third way which will result in a file containing only those parts of map features of the first file that are not present on the second file. This process could, for example, produce data records showing land areas classified as poor range lying outside of any grazing system.

The basic system capability for data file creation and manipulation is accompanied by system subroutines that can produce plots or printed output from permanent or temporary data files. Intermediate results as well as final results of file manipulations can be plotted or printed at the option of the land manager. A wide variety of plot and print options are also available to the user in order that diverse data can be displayed in the most effective way.

## 2.2 Program Modules

### 2.2.1 Main Program

The Natural Resources Information System is written entirely in Fortran IV and is operational on the CDC 6600. The program utilizes the overlay capability of the 6600. It consists of a small control program with the five programming functions CONVERT, EDITOR, PLOTMP, EXTRACT and REPORT located in primary overlay modules. The program requires no more than 110 K core for execution.

Program execution is controlled by data card instructions read by the control program. The function of the control program is to transfer to the appropriate overlay as determined by the data card instruction. Each overlay continues reading and processing instructions until either reaching the end of the input stream or reading an unknown directive. In the first case the program stops execution, in the second it returns to the control program for appropriate transfer action.

### 2.2.2 CONVERT Module

The purpose of the CONVERT portion of the system is to read the magnetic tape containing the digitized map features and write a data file using the standard land management record format. Alternately, this program can create a file from data card input. This file is considered an intermediate file because it contains no numeric or descriptive attributes; but, since it is written in the standard format, it can be read or printed by any of the basic input/output subroutines. After this file is created, it is useful to plot and list the data so that it may be checked for accuracy with the original map. Any map features with incorrect identifiers or erroneous data may either be redigitized, or input via data cards, or modified utilizing the other program processes such as edit, intersect, union, etc.

### 2.2.3 PLOTMP Module

The PLOTMP portion of the system reads data files and writes output files that can be plotted on the CALCOMP 763 drum plotter. The program will optionally write plot files for entire data files or parts of data files as specified by map identifiers, unit identifiers or property numbers. This program will scale the data as specified and optionally label plots and/or individual map features. Point data may be plotted using a symbol as defined by the user. Grid marks may be produced for a plot if desired. This program is necessary for assuring the correlation of the basic data files with original map data. It is also essential in order to view the results output from the routines that create new data files from the interaction of existing files.

#### 2.2.4 EDITOR Module

The purpose of the EDITOR program is to modify data files and write the new data on another file. This module is necessary to add desired attributes to map feature data on intermediate files that are output from the CONVERT program. These attributes are input to the program on data cards. In addition, specific units can be deleted or added to a file or replaced on a file from another file. As part of this file creation process, the map feature coordinate points are converted from the local digitizer coordinate system (inches) to Universal Transverse Mercator coordinates (meters). This is done by using the map reference points which are given both in latitude and longitude and digitizer coordinates. These reference points continue to be part of the data record so that it is possible to convert the data values to other coordinate systems. This program also contains routines which read fire and timber data cards and write data files that contain records of fire reports and timber cutting activity.

#### 2.2.5 EXTRACT Module

The EXTRACT program can sort data files and produce new data files by copying specified parts of existing data files as determined by map identifiers, unit identifiers or attribute numbers. In addition, new data files can be produced by the intersection of two files or by the union of one or two files. Another available program option using two files produces an output file that contains those portions of the first file that are not present on the second file. These operations can be performed with files containing map features that are point or linear data as well as polygon data.

#### 2.2.6 REPORT Module

The REPORT program provides descriptive printouts of information from data files. Data files can be listed in their entirety or partially by specifying map identifiers, unit identifiers or property numbers. Polygon area and perimeter and linear feature length are calculated and included in the listed output. Two input files may be specified, and units with the same map and unit identifiers will be compared. This is useful in the case of new data files created by interaction of several data files. The new units may then be compared to the original units, and the calculated values are given in the percentage of new value to old value.

This portion of the program also contains the subroutines which read the fire report file and the timber file and produce the annual timber report. The program will also inventory a data file, listing record number, number of words in record, data type, unit identifier, date entered and map identifier.

Another inventory option is to list data records based on a specified property number. This printout will give unit and map identifier, and all lower level property numbers with their alphanumeric character strings.

### 2.3 Computer File Design

The standard land management data record was designed to be a variable length binary record because of the volume of data and the diversity of types of data needed in the land management decision making process. All data files contain records in this standard format so that all program modules can use the same input/output subroutines. Data files may contain any number of standard data records.

Standard data records may contain one of several varieties of map feature data. Bounded areas or polygons are defined by their vertices and may wholly contain inner regions or holes that are not part of the outer area. Other geographic data may be linear features or points. The data record may also contain the original map reference points that are given in longitude and latitude and corresponding drawing reference coordinate values.

The data record may also contain a variable number of attributes that pertain to the map feature. Each attribute has a unique identifying number. These attributes or properties may have a numeric value or be alphanumeric character strings. Numeric values may be based on area or length of the map feature. In this case these values will change proportionally with changes in area or length. Other numeric values may be identified as not being so dependent and, therefore, these values will be preserved intact.

The data record always contains a map identifier, a unit identifier and a digitizing date or date entered into the system.

Attributes or properties may have a numeric value stored in the real array or be an alphanumeric character string stored in the alpha array. For each attribute the integer array contains a four word block: the property number, the higher level property number, the number of characters in the alphanumeric string, and the character location of the first character within the alphanumeric property block. For a numeric property the third value is equal to zero and the fourth value is equal to one for a constant property value or minus one for a property value dependent on area or length.

The contents of the data record are grouped by integers, decimal data and alphanumerics to facilitate ease of input/output and conversion to another computer. The record contains integer word counters so that input/output can be accomplished with FORTRAN statements. There is an alphanumeric header word to identify the record. There is a trailing word that is the integer sum of all words excluding itself which can be used for input/output error checking.

