United States
Department of
Agriculture

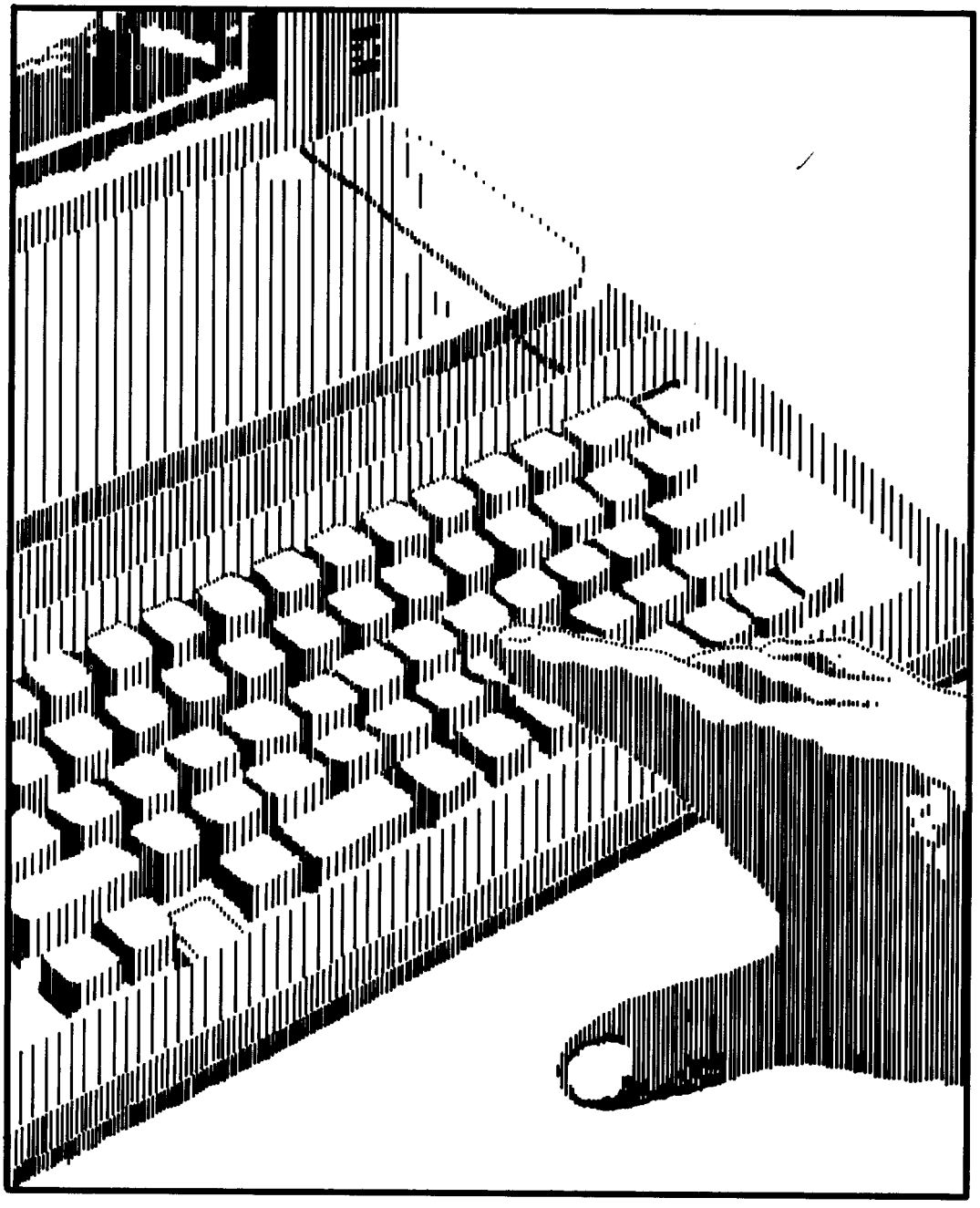
Forest Service

**Pacific Southwest
Forest and Range
Experiment Station**

General Technical
Report PSW-90

Estimating Fire Behavior With FIRECAST: user's manual

Jack D. Cohen



The Author:

JACK D. COHEN, a research forester, earned a bachelor of science degree (1973) in forest science at the University of Montana, and a master of science degree (1976) in biometeorology at Colorado State University. He joined the Station's staff in 1979, and is now assigned to the Chaparral Prescribed Fire Research Unit, headquartered at Riverside, California.

Publisher:

Pacific Southwest Forest and Range Experiment Station
P.O. Box 245, Berkeley, California 94701

May 1986

Estimating Fire Behavior With FIRECAST: user's manual

Jack D. Cohen

CONTENTS

Preface

I first worked on FIRECAST at the Intermountain Station's Northern Forest Fire Laboratory in Missoula, Montana, in 1978, when there was initial user interest in a national fire behavior program. This original FIRECAST fire behavior program was an expanded version of the southern California FIREMOD computer program.* Despite major improvements to the FIRECAST program and encouraging test operation, official development of the program was stopped in 1979 as a result of funding problems. Dick Harrell of the Forest Service's Pacific Southwest Region (R-5) eventually revived FIRECAST. I began redeveloping the program in 1982, at the Pacific Southwest Station's Forest Fire Laboratory in Riverside, California.

