# PACIFIC SOUTHWEST
# Forest and Range
# Experiment Station



FOREST SERVICE
U. S.DEPARTMENT OF AGRICULTURE
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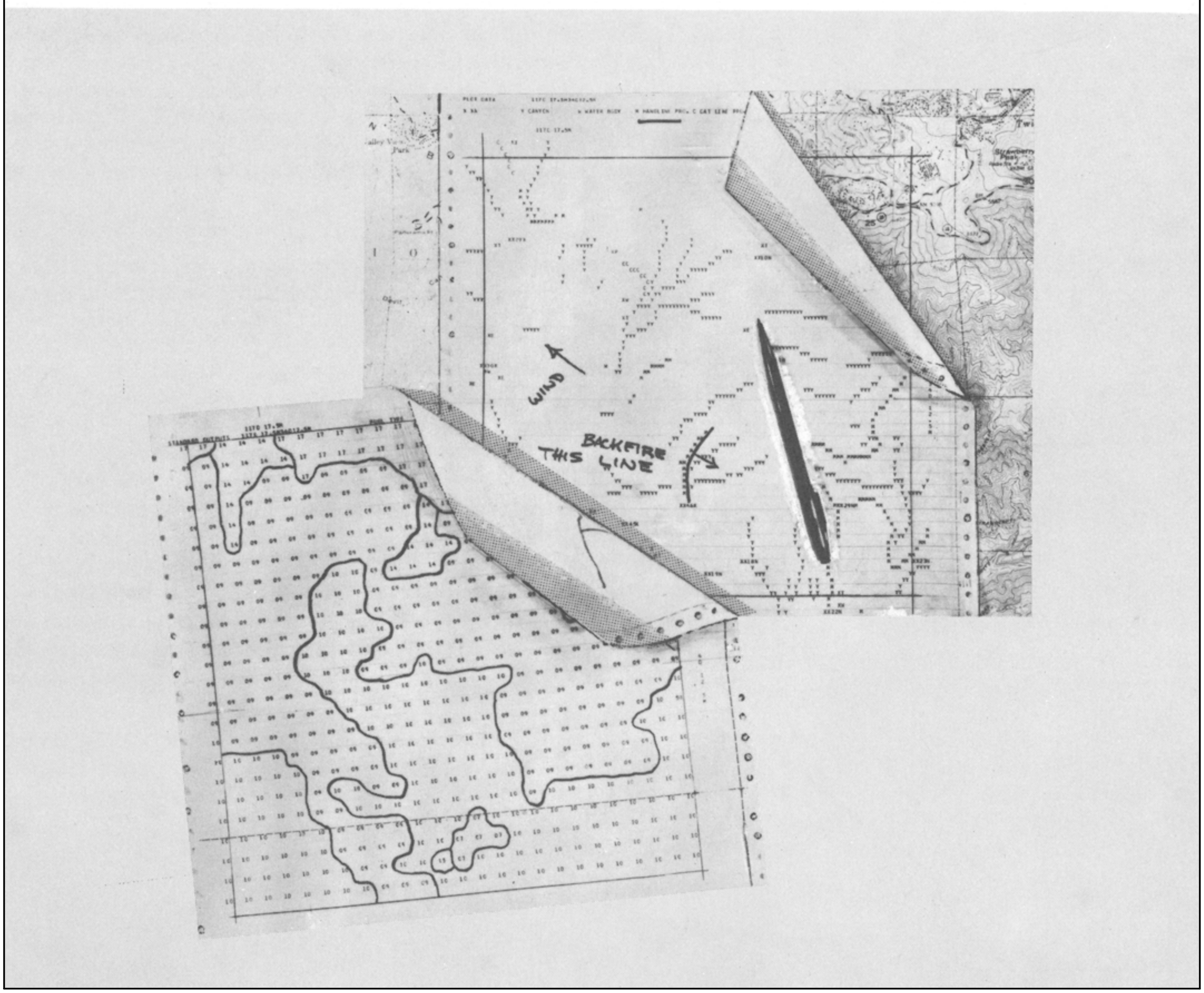
# INFORMAP . . .
## a computerized information system for fire planning and fire control


Theodore G. Storey    Ross D. Carder    Ernest T. Tolin



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INFORMAP (Information Necessary for Optimum Resource Management and Protection) is a computerized system under development for storing, manipulating, retrieving, and displaying data for fire planning and fire control. A prototype for planning applications has been developed and tested. It is programed in Fortran IV for the IBM 7040 computer, and displays information in tabular, narrative, or graphic form. It uses card input of data and programs. Output, also requested by punchcards, is produced by high-speed line printers. Data are coded for input, and stored on magnetic tape.

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# CONTENTS

## The Authors

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Procedures for processing data in fire planning and fire control have not changed significantly since the early 1930's, when the present methods were developed (U.S. Forest Service 1959, 1963, 1968). Data from maps, charts, and lists are still gathered, analyzed, updated, summarized, and displayed by using slow laborious hand methods. This traditional technique in planning before fire occurs limits the number of variables that can be included. And because it is slow, some information becomes quickly outdated, certain variables pertinent to the analysis cannot be included, and all possible alternatives cannot be explored. The shortcomings of current methods can be crucial in fire control manning—planned equipment-levels may be insufficient to suppress the fire, or unneeded forces may be assigned.

Traditional data-handling methods can stall the most effective control action during going fires. Manual techniques are used to dispatch crews, to delineate and update status and strategy maps, to inventory men and equipment, to allocate forces, and to assess and predict fire weather and fire behavior. But in many cases these are too slow to cope with the rapidly changing conditions—sometimes from minute to minute—in a raging fire. Unless the fire boss has up-to-the-minute data, he cannot make the soundest decisions. Needless acres may be burned and damage incurred. Human life could be jeopardized.

Instead of manual methods of data processing, the obvious alternative is machine or automated methods. New and more sophisticated fire planning and fire control systems now under development are based on computer techniques and will require compatible data for both the research and the operational phases. The volume of data needed and their complexity will be greater than that in traditional systems.

We have developed the basic framework of a computerized information system called INFORMAP, or *Information Necessary For Optimum Resource Management and Protection.* The first phase in developing this system has been completed. It consisted of work in (a) identifying the major items of data needed and the data handling requirements of fire planning and fire control, (b) designing a coding system to enter data manually for computer storage, and (c) developing and testing some of the computer programs for retrieving and updating stored data, for combining data, and for displaying results *(fig. 1).*

To test INFORMAP, we used data from a representative 50-square-mile area on the San Bernardino National Forest, in southern California, and a 60-square-mile area on the Coronado National Forest, in Arizona.

INFORMAP uses punchcards to enter, manipulate, update, and retrieve data. Storage is on magnetic tapes. A high-speed line printer in close proximity to the computer produces 12-inch square printouts. The computer program is written in Fortran IV for the IBM 7040 computer. This batch processing operation in which the computer handles one job at a time, has proved fast enough for the fire planning application of INFORMAP, but too slow for the fire control.

This paper compares INFORMAP with other information assembly and display systems, describes the concept and basic characteristics of the system, explains how it may be used in fire planning and fire control, and considers the outlook for its future development.

## INFORMATION ASSEMBLY AND DISPLAY SYSTEMS

Computerized information assembly and display systems fall into two broad classes: planning systems and tactical systems. The distinction between the two is, however, not clear cut, although tactical systems generally are more complex, require greater over-all speed of operation, and more interaction between the man and the computer. A computer is usually the heart of both a planning and a tactical system. Peripheral equipment may include line printers, plotters, listers, microfilm readers, and slide projectors for handling and displaying data.

Tactical systems must enable the decision-maker or operator, who is usually at a remote location, to ask a question or make a request of the system and receive a quick reply, i.e., to converse with the computer. The information received must be current and it must be displayed in a convenient form so that the decision maker can assimilate it as rapidly as possible. Portions of the system must be "real time," with the ability in forest fire applications for example, to compute predicted fire perimeter from data acquired by sensors or by other rapid means before the actual perimeter has changed appreciably. These requirements generally make tactical systems much more expensive than planning systems. Information systems for planning require only rapid compute-speed. Requests and replies can be made by means of relatively slow speed devices and displays can be less sophisticated than those in tactical systems.