The record may be diagrammed as follows:

| RECORD |                | DESCRIPTION                              |
|--------|----------------|------------------------------------------|
| HEADER | -              | Record Header ('LMDR')                   |
| NWORDS | -              | Number Words in Record                   |
| NWCA   | -              | Number Words in Counter Array            |
| NWIA   | -              | Number Words in Integer Array            |
| NWRA   | -              | Number Words in Real Array               |
| NWAA   | -              | Number Words in Alphanumeric Array       |
| .      | NWCA<br>NWORDS | Counter Array, NWCA words in length      |
| .      |                |                                          |
| .      |                |                                          |
| .      | NWIA<br>NWORDS | Integer Array, NWIA words in length      |
| .      |                |                                          |
| .      |                |                                          |
| .      | NWRA<br>NWORDS | Real Array, NWRA words in length         |
| .      |                |                                          |
| .      |                |                                          |
| .      | NWAA<br>NWORDS | Alphanumeric Array, NWAA words in length |
| .      |                |                                          |
| .      |                |                                          |
| CHECK  |                | Checksum Value                           |

The counters array is an integer array designed to identify and locate sub-blocks of data within the other three arrays. The first three words of the counters array are the integer number of counter words for each of the other arrays. For each sub-block of data within the integer, the real, and the alpha array; the counter array contains the number of counter words, the number of words in the sub-block and the type of data. The counters array, therefore, can be used to locate a sub-block of any given type in any one of the other arrays. This means that all data may be variable in length and may be stored in any order. In this way it is possible to add new types of data or eliminate old types in any array without changing the basic record structure or any of the input/output subroutines.

The counters array may be diagrammed as follows:

|            |                                                    |
|------------|----------------------------------------------------|
| I1 = IC(1) | number of counters for integer array               |
| I2 = IC(2) | number of counters for real array                  |
| IC(3)      | number of counters for alpha array                 |
| IC(4)      | number of counter words for integer data sub-block |
| IC(5)      | number of integer words in this sub-block          |
| IC(6)      | type of integer data in this sub-block             |
| .          |                                                    |
| IC(4+I1)   | number of counter words for real sub-block         |
| .          | number of real words in this data sub-block        |
| .          | type of real data in this sub block                |
| .          |                                                    |

|             |                                                     |
|-------------|-----------------------------------------------------|
| IC(4+I1+I2) | number of counter words for alpha sub-block of data |
| :           | number of alpha words in this sub-block             |
| :           | type of alpha data in this sub-block                |

## 2.4 File Updating Methods

The map feature data and/or the attributes may be updated or modified in any land management data record.

There are several methods available to update given map features. The new map feature must first be digitized and converted to magnetic tape or input to the system via data cards. This new file may then be input to the EDITOR program with the file that contained the original map feature. The program will write a new data file, replacing the old map feature with the new map feature.

In the case where the new map feature may impact other map features, the file may be updated by utilizing the options available under the EXTRACT program. The original data file may be copied, eliminating the old map feature. This file may then be compared to the file containing the update map feature. A new file may be created containing all parts of the original file that are not part of the update map feature. The update map feature may then be added to the new file. This would result in an updated file containing the new map feature and changes to all other map features that were affected by the new contours.

The EDITOR program also provides a capability for adding attributes to data records or replacing attributes already established within data records. If the input attributes are already present in the record, their values will be changed to the new input values. If input attributes are not present in the record, they will be added to the attributes already present.

## 2.5 Subroutine Library for Natural Resources Information System

| <u>Program</u> | <u>Description</u>                                                       |
|----------------|--------------------------------------------------------------------------|
| ADDATT         | Add attributes to land management data records.                          |
| AANDB          | Find intersection between two map features.                              |
| AINB           | Find line segments of one map feature that lie inside a closed boundary. |
| ANOTB          | Find parts of a map feature that are not part of another map feature.    |
| AONB           | Find segments of a map feature that lie on a closed boundary.            |

| <u>Program</u> | <u>Description</u>                                                                     |
|----------------|----------------------------------------------------------------------------------------|
| AORB           | Find map features that are a combination of two map features.                          |
| AOUTB          | Find line segments of one map feature that lie outside a closed boundary.              |
| AREAL          | Find the area of a polygon.                                                            |
| ATTRIB         | Read cards and set up attributes for adding to land management data records.           |
| CALDRW         | Write a Calcomp plot file for a series of points or alphanumeric characters.           |
| CAND           | Determine array index in buffer.                                                       |
| CARDIN         | Read cards for input of map features via data cards.                                   |
| CHRDHT         | Calculate the chord height tolerance of a circle through three points.                 |
| CHTYPE         | Change data type in counters array.                                                    |
| CIND           | Determine array index in buffer.                                                       |
| CNTRL          | Provide transfer for writing fire or timber report.                                    |
| CLOCK          | Assures that bounded area is closed.                                                   |
| COMSET         | Set plot values.                                                                       |
| COOP           | Available for expansion to intersect point map features with other point map features. |
| DEFILE         | Delete a map feature from a data file.                                                 |
| DIGALP         | Get map identifier character strings.                                                  |
| DIGINP         | Read digitized data, 140 characters at a time.                                         |
| DIGITZ         | Create land management data records from digitized data.                               |
| DIGPLT         | Plot digitized data records.                                                           |
| DIGPTS         | Return the array of points associated with a digitized unit.                           |
| DIGSTR         | Return the next character string of a digitized record.                                |

| <u>Program</u> | <u>Description</u>                                                                                |
|----------------|---------------------------------------------------------------------------------------------------|
| DIGTRN         | Get reference point data from digitized data.                                                     |
| DIRECT         | Ensure vertices of bounded areas are moving in correct direction.                                 |
| DROPSB         | Delete sub block from data record.                                                                |
| DUMP           | List land management data record.                                                                 |
| FINF           | Write an output file containing intersections of map feature data from two files.                 |
| FIRFIL         | Read fire report data cards and write a file containing fire data records.                        |
| FIT            | Assures map feature data is in UTM coordinates.                                                   |
| FNORF          | Find those parts of map features of one file that are not present on another file.                |
| FUNF           | Write an output file containing all map features that are on two files.                           |
| GENSYM         | Store coordinate values for symbol generation.                                                    |
| GETSET         | Obtain location of given data type in data record.                                                |
| ICHSUM         | Compute an integer sum of data record words.                                                      |
| IDEVIA         | Determines if polygon area is greater than area tolerance.                                        |
| ILISTR         | Lists land management data records.                                                               |
| IMLTPY         | Loads labeled common.                                                                             |
| INDEX          | Returns index and data type of map feature.                                                       |
| INDP           | Returns index of specified data type.                                                             |
| INTBCD         | Converts integers to binary coded decimal.                                                        |
| INOUT          | Determine which points of a given array of points are in, on the border or out of a bounded area. |