The resulting FIRECAST program offers three fuel model options to users: Northern Forest Fire Laboratory (NFFL) fuel models, National Fire Danger Rating System (NFDRS) fuel models, and southern California brushland (SCAL) fuel models. Each of these three technical routines was checked with other independent sources: the NFFL option was checked against the FIREMOD program at the Northern Forest Fire Laboratory; the NFDRS option was checked against outputs (translated for matching fire behavior) from the NFDRS Administrative and Forest Fire Information Retrieval and Management System (AFFIRMS);† and the SCAL option was checked against an independently written program at Colorado State University--a Station cooperator.

Beginning in June 1982, the FIRECAST program and a preliminary user manual were available for operational testing by Federal, State, and local agencies within the State of California. After one season, test users indicated a few operational program changes, which I made for the second season of operational testing in 1983. Users indicated a high level of satisfaction with FIRECAST, and none indicated difficulty in obtaining results.

*Van Gelder, Randall J**. A fire potential assessment model for brush and grass fuels.** Fire Manage. Notes 37(3): 14-16; 1976.

†Helfman. Robert S.: Straub. Robert J.: Deeming, John E. **Users' guide to AFFIRMS: time-share computerized processing for fire danger rating.** Gen. Tech. Rep. INT-82. Ogden. UT: Intermountain Forest and Range Experiment Station, Forest Service. U.S. Department of Agriculture: 1980. 150 p.

1. INTRODUCTION

FIRECAST is a computer program that estimates up to six fire behavior parameters: rate-of-spread, fireline intensity, flame length, perimeter and area, scorch height, and ignition component. Required inputs vary depending on the outputs desired. The program has been operationally tested for use in California.

To obtain a copy of the FIRECAST program software, send your request along with $^1/_2$-inch computer tape and any specific instructions for writing the tape to Director, Pacific Southwest Forest and Range Experiment Station, P.O. Box 245, Berkeley, CA 94701, Attention: Computer Services Librarian. We can write blocked tapes of line images in either ASCII or EBCDIC of the source codes and data. Or, if you have access to the Forest Service distributed processing system and are connected to the U.S. Department of Agriculture Departmental Network (DEPNET), you can contact SCS:S27A and request instructions for retrieving the FIRECAST files.

This report describes the components of the FIRECAST program and contains the complete operating instructions, which should be read carefully before the program is used. Although FIRECAST only *estimates* fire behavior, the outputs are more reliable when the inputs are estimated carefully.

2. PROGRAM COMPONENTS

Several different models contribute to the computational portion of the FIRECAST program. Following is a summary of the fire model components and their related outputs and required inputs.

2.1 Rate-of-Spread

The Rothermel fire spread model (Rothermel 1972) with modifications by Albini (1976a, b), provides the computational basis for rate-of-spread estimates for all the fuel model options. The rate-of-spread refers to the forward spreading (with the wind and slope), quasi-steady state flaming zone. Required inputs include the physical description of the fuel bed (fuel model), fuel moistures by size class (as related to timelag class), and windspeed and slope in the direction of forward spread.

2.2 Fireline Intensity and Flame Length

The formulations by Byram (1959) form the basis for fireline intensity and flame length. They were adapted by Albini (1976a, b) for use in conjunction with the Rothermel fire spread model. Intermediate calculations from the fire spread model and Anderson's (1969) flaming residence time relation provide the values required to derive Byram's formulation.

2.3 Perimeter and Area

Perimeter and area calculations assume that the fire shape approximates a double ellipse (Anderson 1983) based on empirical fire shape data (Fons 1940). The shape of the double ellipse varies with windspeed in the direction of fire spread. The final perimeter and area estimates require the forward spread distance.

2.4 Scorch Height

Van Wagner (1973) formulated the scorch height equation from a theoretical basis and correlated the theoretical prediction with lethal scorch found in several northeastern tree species. The scorch height equation requires the windspeed and ambient temperature roughly at the flaming level. The fireline intensity requirement is supplied by the calculated fireline intensity.

2.5 Ignition Component

The ignition component, from the National Fire Danger Rating System (Deeming and others 1977), is based on Schroeder's (1969) formulations of the requirements for a theoretical ignition. Assumptions include a sufficiently energetic fire brand and available fine fuels for ignition. The NFDRS treats only the reportable fire situation. Ignitions that do not result in fires sufficient for detection are of no concern. The rate-of-spread serves as a measure of fire reportability: the higher the spread rate, the greater the chance of discovery. Further information on the ignition component can be found elsewhere (Bradshaw and others 1983, Cohen and Deeming 1985). Ambient temperature, fine fuel moisture (1-hr timelag), and the sky cover are required inputs.