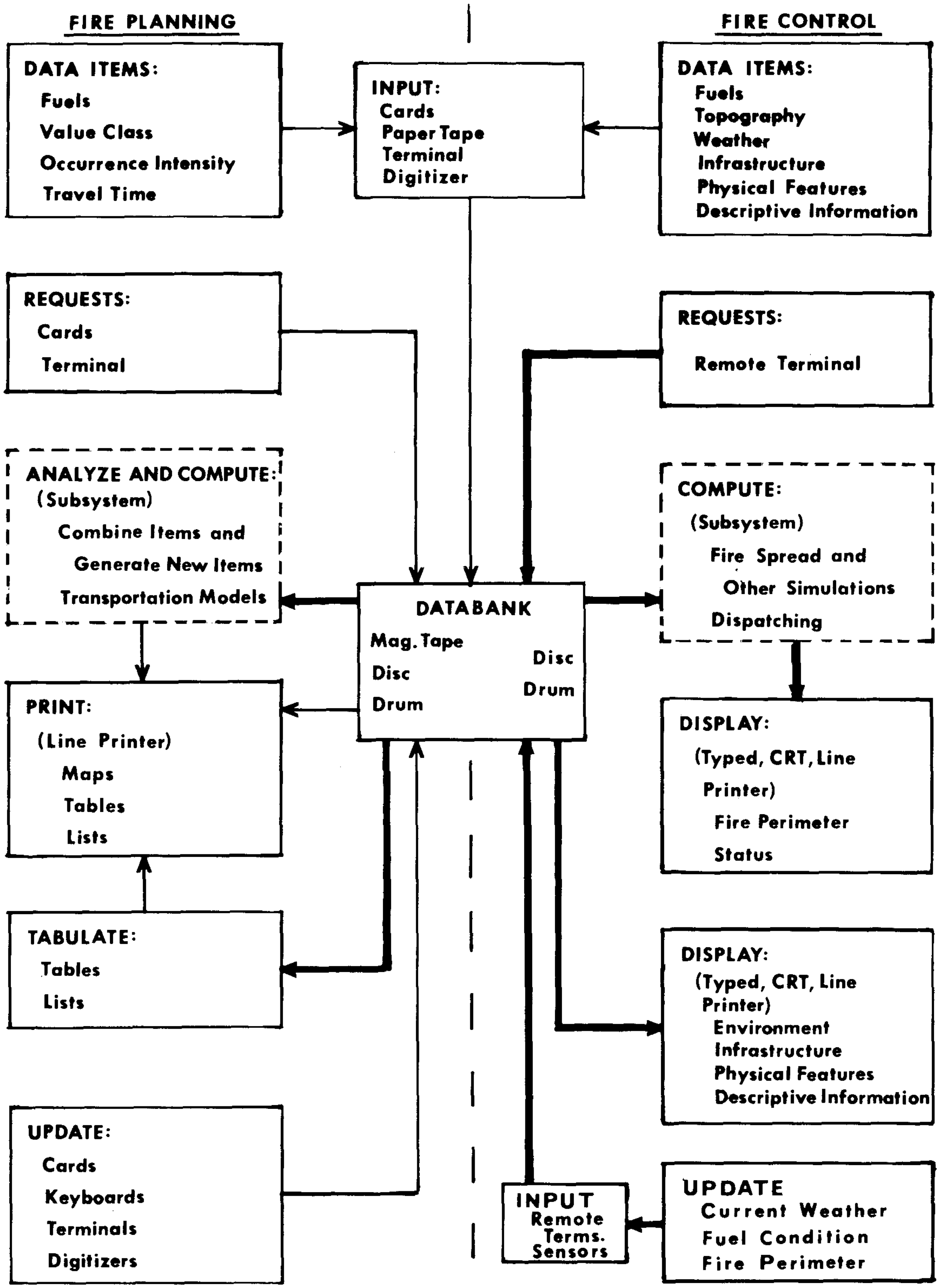



Figure 1.—*Concept of INFORMAP—a computerized system for storing, manipulating, and displaying data—as applied to fire planning and fire control. Arrows show the computer operation required and the direction of flow of data resulting from the operation; width of arrow the relative speed of operation required.*

## Tactical Systems

Probably the most advanced tactical information system is the U.S. Air Force's SAGE system of air defense (Burck 1965; Gentle 1965). SAGE, or Semi-Automatic Ground Environment, can compute and display almost instantaneously on wall-size outline maps the actual and predicted movements of aircraft and missiles anywhere in the Northern Hemisphere. Radar and other electronic sensors acquire data on the location and movement of airborne objects which are fed into computers.

Industry has developed computerized information systems to store and retrieve data. Westinghouse Electric Corporation has developed a tactical system to provide current information on production, sales, and market conditions to top management in real time (Burck 1965). Current information can also be stored and used for longer-range planning. Lockheed Aircraft Corporation also is successfully using a computerized system to control production and inventory. American Airlines' SABRE system for airlines reservations is another example of the use of a computerized system. SABRE also uses stored data to analyze traffic, flights, and profitability.

The Los Angeles City Fire Department is using computer processes to simplify and automate predetermined command and control procedures, such as dispatching, communications, inventory, retrieval, and determining status of men and equipment (Nielson and Ryland 1968). Its system does not include map digitizing and display or the ability to compute and display fire spread or other simulations.

## Planning Systems

Among the computerized planning systems in operation is a system for inventorying resources destroyed and remaining after a nuclear attack on the United States (Lewicke and Gaskill 1961). It was developed for the U.S. Office of Emergency Planning. Data are stored by a system of grid cells, and the grid is referenced to map coordinates. The system is designed primarily for inventory of physical and human resources rather than for the inventory and analysis of land use and for displaying map locations of geographic features, roads, and developments. It does not operate in real time.

Probably the most advanced system for actual inventory and display of land use and resources is being developed for the Canadian Government's inventory program (Tomlinson 1967). Named GeoIS (for Geographic Information System), it includes an automatic scanning device, an XY digitizer, and an IBM System/360 Model 65 computer.

An example of an operational computerized system for wildland management planning information is MIADS2 (Map Information Assembly and Display System) (Amidon 1966). Area-type map information is coded by rectangular cells and punched on computer cards. These data can be stored, updated, summarized, and multiplied by factors in the computer. Results can be displayed by computer line printer as maps, lists, or tables. MIADS2 is adequate for fire planning, but we consider the 2-code spaces per cell and the 2-digit codes too limited for fire control applications and for multiple-use management involving many forestry activities. The second limitation of MIADS2 for our purpose is that data are not referenced to a map coordinate system. A referencing system is particularly vital for conversational, real-time remote terminal operations, as for example, during a fire. The third limitation is this lack of real-time random access capability. Random access of data files in the computer is essential to meet the time requirements of INFORMAP.

Several computerized contour digitizer systems to speed the preparation of contour maps have been developed (Konecny and Refoy 1968; Stoll 1968; Shepherd 1968). This type of equipment shows promise for speeding the coding of data for INFORMAP.

# STATUS OF INFORMAP

## In Fire Planning

INFORMAP for fire planning is a batch processing operation, because a fire planning system does not require the rapid turnaround and processing time of a tactical system.

INFORMAP uses most of the data items now used in Forest Service fire planning, designating them as Fire Environment Item codes. Items include land value class, fuel hazard zone, and past fire frequency. INFORMAP can sum acreages of one item at a time, by classes, and print the sums in tabular form. It can produce as 12-inch square printouts from one to five of the items—one at a time or in combination. The printouts match the scale of the standard Forest Service base map, and are automatically aligned to the standard coordinate system of map references appearing on it. The system can update stored data to reflect changes.