| <u>Program</u> | <u>Description</u>                                                                                |
|----------------|---------------------------------------------------------------------------------------------------|
| INPNT          | Loads buffers with data arrays.                                                                   |
| INPUT          | Loads buffers with data arrays.                                                                   |
| INTPL          | Available for expansion for intersection of point map feature with line map feature.              |
| INTLL          | Available for expansion for intersection of two linear map features.                              |
| INVER          | Transform coordinates from UTM to digitizer coordinates.                                          |
| INVFL          | Lists data records based on given property numbers.                                               |
| IPRCNT         | Compare areas, perimeters and numeric property values between two files.                          |
| ISUMRY         | Print summary output of data files.                                                               |
| IWRITID        | Write map identifier.                                                                             |
| LEGEND         | Write a label for a plot sheet.                                                                   |
| LMDINP         | Read a land management data record from a data file.                                              |
| LMDOUT         | Write a land management data record on a data file.                                               |
| LMDUMP         | Print a land management data record.                                                              |
| LOADSB         | Stores a sub-block of data into a data record.                                                    |
| LOCBLK         | Locate a sub-block of data in a data record.                                                      |
| MAPINP         | Finds a data record with a specified map identifier and unit identifier.                          |
| MAPINV         | List the data records on a data file including map identifier, unit identifier, and type of data. |
| MATCH          | Obtain transfer index based on word matching.                                                     |
| MATC2          | Obtain transfer index based on word matching.                                                     |
| MAXMIN         | Determine maximum and minimum values for x and y coordinates of a map feature.                    |

| <u>Program</u> | <u>Description</u>                                                                               |
|----------------|--------------------------------------------------------------------------------------------------|
| MERGAR         | Merge line segments if their end points match.                                                   |
| PERIMT         | Compute the perimeter of a polygon.                                                              |
| PLTPQ          | Plot coordinate points.                                                                          |
| POCKET         | Determine if a point is located within, on, or outside a closed boundary.                        |
| PTLIMIT        | Limit a point array by a closed boundary.                                                        |
| PLOTMP         | Plot map feature data.                                                                           |
| RATIO          | Multiply numeric property values by ratio of old size of map feature to new size of map feature. |
| RDCARD         | Read fire and timber data cards.                                                                 |
| REPLPT         | Replaces attributes on a data record.                                                            |
| REVR           | Reverse the direction of a data array.                                                           |
| RINVTR         | Reverse transformation values.                                                                   |
| RPLACE         | Replaces land management data records.                                                           |
| RSETTR         | Set transformation values.                                                                       |
| RTRPT          | Transform a point.                                                                               |
| RTSUM          | Print output for summary data.                                                                   |
| SEPDAT         | Separate free field data from data cards.                                                        |
| SETITO         | Determine UTM zone number from longitude.                                                        |
| SIZE           | Get size of map feature depending on data type.                                                  |
| SORTLS         | Sort two arrays of line segments.                                                                |
| SORTPL         | Sort closed areas into inner and outer areas.                                                    |
| TGP            | Transform map feature data to UTM coordinates.                                                   |
| TIMFIL         | Write a data file containing timber activity records.                                            |
| TRF            | Compute transformation values.                                                                   |

| <u>Program</u> | <u>Description</u>                                    |
|----------------|-------------------------------------------------------|
| TRNFRM         | Transforms arrays of points.                          |
| UGRID          | Sets values for grid plotting.                        |
| ULABEL         | Sets values for label plotting.                       |
| ULINE          | Sets values for type of line.                         |
| UORIEN         | Sets values for plotting.                             |
| USCALE         | Sets values for plotting.                             |
| USHADE         | Sets values for type of polygon shading.              |
| USYMBL         | Sets values for symbol plotting.                      |
| UTMGP          | Computes UTM values for given latitude and longitude. |
| WEEDR          | Deletes points based on chord height tolerance.       |
| XCOPY          | Copy files based on identifiers or attributes.        |
| XINTER         | Sets up files for FINF.                               |
| XLDARG         | Reads data cards and stores arguments.                |
| XNOT           | Sets up files for FNORF.                              |
| XRWIND         | Rewinds files.                                        |
| XTOLR          | Sets tolerance values.                                |
| XUNION         | Sets up files for FUNF.                               |
| ZERO           | Zeros an array.                                       |

See Appendix for the list of system subroutines used.

### 3.0 EQUIPMENT

There are four basic hardware components utilized by the Natural Resources Information System. They are:

1. Gerber 2000 Optical Digitizer
2. IBM 360-40
3. CDC 6600
4. CALCOMP 763 Drum Plotter

#### 3.1 The Digitizing Process

A procedure was set up to standardize digitizing output and to aid digitizer operators in providing accurate and acceptable output. Data to be digitized was provided on suitable stable material with a line quality sufficiently dense to allow the operator to utilize an optical line follower.

At the start of each new sheet and at the beginning of each new reel of punched tape, the operator enters onto the punched tape the sheet identification label. The label is alphanumeric information entered via the teletype keyboard. Following the label the date digitized is entered in the same manner.

At least three reference locations must appear on each sheet. The reference points are labeled with latitude and longitude values in degrees, minutes and seconds. Following the date, the operator enters via the keyboard the coordinate labels associated with each reference point. The operator then establishes the table origin at one reference point and proceeds to digitize each reference point in the same order as the coordinate labels were entered.

Prior to digitizing each item on the sheet the operator enters the alphanumeric identifier associated with that item and digitizes a point just below the first character of the label. Each separate item to be digitized must be complete on the reel of punched tape on which its label was entered.

The maximum digitizer increment was set in drawing sheet inches based on the scale of the sheet being digitized. It never exceeded the equivalence of 400 feet in map distance. All polygon boundaries were required to be closed within the given distance tolerance.

Each punched paper tape is re-plotted at the digitizer to verify the tape. Complete units may be digitized again as replacements if the new units are placed on another reel of tape and the word "update" is entered prior to the map identifier. A complete unit is any record of data that follows the entry of a unit identifier and precedes another.

Experience showed that errors occurred in punched tape output even though the above procedures were followed. On the average it was found that one-fourth of the data needed to be digitized again for correction. Based on the maps that were processed it is estimated that an average map containing two hundred map features requires approximately twenty hours of digitizing time and produces twelve reels of paper tape.

### 3.2 Paper Tape Conversion to Magnetic Tape

Eight channel punched paper tape from the digitizer was converted to standard six bit BCD on seven track, non-labeled, magnetic tape using an IBM 360-40 computer. Conversion was a two pass process, first converting to an eight-bit data convert mode magnetic tape.