3. OPERATING INSTRUCTIONS

In the following instructions, a general format is followed. Program prompts issued by the computer are in **boldface.** In most sections, examples of actual FIRECAST sequences follow the explanation. In these examples, FIRECAST prompts are in boldface and the user response is followed by the new line (carriage return) symbol ([NL]). (Every typed response to a FIRECAST prompt must be followed by pushing the new line (carriage return) key [NL].) The entire FIRECAST example run that appears in *section 4* is an illustration of what will appear on your terminal. This example has no boldface or [NL] symbols.

You access the FIRECAST fire behavior program through your particular system's procedure for accessing and running FORTRAN 77 programs.

3.1 "END"

You may type "END" after any FIRECAST prompt. The program responds with:

CONTINUE FIRECAST (Y/N)?

Typing "N" allows you to exit FIRECAST or to start the prompting sequence again from the beginning. Typing "Y" continues program processing. See *section 3.7 Continuing FIRECAST,* for an explanation of continuing FIRECAST processing.

Example 1--You are designating your display outputs, but desire to interrupt the sequence.

```
DESIGNATE THE OUTPUTS YOU DESIRE FOR THE SESSION (Y/N)
DO YOU WANT:
RATE OF SPREAD
Y [NL]
FIRELINE INTENSITY
END [NL]
CONTINUE FIRECAST (Y/N)?
```

Example 2--You are prompted to input fuel moistures, but you wish to interrupt the sequence.

```
INPUT PERCENT 1HR,10HR,100HR AND LIVE
END [NL]
CONTINUE FIRECAST (Y/N)?
```

3.2 Help Document

Immediately upon entry into FIRECAST, the program prompts:

DO YOU WANT HELP (Y/N)?

Typing "Y" yields a help document that gives a brief explanation of the appropriate responses to FIRECAST prompts. The help document is six, 23-line pages. After each page you have three options:

1. To continue to the next page, type "Y."
2. To exit out of the help document for continued FIRECAST processing, type "N."
3. To exit FIRECAST, type "END."

If you do not want the help document, type "N" and push the new line key [NL]. The next prompt in sequence will be displayed. The help document can be viewed only upon entry to FIRECAST.

[1]Trade names and commercial products are mentioned only for information. No endorsement by the U.S. Department of Agriculture is implied.

3.3 Selecting Outputs

You may choose any or all of the available fire behavior outputs for tabular display. The six available outputs are these: rate-of-spread, fireline intensity, flame length, perimeter and area, scorch height, ignition component.

Rate-of-Spread--The forward rate-of-spread is at the head of the fire front. Rate-of-spread is expressed in chains per hour. To convert to feet per minute, multiply the rate-of-spread by 1.1.

Fireline Intensity--Fireline intensity is the amount of heat in British thermal units released in the flaming front per second, per foot of fire line (Btu/ft/s).

Flame Length--Flame length is defined as the distance from the tip to the base of the burning fuel midway in the flaming front. Flame length is expressed in feet.

Perimeter and Area--Fire perimeter and area represent the fire growth rate assuming an elliptical shape. Perimeter is expressed in chains per hour, and area is expressed in acres per hour squared. To find the growth after a period of time, multiply the displayed perimeter value by the time in hours and multiply the displayed area value by the time in hours, squared. For example, after 2 hours, multiply the displayed acre rate by 4 (2 squared equals 4). Notice that the displayed values for perimeter and area are equal to the growth after 1 hour. *Caution:* do not expect reasonable estimates after long time periods or under highly variable conditions of fuels, weather, and topography.

Scorch Height--Scorch height is the height in feet above the ground where lethal foliage scorch occurs. With temperature as an input, the program calculates scorch height at temperatures other than 77 °E No temperature factor is needed as with other procedures (Albini 1976a).

Ignition Component--The ignition component is the same as the NFDRS ignition component. It represents the probability that a fire brand will ignite a fire of reportable size.

The program displays:

DESIGNATE THE OUTPUTS YOU DESIRE FOR THE SESSION (Y/N)
DO YOU WANT:
RATE OF SPREAD

If you desire this output, type "Y." If you do not, type "N." After you hit a new line, the next display output on the above list will appear. Continue entering your choices until the list is exhausted. The next prompt will be displayed.

Example 3--You desire all of the fire behavior outputs.

```
DESIGNATE THE OUTPUTS YOU DESIRE FOR THE SESSION (Y/N)
DO YOU WANT:
RATE OF SPREAD
Y [NL]
FIRELINE INTENSITY
Y [NL]
FLAME LENGTH
Y [NL]
PERIMETER AND AREA
Y [NL]
SCORCH HEIGHT
Y [NL]
IGNITION COMPONENT
Y [NL]
```

Example 4--You want only rate-of-spread, flame length, and ignition component.

```
DESIGNATE THE OUTPUTS YOU DESIRE FOR THE SESSION (Y/N)
DO YOU WANT:
RATE OF SPREAD
Y [NL]
FIRELINE INTENSITY
N [NL]
FLAME LENGTH
Y [NL]
PERIMETER AND AREA
N [NL]
SCORCH HEIGHT
N [NL]
IGNITION COMPONENT
Y [NL]
```

3.4 Environmental Site Data

3.4.1 Windspeed

The program prompts:

INPUT 1 = MIDFLAME OR 2 = 20 FT HEIGHT, INITIAL WIND, FINAL WIND, WIND INCREMENT

MIDFLAME corresponds to hand-held windspeed measurements. The 20 FT HEIGHT corresponds to windspeed measured 20 feet above the surface. That surface can be virtually ground level or a closed tree canopy 100 feet above the ground. Input a "1" or "2" for the appropriate windspeed measurement level.