### *In Fire Control*

For fire control applications, INFORMAP uses most of the data items needed by plans and intelligence sections, designating these data by Fire Control Item codes. Items include, roads, trails, ridges, existing handlines, firebreaks, slope, and aspect. INFORMAP produces the same type of output for fire control as it does for fire planning–12-inch square printouts. And any of the data items used in fire planning can also be used in fire control application. Data items that would change during a fire have not yet been entered into the system, such as wind speed and direction, temperature, humidity, and fire perimeter from airborne scanners.

INFORMAP's manual coding and reference methods are much too slow for updating items that change during a fire. Magnetic tape is unsatisfactory for bulk data storage because it cannot be manipulated with the speed and flexibility necessary for fire control systems. Requesting computer output by punchcards is unsatisfactory for the same reasons, though the high-speed line printer is itself satisfactory for producing the output. But a wider choice of output devices and forms of display is needed; this is being studied. We are also still unable to generate printouts from a remote terminal.

The need for an information system that can operate from remote terminals or computers is essential in fire control operations. The operator should be able to interrupt the computer by using simple, conversational commands and have it work on his job and return the results to him quickly. And he should be able to update the many quickly changing variables in a fire situation with equal speed. Items in the program should be accessible to subprograms for computing fire perimeters and other tactical situations. And the results must be available before the actual perimeters have increased appreciably.

## CHARACTERISTICS OF INFORMAP

The basic operations of INFORMAP consists of coding, storing items of information, and retrieving and printing out these items. The following procedures apply to INFORMAP for fire control and for fire planning, unless noted otherwise.

### *Coding and Referencing*

#### Overlay for Coding

A grid overlay is placed on the map to be coded. Coding is done manually using prescribed characters. The overlay is divided into *Dataspaces, Datacells,* and *Matrixes.*

The *Datacell,* the basic building block, contains 15 *Dataspaces* arranged in three rows of five spaces each–filled by a code character. The character is printed out in the same position that it was entered. A *Matrix* or data module, consists of 576 Datacells (24 Datacells wide by 24 high) and 8,640 Dataspaces (576 Datacells x 15 Dataspaces per Datacell). Therefore, 8,640 Dataspaces or characters must be coded per *Matrix* provided all Dataspaces are used.

INFORMAP presently contains two "sets" of data, one each for fire planning data items and fire control data items. The two sets use different codes, must be coded on separate overlays, and double the amount of coding required to 17,280 characters per *Matrix.* Additional sets can be added as the need arises by changing the programing. The data in each set are handled differently in the computer.

#### Codes

Each set of data in INFORMAP has a theoretical maximum capacity of $(48)^{15}$ or $1.66 \times 10^{25}$ codes using all possible combinations of the 15 Dataspaces in a Datacell and the 48 alphanumeric characters available in the standard character set of the computer line printer. However, codes 15 characters long are difficult to handle and interpret. For the present we have limited to four characters the maximum length of code for any single item in INFORMAP. For example the 11 data items in the fire planning set are assigned to specific single Dataspaces (7 items) or to pairs of Dataspaces (4 items) among the 15 available in the Datacell. And each is assigned a limited number of single-character code or 2-character code, described in detail later. Thus, fire planning INFORMAP as now programed provides for only 9,552 possible combinations per set (7 items X 48 characters + 4 items X $(48)^2$ characters) instead of the $1.66 \times 10^{25}$ combinations theoretically available.

So far as possible codes for each item were given mnemonic value or were made identical to the standard numbers, letters, or symbols used on maps and lists in fire management. This way, the codes are more easily interpreted when printed or displayed. For example, the 17 fire fuel types recognized by the California Region of the Forest Service are coded from 01 to 17. And the fire control item Highway is assigned the code character H.

## Card Preparation

Data and programs are entered by punch cards. One row of a Matrix representing 120 Dataspaces or characters (5 columns per Datacell X 24 Datacells per Matrix) is keypunched on two cards. Each Matrix requires 144 cards (2 cards per row X 3 rows per Datacell X 24 Datacells per Matrix). Each square mile on a map requires 960 Dataspaces of codes, or 16 punchcards.

## Referencing System

Each Matrix is referenced to latitude and longitude by the California Coordinate System (CCS) of map reference, part of the United States Coordinate System (Mitchell and Simmons 1945; *fig. 2*). Most National Forest base maps are marked at 2-1/2-minute intervals on the CCS scale. At the map scale adopted for INFORMAP, one or more of these references marks for latitude and longitude are in each Matrix. The marks are coded on the border of each Matrix and are printed out. Matrixes are called out of storage by their coordinates. For example, a fire manager wanting information on conditions in the vicinity of a certain fire would ask for the information by specifying to the computer the nearest latitude and longitude marked on the map and names of the items of information desired.

## Map Scale

For convenience in developing INFORMAP, a map scale of 4 inches = 1 mile, an area coding minimum of 10 acres, and a Matrix size of 5,760 acres, or 9 square miles, have been adopted as standard *(fig. 2; table 1).* At this scale, 10 acres or one Datacell is represented by a square 1/2 inch by 1/2 inch on both the map and computer printout. A Matrix is represented by a square 12 inches by 12 inches or 24 Datacells by 24 Datacells on both the map and printout, or 3 miles by 3 miles ground measurement.

The coding minimum (10 acres) exactly matches the dimensions of the Datacell on the coding grid and on the computer printout. There is also space for an adequate number of coding items, and for entering code by hand in each Dataspace. For use in orienting and interpreting the printout, particularly in fire control applications, it usually is necessary to overlay it on the corresponding National Forest topographic base map. It is most convenient if both are of the same scale rather than resorting to optical projection devices to match scales.

As the first step in preparing data for coding, assemble the necessary map data and enlarge or reduce the maps as necessary to the standard 4 inches = 1 mile scale. Next, prepare a grid overlay for hand coding the map data. Each Dataspace on the overlay grid for coding is 1/10-inch wide by 1/6-inch high.

But any coding minimum can be used for INFORMAP. Table 1 is a partial listing of map scales and corresponding ground dimensions and areas for the standard-sized 1/2-inch by 1/2-inch Datacell and the 12-inch by 12-inch Matrix. A smaller coding minimum yields greater precision—a desirable characteristic in fire control applications of INFORMAP, particularly for fire spread simulations and displays of fire perimeters.

The scale of the grid overlay for coding can be matched to the map scale rather than the other way around. But we do not recommend it be done. Computer printer output can be programed to a

Table 1.—*Datacell and Matrix dimensions for various map scales for the standard-sized coding overlay and computer output*

| Map scale | Datacell | | Matrix | |
|---|---|---|---|---|
| | Length of one side | Area | Length of one side | Area |
| | | *Acres* | | *Acres* |
| 8 inch = 1 mi. (1:7,920) | 5 chains (330 ft.) | 2.5 | 120 chains (1.5 mi.) | 1,440 |
| [1] 4 inch = 1 mi. (1:15,840) | [1] 10 chains (660 ft.) | [1] 10 | [1] 240 chains (3 mi.) | [1] 5,760 |
| 2 inch = 1 mi. (1:31,250) | 20 chains (1/4 mi.) | 40 | 480 chains (6 mi.) | 23,040 |
| 1 inch = 1 mi.(1:62,500) | 40 chains (1/2 mi.) | 160 | 960 chains (12 mi.) | 92,160 |
| 1/2 inch = 1 mi. (1:125,000) | 80 chains (1 mi.) | 640 | 1,920 chains (24 mi.) | 368,640 |
| 1/4 inch = 1 mi. (1:250,000) | 160 chains (2 mi.) | 2,560 | 3,840 chains (48 mi.) | 1,474,560 |

[1]Standard for developing INFORMAP.