4. OPERATIONS - SYSTEM INSTRUCTIONS

### 4.1.2.1.1 System Instructions

Instructions input on data cards control the execution of the Natural Resource Information System. The following list of major directives is grouped according to the program modules responsible for processing these directives. All of these commands start in card column one. The first directive listed in each group is the data command that is present to bring about a transfer to the corresponding program module. Two basic directives REWIND and MAPINV are recognized and processed by all modules in order to minimize program transfers. A detailed explanation of each data instruction including minor directives and their parameters follows this list.

| PROGRAM LAND DIRECTOR |               |               |                |               |
|-----------------------|---------------|---------------|----------------|---------------|
| <u>CONVERT</u>        | <u>PLOTMP</u> | <u>EDITOR</u> | <u>EXTRACT</u> | <u>REPORT</u> |
| REWIND                | FEATURES      | ADD           | COPY           | FIRE          |
| MAPINV                | GRID          | CHARACTERI    | INTERSECT      | INVENTORY     |
|                       | LABEL         | CREATE        | NOT            | LIST          |
|                       | LEGEND        | DELETE        | TOLERANCE      | MAPINV        |
|                       | ORIENT        | REPLACE       | UNION          | PERCENT       |
|                       | SCALE         | REWIND        | REWIND         | REWIND        |
|                       | SYMBOL        | MAPINV        | MAPINV         | SUMMARY       |
|                       | REWIND        |               |                | TIMBER        |
|                       | MAPINV        |               |                |               |

## 4.1.1 CONVERT A B C D E F G H I

Converts a magnetic tape of digitized data or data from card input to land management data records. Command begins in card column one and arguments A through I are integers starting on or after card column 11 and separated by at least one blank.

| <u>Argument</u>                         | <u>Explanation</u>                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A                                       | Input file number<br>=0, data is to be read from cards                                                                                                                                                                                                                                                                 |
| B                                       | Output file number                                                                                                                                                                                                                                                                                                     |
| (arguments C-I are not needed if A = 0) |                                                                                                                                                                                                                                                                                                                        |
| C                                       | Number of characters per digitized coordinate<br>=0, assumes 6 characters                                                                                                                                                                                                                                              |
| D                                       | Number of characters left of decimal point in digitized coordinate<br>=0, assumes 3 characters.                                                                                                                                                                                                                        |
| E                                       | Number of reels of paper tape that are on the input file.                                                                                                                                                                                                                                                              |
| F                                       | Chord height tolerance for weeding                                                                                                                                                                                                                                                                                     |
| G                                       | Data type of output data<br>=0, program will determine<br>=1, all polygon data<br>=2, all linear data<br>=3, all point data                                                                                                                                                                                            |
| H                                       | Code for setting map identifier<br>=0, map identifier read from input file<br>≠0, map identifier will be read from first 20 columns of next data card.                                                                                                                                                                 |
| I                                       | Code for reference points<br>=0, reference points are read from input file<br>≠0, number of reference points to be read from following data cards. The latitude and longitude of the reference points are input first in degrees, minutes and seconds. The drawing sheet coordinates are then input in the same order. |

If A=0, this instruction must be followed by six data commands that begin in card column 11. The six commands are:

## 4.1.1 CONVERT continued:

| <u>Instruction</u> | <u>Arguments</u> | <u>Explanation</u>                                                                                                                                                                                                         |
|--------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MAP                | MAP ID           | Argument is alphanumeric character string that must start in card column 21                                                                                                                                                |
| DATE               | DATE             | Same as above                                                                                                                                                                                                              |
| UNIT               | UNIT ID          | Same as above                                                                                                                                                                                                              |
| REFERENCES         | N T              | N = number of reference points that follow on data cards. The points are input as described under argument I of the CONVERT command.<br>T = 4, points are in digitizer coordinate system<br>=7, points are UTM coordinates |
| TYPE               | type x y         | type =1, data is polygon<br>=2, data is linear<br>=3, data is points<br>x, y= coordinates of reference point for location of map feature label.                                                                            |
| POINTS             | N                | N = number of data points that follow on data cards.                                                                                                                                                                       |

Note: Reference points and data points are input on data cards as decimal numbers in free field format separated by at least one blank.

## 4.1.2 PLOTMP A B C D E F G

Creates a plot file for the CALCOMP plotter. Command begins in card column 1 and arguments A through G are numbers starting on or after card column 11 and separated by at least one blank.

| <u>Argument</u>                       | <u>Explanation</u>                                                                          |
|---------------------------------------|---------------------------------------------------------------------------------------------|
| A                                     | Input file number                                                                           |
| B                                     | Code for special check plot option<br>=0, standard plotting<br>≠0, x,y scale for check plot |
| (arguments C-G are not needed if B=0) |                                                                                             |
| C                                     | x value of lower left corner                                                                |
| D                                     | y value of lower left corner                                                                |
| E                                     | Distance to right for lower left corner of exploded view<br>=0, no exploded view            |
| F                                     | Number of consecutive maps to be drawn                                                      |
| G                                     | y scale, if different from x scale<br>=0, ignored                                           |

If B=0, this instruction must be followed by further plotting directives. These directives plus optional plotting commands and their arguments are explained below. Unless specifically stated otherwise all command words start in card column one.

| <u>Instruction</u> | <u>Arguments</u> | <u>Explanation</u>                                                                                                                                                                                                                           |
|--------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ORIENT             | A B C D E F G H  | Mandatory command<br>A= lower left x margin<br>B= total x plotting distance<br>C= lower y margin<br>D= total y plotting distance<br>E= minimum x data value<br>F= maximum x data value<br>G= minimum y data value<br>H= maximum y data value |
| SCALE              | A                | Mandatory command<br>A= value for scaling data                                                                                                                                                                                               |
| GRID               | A B C D E F      | Optional command<br>Provides grid marks on output plot                                                                                                                                                                                       |

## 4.1.2 PLOTMP continued

| <u>Instruction</u> | <u>Arguments</u> | <u>Explanation</u>                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GRID continued     |                  | <p>A= starting x value<br/> B= grid width in x<br/> C= x increment for grid marks<br/> D= starting y value<br/> E= grid height in y<br/> F= y increment for grid marks</p>                                                                                                                                                                                                                                                            |
| LABEL              | A B C            | <p>Optional command<br/> provides alphanumeric label for specific map feature<br/> A= number of characters to be plotted<br/> if A≠0, all plotted map features are labeled with the alphanumeric character string that follows on the next card beginning in card column 11.<br/> B= character size<br/> C= property number<br/> if C≠0, the alphanumeric label is acquired from the data record identified by C property number.</p> |
| SYMBOL             | A                | <p>Optional command<br/> A= number of data values that follow on additional cards. These data values define a symbol shape for plotting discrete point data.</p>                                                                                                                                                                                                                                                                      |
| LEGEND             | A B C D E        | <p>Optional command - provides plot label<br/> A= drawing sheet x location for start of label<br/> B= drawing sheet y location for start of label<br/> C= character size<br/> D= number of lines to be plotted<br/> E= maximum number of characters in any one line<br/> This card must be followed by additional cards containing alphanumeric strings starting in card column 11, with one line per card.</p>                       |
| FEATURES           |                  | <p>Mandatory command<br/> If no data cards follow this instruction the entire input file will be plotted.<br/> Optional data cards may follow this instruction to select certain data records to be plotted.</p>                                                                                                                                                                                                                      |