You can select a windspeed range starting with "INITIAL WIND," ending with "FINAL WIND" and incremented by "WIND INCREMENT." The maximum number of wind values in the output table is six. Therefore, if you select a wind range and an increment that results in more than six wind incremental values, your "FINAL WIND" input is recalculated. Input all the windspeeds to the nearest whole number value in miles per hour.

Example 5--You wish to enter midflame windspeeds. The wind range is 0 to 10 mi/h. You wish to see a fire behavior estimate for each 2 mi/h within the range.

```
INPUT 1=MIDFLAME OR 2=20FT HEIGHT, INITIAL WIND,FINAL WIND,WIND INCREMENT
[1,0,10,2] [NL]
```

3.4.2 Percent Slope, Temperature, and Sky Cover

The program prompts:

INPUT PERCENT SLOPE, TEMP, AND SKY COVER

The percent slope used is the conventional slope tangent times 100, to the nearest whole percent. The program assumes that the slope input is in the average wind direction.

The temperature and sky cover inputs apply to the calculation of only the IGNITION COMPONENT and the SCORCH HEIGHT. If you do not desire to output the IGNITION COMPONENT and the SCORCH HEIGHT, you must still input "TEMP" and "SKY COVER" to satisfy format requirements of the computer program.

"TEMP" is the instrument level (4.5 ft above ground) temperature in degrees Fahrenheit, to the nearest whole number.

"SKY COVER" accounts for the increase in fuel temperature above the instrument level temperature due to solar radiation. It applies to cloud or vegetative canopy cover or both.

"SKY COVER" input is the same as the NFDRS code (Cohen and Deeming 1985) describing the sky cover (state of the weather equals 0-3):

"SKY COVER"	Sky or canopy coverage
	Percent
0	0 - 10
1	10 - 50
2	50 - 90
3	90 +

Example 6--You wish to enter percent slope, temperature, and sky cover. The percent slope in the direction of the wind is 30 percent. The instrument level (4.5 ft above ground) temperature is 80 °F The sky is 40 percent cloud covered, and the sky cover code is 1.

```
INPUT PERCENT SLOPE, TEMP, AND SKY COVER
30,80,1 [NL]
```

3.5 Selecting a Fuel Model

FIRECAST offers three fuel model sets: the Northern Forest Fire Laboratory (NFFL) fire behavior fuel models (Rothermel 1983), the National Fire Danger Rating System (NFDRS) fuel models (Cohen and Deeming 1985), and the southern California (SCAL) brush fuel models (Rothermel and Philpot 1973). The NFFL models are those offered by the TI-59 fire behavior module (Burgan 1979) and used for fire behavior predictions.[1] The NFDRS fuel models are included for those managers who are already comfortable selecting these fuel models and find them appropriate for their situations. The NFDRS context and standards do not apply when using these fuel models in FIRECAST. Further explanation of the NFDRS and its component models can be found elsewhere (Cohen 1985). The SCAL fuel models are specifically included for southern California brushland fuels because these models currently provide the best input for predictive modeling of fire behavior in these fuels.

The program prompts:

INPUT FUEL MODEL SOURCE AND FUEL MODEL

You may use any of the three sets of fuel models contained in FIRECAST. The Northern Forest Fire Laboratory (NFFL) set has 13 fuel models, the National Fire Danger Rating (DR78) set has 20 fuel models, and the southern California (SCAL) set has 2 variable brushland fuel models. The required inputs for selecting the fuel model source and fuel model are these:

Fuel model source	Fuel model
NFFL	1-13
DR78	A-L,N-U
SCAL	B,C

Keep in mind that selecting a fuel model is a "best fit" to your actual fuel bed situation. Following are the fuel model designators and the fuel types by source.

NFFL

1 Short grass
2 Timber/grass understory
3 Tall grass
4 Mixed brush/heavy dead
5 Brush/not chaparral
6 Dormant brush
7 Southern rough
8 Closed timber litter
9 Hardwood litter
10 Heavy timber litter
11 Light logging slash
12 Medium logging slash
13 Heavy logging slash

DR78

A Western annual grass
B California mixed chaparral
C Pine/grass savanna
D Southern rough
E Hardwood litter (winter)
F Intermediate brush
G Short-needle conifer (heavy dead)
H Short-needle conifer (light dead)
I Heavy slash
J Medium slash
K Light slash
L Western perennial grass
N Sawgrass
O High pocosin
P Southern pine
Q Alaskan black spruce
R Hardwood litter (summer)
S Tundra
T Sagebrush/grass
U Western long-needle pine

SCAL

B Mixed chaparral (nonchamise)
C Chamise

Example 7--You have decided to use the southern California brushland fuel model (SCAL) for chamise (C).

```
INPUT FUEL MODEL SOURCE AND FUEL MODEL
SCAL,C [NL]
```

3.6 Fuel Bed Data

3.6.1 NFFL and DR78 Options

Further prompts for input depend on the fuel model source chosen. If you chose NFFL, then the next (and last) prompt is:

INPUT PERCENT 1HR,1OHR,100HR, AND LIVE

1 HR represents 1 hour timelag class fuel moisture.
10HR represents 10 hour timelag class fuel moisture.
100HR represents 100 hour timelag class fuel moisture.
LIVE represents average fuel moisture of all living fine fuels less than $^{1}/_{4}$ inch in thickness or diameter.