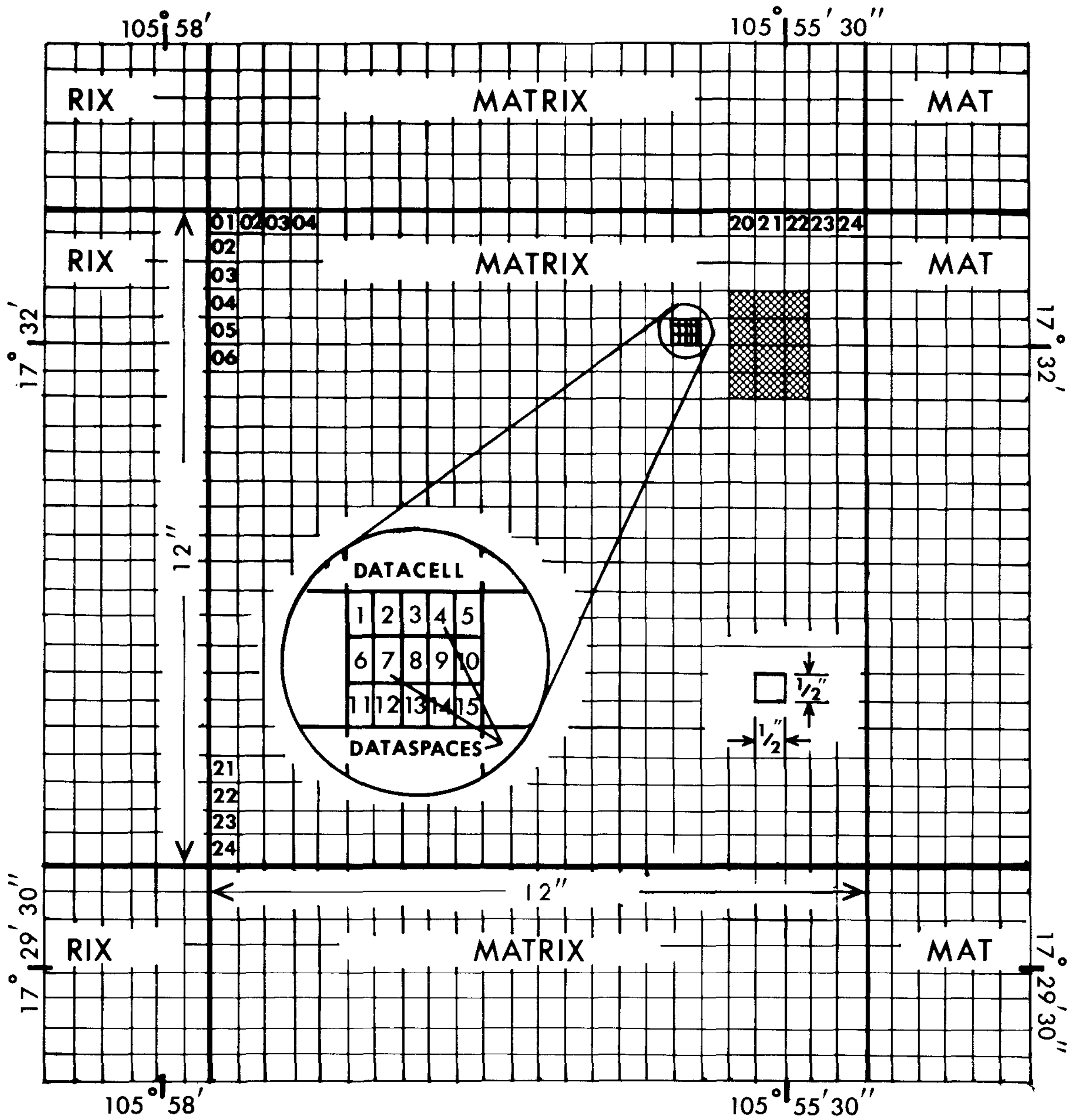



Figure 2.—*Processing data for INFORMAP starts with coding each data item in one or more Dataspaces. Each Datacell has 15 such spaces. Each 12- by 12-inch Matrix consists of 576 Datacells. Printouts are in Matrix form and size. Shaded area is shown coded in fig. 3.*

limited number of other scales by printing in every other space, every third space, etc. This procedure results in insufficient resolution, however, for most fire uses.

## Coding

Data are entered into INFORMAP initially by hand coding. However, once the data are in the system, they can be updated rather easily. Many items never change and others change infrequently or slowly.

In the future, it may be possible to use rapid, automatic, electronic methods—such as digitizers and scanners—for coding and inputting data into INFORMAP.

At all times in planning and coding, it is important to keep in mind the needs of the fire crews and other personnel who will be using the

INFORMAP information. They need to know precisely where physical features are, such as access routes, both man-made and natural. Entries must be clear and unambiguous. Every effort should be made to assure that the basic data are accurate. And when better data become available on any item—on value classes or fire fuel types, for example—the item should be updated as soon as possible.

## Data Coded in the System

Basic data for developing and testing INFORMAP were supplied by the San Bernardino National Forest. They cover an area of approximately 50 square miles on the Cajon Ranger District. Conditions of fuel, topography, and fire incidence there are fairly typical of those in southern California's mountainous regions. Basic data were extracted from Forest base maps, all of the special maps and map overlays of items used for fire planning, and pre-attack maps and descriptions used for fire control. The data were then coded for entry into INFORMAP.

We also coded some of the same data items on about 60 square miles of the Palisades Ranger District on the Coronado National Forest, Arizona. Data were coded to a 40-acre minimum *(table 1)* rather than the 10-acre minimum used on the San Bernardino National Forest. We wanted to determine the effect of decreased precision, or larger coding minimum, on usefulness of INFORMAP for fire planning and fire control applications.

Three general types of data items are hand-coded, keypunched, and stored on tape: (a) static fire environment, (b) fire control, and'(c) library or listed information. They represent the information needed by the Forest Service in fire planning and fire control.

### Static Fire Environment Data

The eight Static Fire Environment items in INFORMAP, include slope, aspect, and resource value class *(table 2)*. Each item represents the average condition for the 10 acres. The code, consisting of one or alphanumeric characters, is assigned either one or two specific Dataspaces in the Datacell *(table 2)*.[1] The Static Fire Environment items occupy one "set" of 15 Dataspaces. Each item is divided into several classes from 6 to 76 in number, and each class is assigned a numeric code between 00 (zero) and 75 *(fig. 3)*.

[1]Lists of detailed codes for Static Fire Environment items are available upon request to Director, Pacific Southwest Forest and Range Experiment Station, P.O. Box 245, Berkeley, California 94701.

Four of the five remaining Dataspaces are used to record the coordinates of the particular Datacell in the Matrix: the row in the left-hand pair of Dataspaces and the column in the right-hand pair. This arrangement permits locating a particular Datacell in a Matrix.

The center Dataspace can be used to code Ownership or can be reserved for Fire Perimeter when a fire-spread simulation subprogram is developed. If reserved for fire perimeter, it is to be left blank when coding the other items. Additional Fire Environment items can be added when needed by setting up additional "sets" of Datacells and assigning Data-spaces and codes.

Code all Static Fire Environment items on a blank grid overlay of Datacells and Dataspaces to the appropriate 4 inches = 1 mile base map. A grid one Matrix in size—12 inches by 12 inches, 3 miles by 3 miles ground measurement—has been adopted as standard *(fig. 2)*. This size is easy to handle for hand coding and is the unit used for keypunching the coded data into cards.

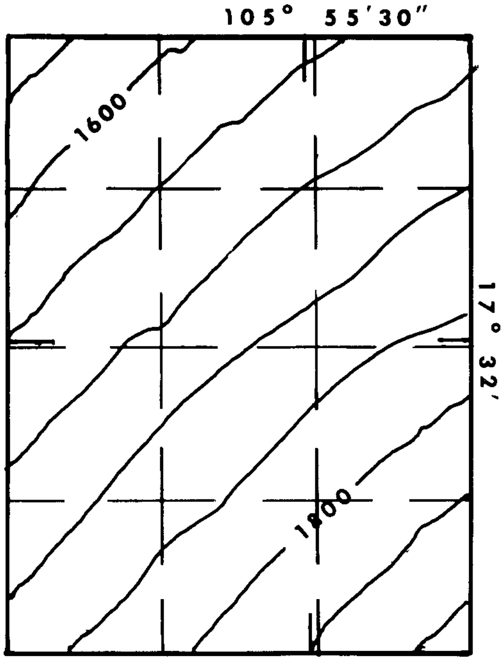
### Fire Control Data

The 41 Fire Control items now in INFORMAP are grouped in four categories: Pre-Attack, Infra-structure (highways, roads, etc), Physical, and Other items *(table 3)*. The name Fire Control items was assigned for convenience in distinguishing them from Fire Environment items. Either class of items may be useful in planning and in fire control, and are accessible to programs for planning and control.