## 4.1.2 PLOTMP continued

| <u>Instruction</u>                             | <u>Arguments</u>                                                    | <u>Explanation</u>                                                                                                                                                                                                                                                      |
|------------------------------------------------|---------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Optional instructions follow FEATURES command. |                                                                     |                                                                                                                                                                                                                                                                         |
| cc<br>11<br>MAP                                | cc<br>21<br>MAP ID                                                  | Only those data records having this map identifier will be plotted.                                                                                                                                                                                                     |
| UNIT                                           | UNIT ID                                                             | Only those data records with specified map and unit identifiers will be plotted. May be followed with additional cards containing only unit identifiers. These cards can only follow a map card.                                                                        |
| cc<br>11<br>PROPERTY                           | cc<br>21<br>N<br>N <sub>1</sub><br>N <sub>2</sub><br>N <sub>n</sub> | N= property number<br>Only those data records containing this property as identified by N will be plotted. May be followed with additional cards containing only a property number. This card cannot be used with map or unit instructions but must be used separately. |
| cc<br>11<br>EXCLUDE                            |                                                                     | This instruction may be followed by map and unit or property commands. The effect of this will be to plot all data records that do not have the specified identifiers or properties.                                                                                    |

Note: The GRID directive activates the plotting of the grid so all mandatory plotting directives must precede the GRID instruction. The FEATURES directive activates writing the plot file so all mandatory plotting instructions and any optional commands desired must precede the FEATURES instruction. A PLOTMP instruction will advance the plotting file so that a new plot can be provided.

## 4.1.3 EDITOR A B

Modifies the data records contained on the input file and writes the new data records on the output file. Command begins in card column one and arguments are integers starting on or after card column 11 and separated by at least one blank.

| <u>Argument</u> | <u>Explanation</u>      |
|-----------------|-------------------------|
| A               | Input data file number  |
| B               | Output data file number |

This instruction must be followed by one or more of the following commands describing the operation to be performed. The following command words all start in card column one.

| <u>Instruction</u> | <u>Arguments</u> | <u>Explanation</u>                                                 |
|--------------------|------------------|--------------------------------------------------------------------|
| ADD                | C                | C is additional input file number.<br>Copy A to B and copy C to B. |
| DELETE             | C                | C is a scratch file.                                               |

Optional commands following DELETE instructions.

|            |         |                                            |
|------------|---------|--------------------------------------------|
| cc         | cc      |                                            |
| 11         | 21      |                                            |
| MAP        | MAP ID  | Copy data records from file A to file      |
| UNIT       | UNIT ID | B except those having map and unit         |
|            | UNIT ID | identifiers listed.                        |
| REPLACE    | C       | Copy file A records to file B except       |
|            |         | those data records on A that have the same |
|            |         | map and unit identifiers of records on     |
|            |         | file C. Copy file C to B.                  |
| CHARACTERI |         | Add or replace data record attributes.     |

Optional commands following CHARACTERI instruction.

|           |         |
|-----------|---------|
| cc        | cc      |
| 11        | 21      |
| MAP       | MAP ID  |
| ATTRIBUTE | A B C D |

A= Property number  
 B= higher level property number  
 C= number of characters in the alphanumeric character string or numeric value of this property.  
 D=0, property is described by alphanumeric character string on next card starting in card column 11.  
 D≠0, property is numeric; numeric value follows on next card in card column 11.  
 D=1, property is a constant value  
 D=-1, property is a function of area or length.

## 4.1.3 EDITOR continued

| <u>Instruction</u> | <u>Arguments</u> | <u>Explanation</u>                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| UNIT               | UNIT ID          | <p>Add the attributes following the MAP card to all data records having that map identifier. Add the attributes following UNIT cards to data records having that unit identifier. If no attributes follow UNIT card use preceding attributes.</p> <p>If an attribute is already present in the data record the new attribute will replace the old one. If other attributes are present in the data record these attributes will be included.</p> |

Note: Unit card has a special capability. If card columns 41-50 contain any alphanumeric values the property number is calculated by using the last property number, the column number of the character (41-50) and a code for the character. The code equals 1-26 for A-Z, 27-36 for 0-9 and 37-44 for special characters. The property number is computed by:  $PN = 1000 \times (\text{last property number}) + (\text{column number} - 41) \times 50 + \text{character code}$ . The character itself then becomes the alphanumeric property.

|        |   |                                                                                                                                                                                       |
|--------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CREATE | A | <p>=1, write fire data file<br/>this card must be followed by<br/>fire report data cards</p> <p>=2, write timber data file<br/>this card must be followed by<br/>timberdata cards</p> |
|--------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

The set of fire data cards follows. Arguments are free format unless noted.

|        |       |                                                                                                                                          |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------------------|
| AGENCY | A B C | <p>A= reservation name<br/>B= agency name<br/>C= state</p> <p>These arguments must start in card column 11, 31 and 51, respectively.</p> |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------------------|

|      |             |                                                                                                                                                          |
|------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| LAND | A B C D E F | <p>A= total state and private acres<br/>B= tribal acres<br/>C= allotted acres<br/>D= government acres<br/>E= government acres not needing protection</p> |
|------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|

## 4.1.3 EDITOR continued

| <u>Instruction</u> | <u>Arguments</u>   | <u>Explanation</u>                                                                                                                                                                                                                                                                                                                                               |
|--------------------|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| LAND               | A B C D E          | A= commercial forest acres<br>B= non-commercial forest acres<br>C= brush acres<br>D= grass acres<br>E= other acres<br>All these values are for state and private lands                                                                                                                                                                                           |
| LAND               | A B C D E          | Same as above but values are government owned lands                                                                                                                                                                                                                                                                                                              |
| LOCATION           | A B C              | A= township<br>B= range<br>C= section<br>These arguments must start in card columns 11, 31 and 51, respectively.                                                                                                                                                                                                                                                 |
| DATE               | A                  | A= date of fire. Argument must start in card column 11.                                                                                                                                                                                                                                                                                                          |
| FIRE               | A B C D E          | A= cause of fire (lightning, equipment, smoking, recreation, forest use, occupant, incendiary, miscellaneous)<br>B= size class (A-G)<br>C= government or private land (I&G, S&P)<br>D= responsibility class (railroad, timber, recreation, other)<br>E= type of land burned (com-forest, seedlings, other-for, watershed, recreation, range, improvement, other) |
| FIRE               | A B C D E F        | A= number of acres burned<br>B= cost of suppression, regular<br>C= cost of suppression, special<br>D= manhours, regular<br>E= manhours, seasonal<br>F= manhours, emergency                                                                                                                                                                                       |
| FIRE               | A B C D E F<br>G H | Arguments A through H are damage in dollars to type of land burned in argument E in first fire card.                                                                                                                                                                                                                                                             |