Example 8--You chose the NFFL source fuel model. Your fuel moistures by timelag class are these:

1HR = 3 percent
10HR = 5 percent
100HR = 7 percent
LIVE = 100 percent

```
INPUT PERCENT 1HR,10HR,100HR AND LIVE
3,5,7,100 [NL]
```

If instead you chose DR78, then the next prompt will be

INPUT PERCENT 1HR, 10HR, 100HR, 1000HR, HERB AND WOODY

1HR represents 1 hour timelag class fuel moisture.
10HR represents 10 hour timelag class fuel moisture.
100HR represents 100 hour timelag class fuel moisture.
1000HR represents 1000 hour timelag class fuel moisture.
HERB represents the average percent live fuel moisture of all fine herbaceous fuels less than $^1/_4$ inch thick or diameter.
WOODY represents the average percent live fuel moisture of all fine woody fuels less than $^1/_4$ inch thick or diameter.

As with the NFFL option, after you input the fuel moistures, the program processes the information and displays the results in the output table.

Example 9--You chose the DR78 source fuel model. Your percent fuel moistures by timelag class are these:

1HR = 5 percent
10HR = 7 percent
100HR = 10 percent
1000HR = 13 percent
HERBACEOUS = 120 percent
WOODY = 100 percent

```
INPUT PERCENT 1HR,10HR,100HR,1000HR,HERB AND WOODY
5,7,10,13,120,100 [NL]
```

3.6.2 SCAL Option

If you chose the brush option SCAL, a much different set of prompts appears requesting fuel moistures and the time of the year:

INPUT PERCENT 1-HR FM, 10-HR FM, AND MONTH AND DAY

This prompt is followed by

OPTIONAL USER INPUTS FOR SCAL

then

INPUT PERCENT DEAD AND BRUSH DEPTH (FT):

Input is optional here. FIRECAST limits your inputs to between 10 and 64 percent. Inputs less than 10 percent are set to 10 percent; inputs greater than 64 percent are set to 64 percent. You may enter the inputs as requested, or if you do not have the information, entering "NO" will lead to the prompt,

INPUT BRUSH AGE (YRS):

Caution: recent research indicates that age is not a reliable indicator of chaparral fuel characteristics.

You must enter "NO" to the previous prompt for brush percent dead and depth, if you enter an age. Otherwise, previous inputs for percent dead and depth will be used if available. If not available, an "INPUT ERROR..." results. FIRECAST limits your age inputs to a maximum of 55 years. An age input greater than 55 years is set to 55 years.

You must input information to one of these two prompts. The percent dead and depth input option is available to help you provide better brush fuel estimates. Brush age does not describe site-specific brush fuel characteristics nearly as well as estimates of percent dead and brush depth. Therefore, try to use the specific inputs of percent dead and brush depth whenever possible.

The next prompt,

INPUT NEW AND OLD GROWTH LIVE PERCENT FUEL MOISTURES:

requests the live brush moisture contents that correspond to the new and old growth sampled moisture contents. If you do not have site-specific live moisture samples, choose the nearest or most appropriate standard sample site. If you do not have the live moisture information, you must enter "NO." This defaults to the live moisture contents calculated by the program on the basis of the time of the year. (Note: You must enter the month and day in the previous prompt whether or not live moisture contents are entered.) No more prompts appear until display of the outputs is completed.

Example 10--You chose the SCAL source fuel model. Your dead percent fuel moistures are these:

1 HR = 4 percent
10HR = 7 percent.
The month and day are SEPTEMBER 15.
You have the following percent dead and brush depth:
PERCENT DEAD = 40
BRUSH DEPTH = 5 feet.
You also have the current new and old growth percent live fuel moistures from the nearest appropriate sampling site:
NEW GROWTH = 60
OLD GROWTH = 50

```
INPUT PERCENT 1HR,10HR, AND MONTH AND DAY
4,7,9,15 [NL]
OPTIONAL USER INPUTS FOR SCAL
INPUT PERCENT DEAD AND BRUSH DEPTH (FT):
40,5 [NL]
INPUT PERCENT NEW AND OLD GROWTH LIVE FUEL MOISTURES:
60,50 [NL]
```

Example 11--You chose the SCAL source fuel model. Your dead fuel percent moisture contents and month and day remain the same as in example 10. However, you do not have information on the percent dead, brush depth, or new and old growth live percent fuel moistures. You do have a brush age estimate of 50 years.

```
INPUT PERCENT 1HR,10HR, AND MONTH AND DAY
4,7,9,15 [NL]
OPTIONAL USER INPUTS FOR SCAL
INPUT PERCENT DEAD AND BRUSH DEPTH (FT):
NO [NL]
INPUT BRUSH AGE (YRS):
50 [NL]
INPUT NEW AND OLD GROWTH LIVE PERCENT FUEL MOISTURES:
NO [NL]
```

3.7 Continuing FIRECAST

Immediately following the output display table or after you type "END," the program prompts:

CONTINUE FIRECAST (Y/N)?