The Fire Control items occupy the second "set" of 15 Dataspaces in INFORMAP. These items are coded in the nearest Dataspace(s) to their actual map location. Since each Dataspace represents 2/3 acre (10 acres per Datacell divided by 15 Dataspaces per Datacell) on the ground, the precision of any

Table 2.—*Static Fire Environment items and assigned positions*

| Dataspace number in Datacell | Static fire environment item |
|---|---|
| 1 | Average slope |
| 2 | Aspect |
| 3 | Past fire frequency |
| 4 and 5 | Average elevation |
| 6 and 7 | Datacell coordinate in Matrix (row) |
| 8 | Ownership *or* fire perimeter |
| 9 and 10 | Datacell coordinate in Matrix (column) |
| 11 | Resource value zone |
| 12 | Occurrence intensity zone |
| 13 | Fuel hazard zone |
| 14 and 15 | Fuel type |




BASE MAP

## CODES

**Average Slope**

| Code No. | Percent |
|---|---|
| 0 | 0-9 |
| 1 | 10-19 |
| 2 | 20-29 |
| 3 | 30-39 |
| 4 | 40-49 |
| 5 | 50-59 |
| 6 | 60-69 |
| 7 | 70-79 |
| 8 | 80-89 |
| 9 | over 100 |

**Average Aspect**

| Code No. | Description |
|---|---|
| 0 | North |
| 1 | East |
| 2 | South |
| 3 | West |
| 4 | Northeast |
| 5 | Southeast |
| 6 | Southwest |
| 7 | Northwest |
| 8 | Ridgetop |
| 9 | Flat |

**Average Elevation**

| Code No. | Amount (200's of feet) |
|---|---|
| 00 | 0 - .5 |
| 01 | .6 - 1.5 |
| 02 | 1.6 - 2.5 |
| ⋮ | ⋮ |
| 75 | 74.6 - 75.5 |

CODED OVERLAY

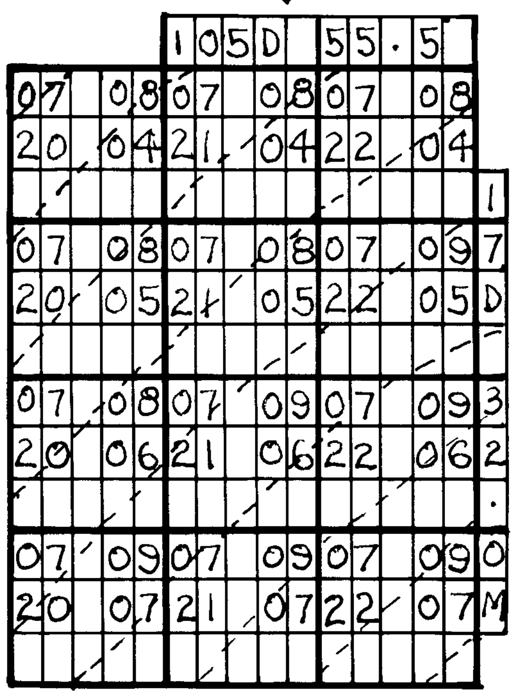


Figure 3.—*Static Fire Environment items of slope, aspect, and elevation; Datacell coordinates; and Matrix coordinates are coded for a portion of one Matrix (shaded area in fig. 2).*

Pre-Attack item is 2/3 acre. Any of the 15 Dataspaces can be used to record data.

As many Dataspaces as necessary should be coded to show accurately the position of the particular feature. For example, a road (Infrastructure) traversing a Datacell might be coded in five adjacent Dataspaces, all with the same symbol. On the other hand, a helispot might require only one Dataspace. Occasionally, when several features occur in one Datacell, it may be necessary and desirable to arrange the coding so that all features are represented. This may mean omitting some of the string of code symbols—for a road or trail, for example—and coding in a helispot location. The coding should be done so that each feature is clearly identifiable—just like an actual map *(fig. 4).*

Table 3.—*Fire control items and codes*

| Code symbol | Item |
|---|---|
| | PRE-ATTACK |
| C | Tractor line – proposed |
| D | Tractor line – existing |
| F | Tractor line and all-wheel drive – proposed |
| G | Tractor line and all-wheel drive – existing |
| M | Handline – proposed |
| N | Handline – existing |
| I | Firebreak – tractor |
| J | Firebreak – all-wheel drive |
| K | Firebreak – hand |
| A | Outline of barrier |
| / | Boundary of blocks |
| V | Dead-end of C,D,F,G,M,N,I,K |
| XT | Tractor loading location |
| XW | Water source – existing |
| XP | Helispot – proposed |
| XE | Helispot – existing |
| XL | Helispot – all size helicopters |
| XR | Heliport – proposed |
| XH | Heliport – existing |
| XC | Fire camp |
| XA | Staging area |
| XS | X spot (rocks, etc.) |
| XG | Guard station |
| XR | Ranger station |
| XD | Equipment depot |
| | INFRASTRUCTURE |
| H | Highway |
| R | Road |
| T | Trail |
| L | Railroad |
| P | Power line |
| Q | Telephone line |
| U | Deadend of R, T |
| | PHYSICAL |
| E | Ridge |
| S | Stream, river, canal |
| W | Water body outline |
| Y | Canyon or draw bottom |
| PK | Peak |
| RS | Reservoir |
| | OTHER |
| XX | Referenced intersections of fire control features and infrastructure |
| Z | Latitude and longitude information, 2-1/2 minute increments |

Fire Control items are not broken down into classes as was done with Fire Environment items. Such a division is not necessary for planimetric features.

*Pre-Attack items.*—Many of the National Forests, particularly in the California Region, prepare fire pre-attack plans which describe such fire control points as ridge tops and fuel-breaks that are potentially defensible as firelines, water sources, and tractor unloading sites. The 25 Pre-Attack items in INFORMAP *(table 3)* include all of the data items used for such pre-attack planning.

Pre-Attack items can be coded directly from the pre-attack maps onto the INFORMAP grid overlay provided the scales match *(fig. 4).* If scales do not match, the map will have to be brought to the standard 4 inches = 1 mile scale. Usually, the pre-attack items are delineated on the standard Forest topographic base map. Four categories of Fire Control items could then be coded at one time.

*Infrastructure items.*—All seven Infrastructure items (roads, trails, etc.) are planimetric map-type items similar to many of the Pre-Attack items *(table 3).* Most of these items are shown on the Forest base map. They can be coded directly on the grid overlay, provided the map scale is correct *(fig. 4).*

*Physical items.*—Six Physical items are now incorporated in INFORMAP *(table 3).* Included are ridge, stream, etc. All are shown on the Forest topographic base map. They can be coded directly on the INFORMAP grid overlay, provided the map scale is 4 inches = 1 mile *(fig. 4).*

*Other items.*—Two items of miscellaneous or supplemental information are included in INFORMAP *(table 3)*, and each is coded in its exact map location. Referenced intersections of Pre-Attack items and Infrastructure mark, for example, the termini of a preplanned Handline. "Z" designates latitude and longitude information for orienting printed INFORMAPs on Forest base maps. Both latitude and longitude are coded on the grid overlay so that the actual coordinate line passes between the degree and minute symbols *(figs. 3,4).*