The set of timber report data cards follows. Arguments are free field unless noted.

|        |       |                                                                                                                              |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------|
| AGENCY | A B C | A= reservation name<br>B= agency name<br>C= state<br>These arguments must start in card column 11, 31, and 51, respectively. |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------|

## 4.1.3 EDITOR continued

| <u>Instruction</u> | <u>Arguments</u> | <u>Explanation</u>                                                                                                                                                                                                                                |
|--------------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TIMBER             | A B C D          | A= type of cutting (contract, permit,<br>free use or trespass)<br>B= Purchaser (Indian or non-Indian)<br>C= type of land (tribal, allotted or<br>government)<br>D= cost (free use or stumpage)                                                    |
| CONTRACT           | A B C D          | A= type of contract (new, active or<br>complete) must start in card column 11<br>B= contract number - must start in<br>card column 21<br>C= cutting unit name - must<br>start in card column 41<br>D= purchaser - must start in card<br>column 61 |
| SPECIES            | A B              | A= type of lumber<br>B= green or dead                                                                                                                                                                                                             |
| AMOUNT             | A B C            | A= number or MBM<br>B= price per number or MBM<br>C= conversion factor to MBM<br>=0, A= MBM<br><0, store cost only, not MBM                                                                                                                       |
| PAYMENT            | A                | A= dollars paid                                                                                                                                                                                                                                   |
| END                |                  | End of specific set of data, may<br>be followed by another data set.                                                                                                                                                                              |

## 4.1.4 EXTRACT

This directive has no arguments as its only purpose is to initiate a transfer to the extract overlay.

This instruction must be followed by one or more of the following commands describing the operation to be performed.

| <u>Instruction</u> | <u>Arguments</u> | <u>Explanation</u>                                                                                                                            |
|--------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| COPY               | A B              | A= input file number<br>B= output file number<br>If no further directives follow the COPY instruction file A is rewound and copied to file B. |

Optional instructions follow the COPY directive:

|     |        |                                                                                       |
|-----|--------|---------------------------------------------------------------------------------------|
| cc  | cc     |                                                                                       |
| 11  | 21     |                                                                                       |
| MAP | MAP ID | Only those data records having this map identifier will be copied to the output file. |

|      |         |                                                                                                                                                                                                                    |
|------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| cc   | cc      |                                                                                                                                                                                                                    |
| 11   | 21      |                                                                                                                                                                                                                    |
| UNIT | UNIT ID | Only those data records with specified map and unit identifiers will be copied to the output file. May be followed with additional cards containing only unit identifiers. These cards can only follow a map card. |
|      | UNIT ID |                                                                                                                                                                                                                    |
|      | UNIT ID |                                                                                                                                                                                                                    |

|          |    |    |    |                                                                                                                                            |
|----------|----|----|----|--------------------------------------------------------------------------------------------------------------------------------------------|
| cc       | cc | cc | cc |                                                                                                                                            |
| 11       | 21 | 31 | 41 |                                                                                                                                            |
| PROPERTY | A  | B  | C  | A= property number                                                                                                                         |
|          | A1 |    |    | Arguments B and C can only be used if A refers to a numeric property.                                                                      |
|          | A2 |    |    | If B and C are blank copy only those records containing property number A or A - AN if more cards containing only property numbers follow. |
|          | A3 |    |    | If B is blank then copy only those data records containing a numeric property whose number is A and whose value is C.                      |
|          | AN |    |    | If B= MAX then copy data records containing numeric property whose number is A and has a value less than or equal to C.                    |
|          |    |    |    | If B= MIN then copy data records containing numeric property numbered A and has a value greater than or equal to C.                        |

## 4.1.4 EXTRACT continued

| <u>Instruction</u> | <u>Arguments</u>      | <u>Explanation</u>                                                                                                                                                                                                                                                                                                                                                     |
|--------------------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                    | cc<br>11<br>EXCLUDE   | The property card may be followed by further cards containing only property numbers or arguments A, B and C as described above.<br><br>If this key word precedes any of the other data cards then the records copied will be those not containing the specified map or unit identifiers or property numbers.                                                           |
| INTERSECT          | A B C                 | Finds the portion of map features on file A which overlay file B map features and outputs the results on file C. Arguments are integers starting on or after card column 11 and separated by blanks.                                                                                                                                                                   |
| NOT                | A B C                 | Finds the portions of map features on file A which do not overlay file B map features and outputs the results onto file C. Arguments are integers starting on or after card column 11 and separated by blanks.                                                                                                                                                         |
| TOLERANCE          | cc cc<br>11 31<br>A B | If B equals the word feet, meters or miles the extract program linear tolerance is set equal to A. If this card is not present, the linear tolerance is defaulted to 400 feet. If B equals the word square feet, square meters or acres the extract program area tolerance is set equal to A. If this card is not present the area tolerance is defaulted to 40 acres. |
| UNION              | A B C                 | Finds the union of all polygon map features on both files A and B and outputs the results on file C. If B=0, or only 2 arguments are present, then the union will be performed only on the map features within file A. Arguments are integers starting on or after card column 11 and separated by blanks.                                                             |

## 4.1.5 REPORT

This directive has no arguments as its only function is to initiate a transfer to the report overlay.