If you desire to end your FIRECAST processing, enter "N." Your response will be answered with

STOP

[your system's prompt]

FIRECAST has returned you to your system's command.

If you desire to continue FIRECAST processing, enter "Y." The prompt,

CHANGE OUTPUT DISPLAY (Y/N)?

follows. You now have the option of changing what fire behavior outputs appear in the display table (from the list of available fire behavior outputs). If you are satisfied with the type of fire behavior options displayed, enter "N."

If you desire an output display change, enter "Y." FIRECAST processing continues with the prompt,

DESIGNATE THE OUTPUTS YOU DESIRE FOR THE SESSION (Y/N)
DO YOU WANT:
RATE OF SPREAD

You have seen this before; continue as before (*sec. 3.3*). The program processing continues with the prompt,

1=MIDFLAME OR 2=20FT HEIGHT, INITIAL WIND, FINAL WIND,WIND INCREMENT

Once you have initially input the required data and received the output table, you may wish to continue FIRECAST processing. Those lines of data that do not change need not be reentered. Note: This procedure does not apply to changing the output display. You must always enter "Y [NL]" if you want the option displayed. When the prompt requests your data input, pressing the [NL] key will execute the next operation in sequence. The data for the line remains unchanged. This also applies if you have been using several fuel model options. If you return to a previously selected source option, you do not have to reenter data for a line that remains unchanged. This procedure does not apply once you exit the FIRECAST program and then reenter. Also, if an "INPUT ERROR. .. " occurs, the data for that prompt has been disturbed and needs to be reentered. The above procedure replaces the data file procedures of the previous FIRECAST version.

When making subsequent FIRECAST runs, you will probably need to review information previously input. You can display a line of input data by typing "DISPLAY" after the program prompt. Only the previously input information pertaining to the last prompt is displayed. After the input data listing, the last prompt appears below the data list. You can enter new data, leave data unchanged, or exit according to regular procedures. "DISPLAY" does not apply to the selection of the fire behavior output options.

Example 12--You have completed a run and wish to continue FIRECAST processing. You want to display a line of previously input data and then change the data.

```
INPUT 1=MIDFLAME OR 2=20FT HEIGHT, INITIAL WIND,FINAL WIND,WIND INCREMENT
DISPLAY [NL]
                1                       0          10          2
INPUT 1=MIDFLAME OR 2=20FT HEIGHT, INITIAL WIND,FINAL WIND,WIND INCREMENT
2,0,30,5 [NL]
```

3.8 Unexpected Characters

3.8.1 Appearance of "*" After the Rate-of-Spread Value

You may see an asterisk (*) with the displayed rate-of-spread values. You will also notice that the rate-of-spread values as well as other values (except scorch height) remain constant. This condition indicates that the windspeeds for which the * appeared are at or above maximum for the reaction intensity of the modeled fire. Fire behavior estimates are not reliable for conditions that produce an * in the display table.

3.8.2 Appearance of "******"

The ****** indicates that the number displayed is larger than the allotted space for the Data General MV series computers. The number displayed is larger than 99999 when ****** appears. This sometimes occurs when you model severe conditions. This representation may differ for various other computers.