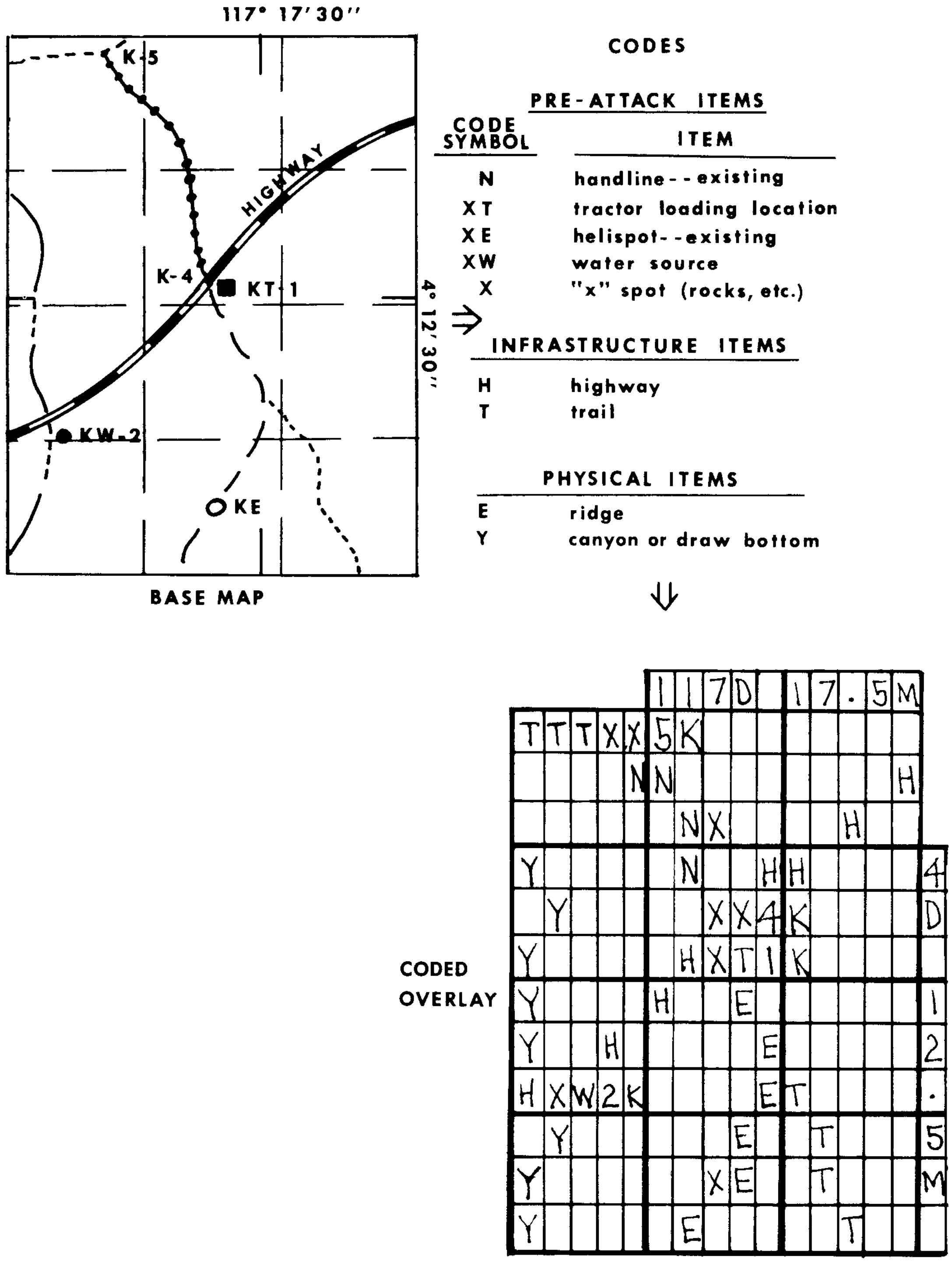



Figure 4.–*Nine Fire Control items plus Matrix coordinates of latitude and longitude are coded for a portion of one Matrix in pre-attack block "K."*

## Library Data

The one type of Library or listed information in INFORMAP has data on pre-attack line, fire camp locations, tractor unloading locations, and other items shown in the pre-attack maps prepared by the National Forests. It provides supplementary data on the Pre-Attack items described earlier; for example, the length, slope, difficulty of building a line, and type of force required, are listed for specific sections of fireline. Library Information is highly useful for fire control applications. This information is a reproduction of the pre-attack books, uses similar format, and is available from the Forest for coding.

# *Output from the System*

## Requests for Data

To obtain INFORMAP printouts or a listing of Library Information, the user need only know what information he wants out of the system, the proper commands to use, and how to punch and enter cards in the card reader. Major command words used are: "STANDARD OUTPUT" for Static Fire Environment items, "PLOT DATA' for Fire Control items, and "LIST DATA" for Library items. If one of these key words is not found in the input cards, the computer immediately tells the operator that he has made an impossible request. The program then branches back to the starting position and is ready for a new command.

## Printouts

Printouts are produced one at a time as 12- by 12-inch Matrix. These modular units can be used individually or joined together to form map overlays of larger areas *(fig. 5)*. Fourteen-inch-wide computer line printer sheets can easily accommodate the size of the Matrix.

Static Fire Environment items ordinarily will be called for and printed one at a time; occasionally two at a time. Additional items are best called for and printed separately. Since the printer paper is translucent, two printouts can be overlaid one on the other and on base maps for comparing features. The separation makes them easier to assimilate.

To obtain Static Fire Environment information, the fire planner needs only know the longitude and latitude (nearest 2-1/2 minutes) of the area that he

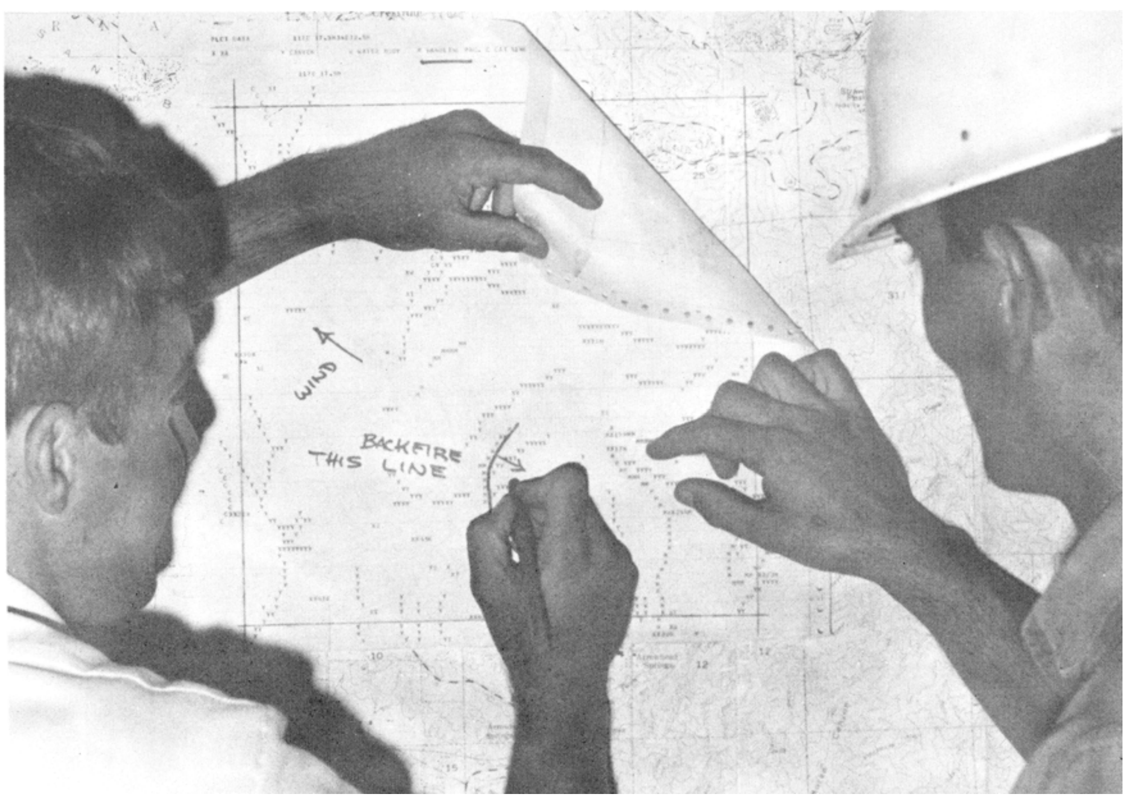



Figure 5.—*INFORMAP printouts of selected Fire Control items can be used as overlays to base maps.*

desires to look at. Then, using the computer card reader, the operator enters the command words, “STANDARD OUTPUT,” and the longitude and latitude. Next, if he desires to see the fuel types for this area, for example, he simply enters the command words, “FUEL TYPE.” The computer then searches the magnetic tape until it finds the proper area. The requested data is then printed out on the high-speed line printer in the following order: latitude and longitude requested, the words “STANDARD OUTPUT,” and the words “FUEL TYPE.”