This instruction must be followed by one or more of the following commands describing the operation to be performed.

| <u>Instruction</u> | <u>Arguments</u> | <u>Explanation</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| INVENTORY          | A B              | <p>A= input file number<br/> B= property number<br/> This directive will produce a listing of all data records on file A with property numbers that have their higher level property number = B. In addition, the alphanumeric character string describing the property will be printed. Arguments are integers starting on or after card column 11 and separated by blanks.</p>                                                                                                                                           |
| LIST               | A                | <p>A= input file number<br/> This directive will write out the contents of all the data records on file A.</p>                                                                                                                                                                                                                                                                                                                                                                                                             |
| MAPINV             | A B C D E        | <p>This card can contain one to twenty arguments that are data file numbers. Each data file will be rewound and the records listed giving record number, number of words in record, data type, unit identifier, date entered and map identifier. Files will be rewound after listing. Arguments are integers that start on or after card column 11 and are separated by blanks.</p>                                                                                                                                        |
| PERCENT            | A B              | <p>Compare data records on file B with records on file A that have the same map and unit identifiers.<br/> Print out the area and perimeter of polygon data and the length of linear data as a percentage of the value of record on B as compared to record on A.</p> <p>Optionally commands MAP, UNIT or PROPERTY can follow this directive to limit the number of records to be compared. These commands and their format are described as optional commands following the FEATURES directive in the PLOTMP overlay.</p> |

## 4.1.5 REPORT continued

| <u>Instruction</u> | <u>Arguments</u> | <u>Explanation</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| REWIND             | A B C D          | This card can contain one to twenty arguments that are file numbers. All files will be rewound. Arguments are integers starting on or after card column 11 and are separated by blanks.                                                                                                                                                                                                                                                                                 |
| SUMMARY            | A                | A is a data file number. This directive produces printed output summarizing the number of records with the same map identifier and the number of records with the same unit identifier. In addition, area and perimeter of polygon data and length of linear data is calculated and printed. If no further directives follow all records on file A are summarized. Optional commands as described under PERCENT are available to limit the number of records processed. |
| FIRE               | A                | A is the file number of the data file containing fire report records. This directive will produce a fire report in the format of that included with the annual timber report.                                                                                                                                                                                                                                                                                           |
| TIMBER             | A                | A is the file number of the data file containing timber cutting data. This directive will produce a timber report in the format of the annual timber report.                                                                                                                                                                                                                                                                                                            |

#### 4.2 Data Output

The program has the capability to output data either in a printed form or on a file that can be plotted by the CALCOMP plotter. The amount and type of output produced by the program is controlled by the user.

##### 4.2.1 Printed Output

Data records on files may be listed, or short inventories of data records can be printed. A summary of data records of a file can be output that will include area and perimeter data and/or descriptive properties. Two files may be compared and the printed values given for the second file as a percentage of the corresponding values of the first file.

##### 4.2.2 Graphic Output

Plots may be created from entire data files or from data records determined by identifiers or property numbers. The scale for all plots may be specified by the user. Grid marks, plot labels and map feature labels may be included in the plot as desired by the user.

#### 4.3 General Description of Operating Experience

To demonstrate the practicality and reliability of the Natural Resources Information System a sample data file was created. The maps that were used included seven Bureau of Land Management Unit Resource Analysis maps of the San Simon region, two Bureau of Indian Affairs maps of the Fort Apache Reservation and several Land Use maps using the Anderson classification system. The map features on the URA maps delineated soil types, land classification and market values, recreation areas, erosion hazards, range conditions, vegetation species, allotment boundaries and grazing systems. The BIA map features described timber and slope conditions. The Land Use maps covered streams, roads, railroads, rights of way and canals.

A series of model problems were executed using this data base and are described in Reference 6. The problems included file sorting, interaction between data files, updating of data files, extracting information from data files and plotting. On the average these jobs used ten CDC 6600 computer resource units plus fifteen minutes of CALCOMP plotting time.

#### 4.4 Details of Solving Problem #1, Reference 6

The purpose of problem #1 is to locate all areas where the range condition is inconsistent with the range utilization. This involves the overlay of three types of URA map features: those describing range conditions, erosion hazards and forage factors. The first step in the problem is to locate all areas with poor, bad or waste range conditions, those with a critical erosion hazard and those with a high forage factor. The next step is to intersect the first two areas and then intersect the result with the third area. The data files that are the results of both intersections are plotted, showing the new map features that have two attributes in common and then those that have all three common attributes. These plotted map features show the location of the new map features in relation to the location of the original areas. The data files that are the results of both intersections are summarized in a printed output showing areas and perimeters of the new map features. The two stage graphical output and associated tabular output is shown in Figures 4.1, 4.2 and 4.3.

The data cards that were used to execute problem #1 are listed below. All URA data files are on file 2.

| cc 1      | cc 11                | cc 21    | cc 31        | cc 41             |
|-----------|----------------------|----------|--------------|-------------------|
| EXTRACT   |                      |          |              |                   |
| COPY      | 2                    | 3        |              |                   |
|           | PROPERTY             | 305002   |              |                   |
|           |                      | 305003   |              |                   |
|           |                      | 305004   |              |                   |
| COPY      | 2                    | 4        |              |                   |
|           | PROPERTY             | 304005   |              |                   |
| COPY      | 2                    | 7        |              |                   |
|           | PROPERTY             | 30741    | MIN          | 6.0               |
| REWIND    | 3                    | 4        | 7            |                   |
| INTERSECT | 3                    | 4        | 8            |                   |
| INTERSECT | 8                    | 7        | 9            |                   |
| PLOTMP    | 8                    |          |              |                   |
| ORIENT    | 5. 10. 5. 20.        | 620000.  | 651000.      | 3560000. 3605000. |
| SCALE     | .00031068            |          |              |                   |
| GRID      | 620000. 31000. 5000. | 3555000. | 46000. 5000. |                   |
| FEATURES  |                      |          |              |                   |
| PLOTMP    | 9                    |          |              |                   |
| ORIENT    | 5. 10. 5. 20.        | 620000.  | 651000.      | 3560000. 3605000. |
| SCALE     | .00031068            |          |              |                   |
| GRID      | 620000. 31000. 5000. | 3555000. | 46000. 5000. |                   |
| FEATURES  |                      |          |              |                   |
| REPORT    |                      |          |              |                   |
| SUMMARY   | 8                    |          |              |                   |
| SUMMARY   | 9                    |          |              |                   |

The first data card EXTRACT causes a transfer to the extract program module. The next card requests that data file two be copied to data file three. The following three data cards limit the copy operation to those data records with the specified property numbers. The result of this copy operation is that all data records from file two that have a poor, bad, or waste range condition are copied to file three. The result of the next copy operation is that all map features from file two that have the attribute of critical erosion hazard as specified by the property number are copied to file four. The next copy operation specifies a numeric property number which refers to a forage factor. It requests that all map features having this numeric property with a value greater than or equal to 6.0 be copied to file seven.

The rewind card asks the program to rewind files three, four and seven. The next card requests the program to intersect the range condition map features on file three with the erosion hazard features on file four. The resultant map features will be written on file eight.

Each map feature on file three is compared with each map feature on file four. The polygon intersection routines first determine by maximum and minimum coordinate values whether it is possible that the two polygons intersect. Subroutines are utilized to return line segments of the first polygon that are within the second and also line segments of the second that are contained within the first. These line segments are sorted and merged if their end points match. The resulting segments are checked for being closed boundaries and are sorted into outer and inner areas.