4. SAMPLE FIRECAST RUN

```
******FIRECAST FIRE BEHAVIOR PROGRAM******
RIVERSIDE FIRE LABORATORY
JACK COHEN  APRIL 1985

DO YOU WANT HELP (Y/N)?
N
DESIGNATE THE OUTPUTS YOU DESIRE FOR THE SESSION (Y/N)
DO YOU WANT:
RATE OF SPREAD
Y
FIRELINE INTENSITY
Y
FLAME LENGTH
Y
PERIMETER AND AREA
Y
SCORCH HEIGHT
Y
IGNITION COMPONENT
Y
INPUT 1=MIDFLAME OR 2=20FT HEIGHT, INITIAL WIND,FINAL WIND, WIND INCREMENT
1,0,10,2
INPUT PERCENT SLOPE, TEMP, AND SKY COVER
30,80,0
INPUT FUEL MODEL SOURCE AND FUEL MODEL
SCAL,C
INPUT PERCENT 1-HR FM,10-HR FM, AND MONTH AND DAY
3,5,9,15
OPTIONAL USER INPUTS FOR SCAL
INPUT PERCENT DEAD AND BRUSH DEPTH (FT):
30,5
INPUT PERCENT NEW AND OLD GROWTH LIVE FUEL MOISTURES:
50,50
-------------------------------------------------------------
                        SUMMARY OF INPUTS                    I
SLOPE:  30.   TEMP:  80.    SKY CVR: 0    1HR:  3.    10HR:  5.   I
DATE:  9/15   %DEAD:   30.  DEPTH:   5.   LIVE(NEW/OLD):  50./ 50.I
-------------------------------------------------------------
SOUTHERN CALIFORNIA BRUSH FUEL MODEL
C...CHAMISE BRUSH
```

```
                        WIND AT MIDFLAME HEIGHT (MPH)
                          0       2       4       6       8       10
------------------I-------I-------I-------I-------I-------I-------I
RATE OF SPREAD    I       I       I       I       I       I       I
  (CH/HR)         I   5.  I  12.  I  24.  I  38.  I  53.  I  70.  I
------------------I-------I-------I-------I-------I-------I-------I
FIRELINE INTENSITY I      I       I       I       I       I       I
  (BTU/FT/SEC)    I  60.  I 160.  I 310.  I 488.  I 687.  I 902.  I
------------------I-------I-------I-------I-------I-------I-------I
BYRAMS FLAME LENGTHI      I       I       I       I       I       I
  (FT)            I   3.  I   5.  I   6.  I   8.  I   9.  I  10.  I
------------------I-------I-------I-------I-------I-------I-------I
PERIMETER (CH/HR) I  18.  I  43.  I  76.  I 109.  I 144.  I 179.  I
AREA (ACRES/SQ HR) I  3.  I  14.  I  40.  I  75.  I 115.  I 155.  I
------------------I-------I-------I-------I-------I-------I-------I
SCORCH HT         I       I       I       I       I       I       I
   (FT)           I  16.  I  30.  I  44.  I  54.  I  62.  I  67.  I
------------------I-------I-------I-------I-------I-------I-------I
IGNITION COMP (PCT)I  25. I  41.  I  57.  I  71.  I  82.  I  82.  I
------------------I-------I-------I-------I-------I-------I-------I
CONTINUE FIRECAST (Y/N)?
CHANGE OUTPUT DISPLAY (Y/N)?
Y

DESIGNATE THE OUTPUTS YOU DESIRE FOR THE SESSION (Y/N)
DO YOU WANT:
RATE OF SPREAD
Y
FIRELINE INTENSITY
Y
FLAME LENGTH
Y
PERIMETER AND AREA
N
SCORCH HEIGHT
N
IGNITION COMPONENT
Y
INPUT 1=MIDFLAME OR 2=20FT HEIGHT, INITIAL WIND,FINAL WIND,WIND INCREMENT
DISPLAY
              1                         0          10           2
INPUT 1=MIDFLAME OR 2=20FT HEIGHT, INITIAL WIND,FINAL WIND,WIND INCREMENT
2,0,20,5

INPUT PERCENT SLOPE, TEMP, AND SKY COVER
 (no data change, [NL])
INPUT FUEL MODEL SOURCE AND FUEL MODEL
 (no data change, [NL])
INPUT PERCENT 1-HR FM,10-HR FM, AND MONTH AND DAY
DISPLAY
             3       5             9       15
INPUT PERCENT 1-HR FM,10-HR FM, AND MONTH AND DAY
5,7,6,20
OPTIONAL USER INPUTS FOR SCAL
INPUT PERCENT DEAD AND BRUSH DEPTH (FT):
NO
```

```
INPUT BRUSH AGE (YRS):
45
INPUT PERCENT NEW AND OLD GROWTH LIVE FUEL MOISTURES:
100,80

-----------------------------------------------------------------
                        SUMMARY OF INPUTS                       I
SLOPE:  30.   TEMP:  80.    SKY CVR: 0   1HR:  5.    10HR:  7.   I
DATE:  6/20   AGE: 45.      LIVE(NEW/OLD): 100./ 80.            I
-----------------------------------------------------------------
SOUTHERN CALIFORNIA BRUSH FUEL MODEL
C...CHAMISE BRUSH
                      WIND AT 20 FT HEIGHT (MPH)
                        0      5      10     15     20
------------------I------I------I------I------I------I
RATE OF SPREAD    I      I      I      I      I      I
  (CH/HR)         I   4. I  13. I  26. I  40. I  56. I
------------------I------I------I------I------I------I
FIRELINE INTENSITY I     I      I      I      I      I
  (BTU/FT/SEC)    I  66. I 237. I 464. I 720. I 995. I
------------------I------I------I------I------I------I
BYRAMS FLAME LENGTHI     I      I      I      I      I
  (FT)            I   3. I   6. I   8. I   9. I  11. I
------------------I------I------I------I------I------I
IGNITION COMP (PCT)I  16. I  31. I  43. I  54. I  60. I
------------------I------I------I------I------I------I
CONTINUE FIRECAST (Y/N)?
Y
CHANGE OUTPUT DISPLAY (Y/N)?
N
INPUT 1=MIDFLAME OR 2=20FT HEIGHT, INITIAL WIND,FINAL WIND,WIND INCREMENT
DISPLAY
               2                        0          20           5
INPUT 1=MIDFLAME OR 2=20FT HEIGHT, INITIAL WIND,FINAL WIND,WIND INCREMENT
2,0,30,5
INPUT PERCENT SLOPE, TEMP, AND SKY COVER
 (no data change, [NL])
INPUT FUEL MODEL SOURCE AND FUEL MODEL
NFFL,4
INPUT PERCENT 1HR,10HR,100HR AND LIVE
3,5,7,60

-----------------------------------------------------------------
                        SUMMARY OF INPUTS                       I
SLOPE:  30.   TEMP:  80.    SKY CVR: 0   1HR:  3.    10HR:  5.   I
100HR:  7.    LIVE:  60.                                        I
-----------------------------------------------------------------
NORTHERN FOREST FIRE LAB FUEL MODEL
4...MIXED BRUSH/HVY DEAD
```

```
                        WIND AT 20 FT HEIGHT (MPH)
                          0      5      10     15     20     25
--------------------I------I------I------I------I------I------I
RATE OF SPREAD      I      I      I      I      I      I      I
   (CH/HR)          I  24. I  69. I 143. I 236. I 343. I 461. I
--------------------I------I------I------I------I------I------I
FIRELINE INTENSITY  I      I      I      I      I      I      I
  (BTU/FT/SEC)      I 1405. I 3989. I 8319. I13700. I19902. I26797. I
--------------------I------I------I------I------I------I------I
BYRAMS FLAME LENGTH I      I      I      I      I      I      I
  (FT)              I  13. I  20. I  29. I  36. I  43. I  49. I
--------------------I------I------I------I------I------I------I
IGNITION COMP (PCT) I  29. I  49. I  71. I  82. I  82. I  82. I
--------------------I------I------I------I------I------I------I
CONTINUE FIRECAST (Y/N)?
N
**** STOP
```