The fuel types for the area are then printed out *(fig. 6)*. Printouts may be used directly as maps or as scale overlays to a standard Forest Service base map. Fuel type boundaries may be delineated by hand if desired *(fig. 6).* The Datacell Coordinates can be printed just below the fuel type data in each Datacell. This printing is for reference purposes only and may be eliminated by entering the word “SUPPRESS” immediately behind the command words “FUEL TYPE” *(fig. 6).* Map coordinates latitude and longitude are printed out on the right-hand and top margins, respectively, in their proper map locations to aid in orienting the INFORMAP on the base map.

The second type of data which the program handles is designated Fire Control items. Data are also plotted on the high-speed printer. The user may actually plot to map scale such map features as highways, roads, trails, and power lines *(figs. 5,7).*

Since Fire Control items involve patterns and pattern recognition more items can be assimilated at one time. Up to five items can be called up or plotted at one time, except for Pre-Attack items prefixed by the symbol “X” *(table 3).* These are all printed out whenever any one of them is requested. Fire Control items cannot be summed, combined, tabulated, or

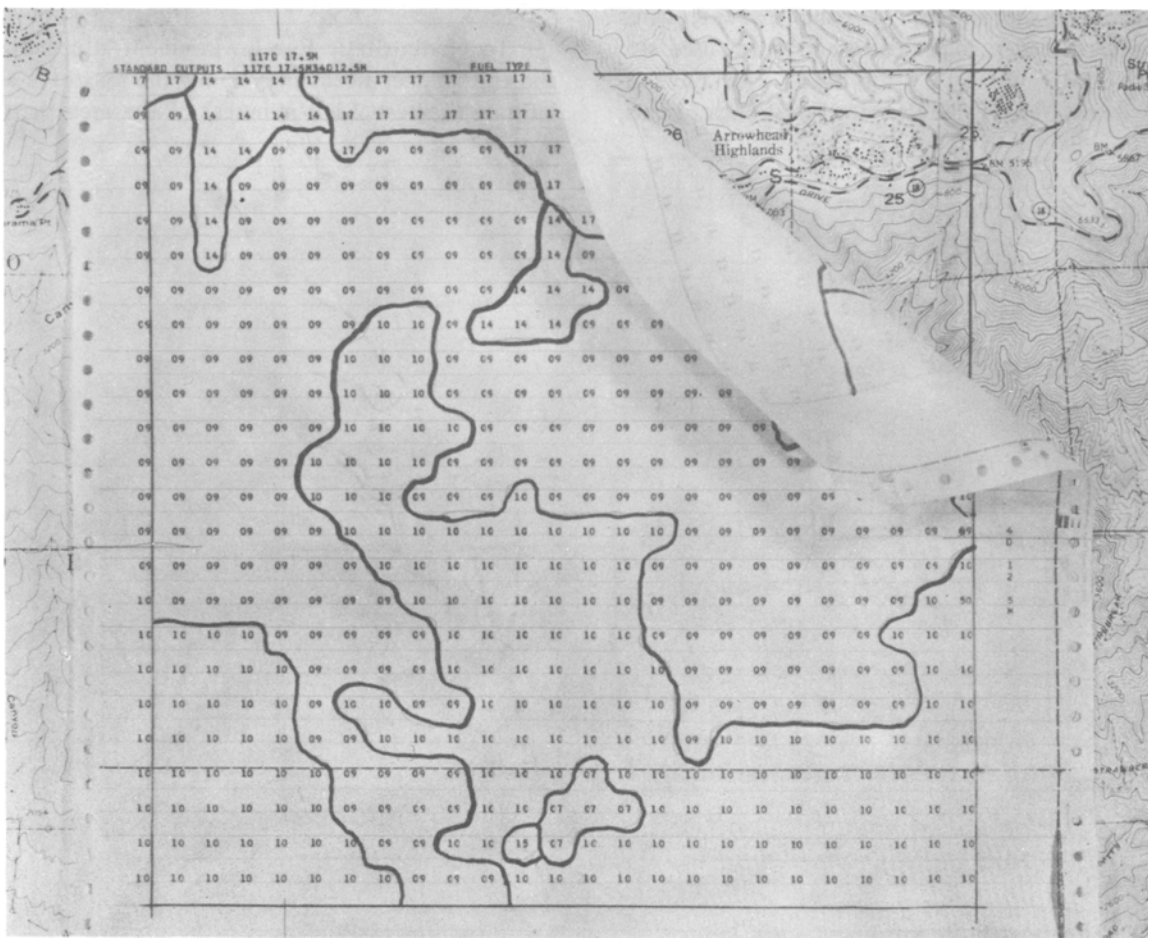



Figure 6.—*Computer line-printer display of one Matrix of the Fuel Type from Fire Environment items. Type boundaries have been delineated by hand for emphasis.*

otherwise manipulated as was the case with Static Fire Environment items.

To obtain information on Fire Control items, a fire planner would enter by cards the command words "PLOT DATA," give the longitude and latitude of the area he wished plotted, and name the features that he wished to plot. For example, if he wished to plot trails, roads, staging areas, highways, and proposed cat lines, he would merely enter the command words "TRAILS," "ROADS," "XA," "HIGHWAYS," and "CAT LINE PRO" (for proposed). The computer would then answer, printing out the longitude and latitude of the area requested and a scale map overlay of the requested items, represented by assigned symbols *(fig. 7).* For example, highways are represented by the letter H, roads by the letter R, and trails by the letter T. If a requested item does not exist in the given map section (i.e., roads), it obviously would not show on the map overlay.

The third type of data is pre-attack information in verbal form—all the information about pre-attack blocks that has been collected by the National Forest. Information on up to ten blocks can be given in one interrogation.

Typical information desired might be locations of water, fire camps, and tractor unloading sites; and characteristics of length, slope, and the fuel resistance to control of a certain section of line. To retrieve this information from the computer, the interrogator need only enter by means of cards the command words "LIST DATA," and give the specific code for the pre-attack block for which information is desired. For example, if he wanted to know everything about lines $N_1$ to $N_2$, $N_1$ to $N_3$, and $N_3$ to $N_4$ in the N block, he would simply enter the code, "N BLOCK,"