New map features are assigned attributes of the original map feature except for numeric property values which are dependent upon size of the area. These property values are modified proportionally to the change in the size of the map feature.

The next card requests the program to intersect the resultant file with the high forage factor areas on file seven. The map features resulting from this second intersection will be written on file nine.

The next ten cards instruct the program to write a plot file for data files eight and nine. The plotting will produce two drawing sheets, one for all the map features of each data file. Both drawings will contain grid marks. The ORIENT cards sets the plot margins and informs the program of the range of data values to be plotted. The SCALE card allows the user to specify the output scale of the data.

The REPORT card causes a transfer to the REPORT program module. This program will read the new data files eight and nine and print out a summary of the map feature data they contain. The summary will include the area and perimeter of all map features.

## 5. SYSTEM RECOMMENDATIONS

The Natural Resources Information System was developed as a first step in a program designed to collect, process and display land management data. The problems encountered in developing this program point out the areas in which further analysis would be beneficial in increasing program efficiency and cost effectiveness.

One of the main program areas where costs were large was in the digitizing of the original map data. The time spent processing the maps was increased by the necessity to re-digitize parts of maps to correct errors. Since this program is basic to the application of the system and because it is assumed that large amounts of data will be needed, here is an area in which further investigation should be directed. Other possible methods of acquiring map coordinate data should be evaluated, including photographic processing. Attention should also be given to determining more automatic methods by which output errors can be corrected, reduced or eliminated. It may also be possible to reduce costs by simplifying or eliminating the conversion step from punched paper tape to magnetic tape.

Another main program area where more automatic processing is needed is in the addition of attributes to the land management data records. At the present time each numeric or descriptive property with its identifying number must be input to the program on data cards. To cut down on the volume of data cards needed for each map feature, programming techniques should be added to automate the process. The program could compute property identifiers and read character strings in a free field format.

Another programming area which should be given further consideration is the question of sequential versus random access data record storage. An analysis should be made of the search time required for locating records on sequential files of a given size. Depending on the size of the files that will be used for a specific program application, it may be more advantageous to add an index to the file to locate records without searching.

The utility of the program could be increased by including additional graphic display capabilities. The addition of variable shading for polygon areas would aid in distinguishing types of output data features. The effective display of data could be enhanced by the addition of variable line forms and variable pre-set symbols for points. Additional lettering capability could be added so that some automatic titles could always be output on a drawing sheet. Modifications could be added to the program so that output could be displayed on other available plotting devices such as the Gerber, the SC4020 or a cathode ray tube.

Useful additions could also be made in the transformation capabilities of the program. The ability to input or output coordinates in state plane coordinate systems could be helpful to land managers. A capability to convert data from canted plane input could be added so that aerial photography maps could be used.

Data manipulation capabilities that could be added to the program include smoothing or splining of widely spaced input point data. It would also be possible to give the user the option of data translation and/or rotation before output data is plotted or printed.

The general form in which the program is written lends itself to the addition of added capabilities. More options for data calculations and reporting could be added without affecting any of the existing programs. Land managers could propose a land classification system suited to their application with no changes to the basic record format or existing program modules.

## 6.0 APPENDIX

### 6.1 Computer System Library Routines

#### FORTTRAN Library Functions

ATAN  
SINCOS  
SQRT

#### CALCOMP Plotting Subroutines

BLOCK  
FACTOR  
LINE  
PLOT  
PLOTS  
STOER  
SYMBOL  
WHERE

#### System Library Routines

|        |                                                   |
|--------|---------------------------------------------------|
| DATE   | -store date                                       |
| ENCODE | -transfer information under format specifications |
| ISCAN  | -scan character string for given character        |
| KNVRT  | -convert display code to numeric values           |
| KOMSTR | -compare character strings                        |
| POOL   | -assign files                                     |
| SECOND | -store time                                       |
| STRMOV | -move character strings                           |

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-----------------------------|-----------------------------------------------------------------------------------|---------------------------------|
| STANDARD TITLE PAGE<br>FOR TECHNICAL REPORTS                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  | 1. Report<br>USGS-DO-72-013 | 2. Recipient's Catalog No.                                                        | 3. Recipient's Catalog No.      |
| 4. Title and Subtitle<br>Natural Resource Information System, V. 2, System Operating Procedures and Instructions                                                                                                                                                                                                                                                                                                                                                                                                  |  |                             | 5. Report Date<br>August 1972                                                     | 6. Performing Organization Code |
| 7. Author(s)<br>Boeing Computer Services, Inc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  |                             | 8. Performing Organization Report No.                                             |                                 |
| 9. Performing Organization Name and Address<br>U.S. Geological Survey<br>Washington, D.C. 20242                                                                                                                                                                                                                                                                                                                                                                                                                   |  |                             | 10. Project/Task/Work Unit No.<br>160-15-04-12-14<br>11. Contract/Grant No.       |                                 |
| 12. Sponsoring Agency Name and Address<br>National Aeronautics and Space Administration<br>Washington, D.C. 20546                                                                                                                                                                                                                                                                                                                                                                                                 |  |                             | 13. Type of Report & Period Covered<br>Final report<br>14. Sponsoring Agency Code |                                 |
| 15. Supplementary Notes<br>This project was jointly funded by Bureau of Indian Affairs, Earth Resources Observation Systems Program and NASA                                                                                                                                                                                                                                                                                                                                                                      |  |                             |                                                                                   |                                 |
| 16. Abstracts<br>This report provides a total computer software system description for the prototype Natural Resource Information System designed to store, process, and display data of maximum usefulness to land management decision making. Program modules are described, as are the computer file design, file updating methods, digitizing process, and paper tape conversion to magnetic tape. Operating instructions for the system, data output, printed output, and graphic output are also discussed. |  |                             |                                                                                   |                                 |
| 17. Key Words and Document Analysis. (a). Descriptors<br>Data processing, Information systems, Digital techniques, Computer programming                                                                                                                                                                                                                                                                                                                                                                           |  |                             |                                                                                   |                                 |
| <p><i>This is DRA<br/>CR# 127811<br/>w/ 8-72</i></p> <p>17b. Identifiers/Open-Ended Terms<br/>Natural Resource Information System</p> <p>17c. COSATI Field/Group<br/>5 B</p>                                                                                                                                                                                                                                                                                                                                      |  |                             |                                                                                   |                                 |
| 18. Distribution Statement<br>Unclassified - Unlimited                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  |                             | 19. Security Class (This Report)<br>UNCLASSIFIED                                  | 21. No. of Pages<br>56          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |                             | 20. Security Class. (This Page)<br>UNCLASSIFIED                                   | 22. Price                       |