5. REFERENCES

Albini, Frank A. **Estimating wildfire behavior and effects.** Gen. Tech. Rep INT-30. Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1976a. 92 p.

Albini, Frank A. **Computer-based models of wildland fire behavior: a user's manual.** Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 19766. 68 p.

Anderson, Hal E. **Heat transfer and fire spread.** Res. Paper INT-69. Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1969. 20 p.

Anderson, Hal E. **Predicting wind-driven wildland fire size and shape.** Res. Paper INT-305. Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1983. 26 p.

Bradshaw, Larry; Deeming, John E.; Burgan, Robert E.; Cohen, Jack D. 1978 **National Fire-Danger Rating System--technical documentation.** Gen. Tech. Rep. INT-169. Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1983. 44 p.

Burgan, Robert E. **Fire danger/fire behavior computations with the Texas Instruments TI-59 calculator: a user's manual.** Gen. Tech. Rep. INT-61. Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1979. 25 p.

Byram, George M. **Combustion of forest fuels.** In: Davis, Kenneth P., ed. McGraw-Hill forest fire control and use. New York: McGraw-Hill Book Co., Inc.; 1959: 90-123.

Cohen, Jack D. **Should the 1978 National Fire-Danger Rating System be updated: a technical comparison to fire behavior prediction.** In: Proceedings, eighth conference on fire and forest meteorology; 1985 April 29-May 2; Detroit, Ml. Bethesda, MD: Society of American Foresters; 1985: 163-168.

Cohen, Jack D.; Deeming, John E. **The National Fire-Danger Rating System: basic equations.** Gen. Tech. Rep. PSW-82. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1985. 16 p.

Deeming, John E.; Burgan, Robert E.; Cohen, Jack D. **The National Fire-Danger Rating System--1978.** Gen. Tech. Rep. INT-39. Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1977. 63 p.

Fons, Wallace L. **Forest Fuels Progress Rep. 6.** 1940. Unpublished report. Berkeley: California Forest and Range Experiment Station.

Rothermel, Richard C. **A mathematical model for predicting fire spread in wildland fuels.** Res. Paper INT- 115. Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1972. 40 p.

Rothermel, Richard C. **How to predict the spread and intensity of forest and range fires.** Gen. Tech. Rep. INT-143. Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1983. 161 p.

Rothermel, Richard C.; Philpot, Charles W. **Fire in wildland management predicting changes in chaparral flammability.** J. For. 71(l): 640-643; 1973.

Schroeder, Mark J. **Ignition probability.** 1969. Unpublished Office Report 2106-1 supplied by author.

Van Wagner, Charles E. **Height of crown scorch in forest fires.** Can. J. Forest Res. 3(3): 373-378; 1973.

Cohen, Jack D. **Estimating fire behavior with FIRECAST: user's manual.** Gen. Tech. Rep. PSW-90. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1986. 11 p.

FIRECAST is a computer program that estimates fire behavior in terms of six fire parameters. Required inputs vary depending on the outputs desired by the fire manager. Fuel model options available to users are these: Northern Forest Fire Laboratory (NFFL), National Fire Danger Rating System (NFDRS), and southern California brushland (SCAL). The program has been operationally tested for use in the State of California. Complete operating instructions are given along with a description of program components and a complete sample run.
Retrieval Terms: fire behavior, fire modeling, fuel models