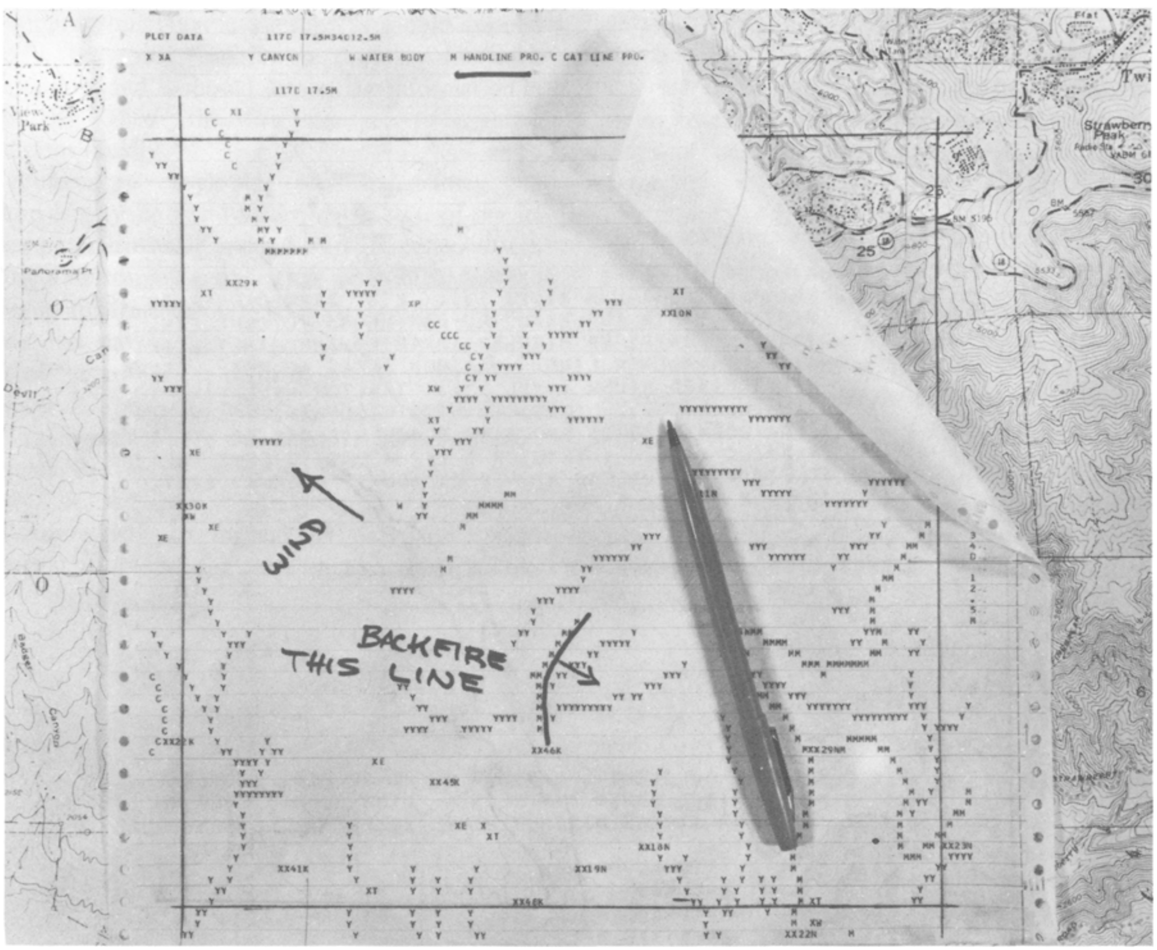



Figure 7. -*Computer line printerdisplay of five Fire Control items: All X-type Pre-Attack items (X), canyon (Y), water body (W), handline (M), and cat line proposed (C).*

and "FILES REQUESTED." The computer would proceed to print out all data that it had about these lines *(fig. 8).* In our example, the databank contained no information on line $N_1$ to $N_3$, so this request could not be filled.

## Sumations and Updating

The ability to sum, by acreage, and to combine items of data is vital in fire planning and fire control. Acreages of any Dataspace in INFORMAP can be summed, but acreage summaries are not useful for Fire Control-Type items.

Information in the INFORMAP system can be updated rapidly for any reason; for example, fire-induced changes in the fuel type. If the longitude and latitude of a given matrix are known, a new deck of cards containing the changes is punched. The only data that appear on these cards are the desired changes. The updated data are then read by the card reader, and the desired changes are made automatically on the magnetic tape.

```
FIRE PRE-ATTACK

N BLOCK


FILES REQUESTED

   1 TO  2

   1 TO  3

   3 TO  4


( 1 TO  2)


N1 TO N2        20 CHAINS OF HANDLINE   MAXIMUM SLOPE 80 PCT.  COVER -
                      HEAVY MIXED BRUSH (TYPE 13).  LINE BURNED OVER IN 1954.
                      MINIMUM WIDTH 10 FEET.  40 MAN HOURS TO COMPLETE.
                CREW TRAVEL   DRIVE UP HIGHWAY 18 TO N2 AND START WORK.
                30 CHAINS OF TRACTOR LINE   MAXIMUM SLOPE 60 PCT.  COVER -
                      HEAVY MIXED BRUSH (TYPE 13).  TRACTOR WILL HAVE TO WORK
                      DOWN HILL ONLY.  ALSO, TRACTOR WILL HAVE TO SWITCH
                      BACK DOWN EAST OF RIDGE TO REACH HIGHWAY 18 AFTER COM-
                      PLETING LINE.  1 TRACTOR 1 1/2 HOURS TO CONSTRUCT.
                TRACTOR TRAVEL   UNLOAD AT NT1 BY COUNTY HIGHWAY STATION.
                      1 HOUR TRAVEL TIME.
                WATER   NW1 AND NW2
                HELISPOT   NH1 PROPOSED
                FIRE CAMP   NFC1 AND NFC2


( 3 TO  4)


N3 TO N4        26 CHAINS OF HANDLINE   MAXIMUM SLOPE 60 PCT.  COVER -
                      HEAVY MIXED BRUSH (TYPE 13).  LINE BURNED OVER IN 1955
                      ON SOUTH SIDE.  MINIMUM WIDTH 10 FEET.  50 MAN HOURS TO
                      COMPLETE.
                CREW TRAVEL   TO N3 OR N4.
                WATER   NW1 AND NW2
                HELISPOT   NH1 PROPOSED
                FIRE CAMP   NFC1 AND NFC2
```

Figure 8.—*Computer line printer display of Library items of supplemental Pre-Attack information for a portion of block "N."*

# FUTURE DEVELOPMENT

We have made more progress to date in developing INFORMAP for fire planning than for fire control. One reason is that the potential advantages of INFORMAP are more readily apparent in the planning application than in the control application. Also, the state-of-the-art and the development costs in computer hardware and software are more favorable for planning than for control applications. For planning, INFORMAP uses stored items directly in a batch process to prepare maps and summary tabulations. And it does so faster and with less work than present methods of data processing. The hardware and software to accomplish this on a research basis are presently within our means.

For fire control applications, however, the system also needs to use stored data indirectly, for example, to compute fire perimeter, to determine how to allocate fire suppression forces, to simulate fire suppression action and results. It should respond quickly (in "real time") to requests for such information, and it should display the information in ways that allow the fire manager to evaluate conditions rapidly.

Progress in developing such capabilities will depend largely upon advances in the state-of-the-art in computer hardware and software. Experience with coding and computer operation of INFORMAP for planning applications on the San Bernardino National Forest has shown that we are already pushing the state of the art for fire control operations. Moreover, we must recognize that adoption of a computer-based fire intelligence system will require a special effort to acquaint fire managers with such unfamiliar techniques. It is likely that costs in fire control applications will be higher not only for system operation, but also for research and development, than in planning applications.

Long-range plans for development include work to:

- Add and code more Static Fire Environment, Fire Control, and Library data items as the need for them is identified. We also intend to keep in mind the types of data and manipulations required in applying INFORMAP to other resource management purposes.

- Identify and code Dynamic Fire Environment data items, such as speed and direction of wind, temperature, humidity, fire danger–all of which may change rapidly during a fire and are vital in evaluating fire behavior. These data are needed in subprograms of fire spread and other simulations.

- Investigate electronic digitizers, scanners, and remote sensors for speeding up data input and for updating stored data.

- Improve the programing to compute the intersection of three or more Static Fire Environment items instead of summing only one item; for example, acres of past fire frequency by resource value by slope.

- Investigate, acquire, and adapt to INFORMAP wherever possible, existing database and mapping programs developed by others.

- Develop and test methods for system operation through remote terminals or computers in a fire camp.

- Fit INFORMAP displays to needs of fire intelligence, including means of enlarging and projecting maps produced by computer systems, overlaying base maps, and copying printouts for distribution to field crews.

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*Retrieval Terms:* fire control systems; fire planning systems; real time systems; batch systems; INFORMAP; computer programs.

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