United States
Department
of Agriculture

Forest Service

**Intermountain
Research Station**

General Technical
Report INT-273

August 1990

RXWINDOW: Defining Windows of Acceptable Burning Conditions Based on Desired Fire Behavior

**Patricia L. Andrews
Larry S. Bradshaw**

THE AUTHORS

PATRICIA L. ANDREWS is a mathematician stationed at the Intermountain Fire Sciences Laboratory in Missoula, MT. She received her B.A. degree in mathematics and chemistry from Eastern Montana College, Billings, in 1970, and her M.A. degree in mathematics and computer science in 1973 from the University of Montana, Missoula. She has been a member of the Fire Behavior research work unit since 1973. She is now team leader of the systems development and applications team.

LARRY S. BRADSHAW is a research meteorologist for Systems for Environmental Management, a nonprofit research organization headquartered in Missoula, MT. He received a B.S. degree in meteorology from the University of Utah in 1975. Since 1975, Larry has been principal investigator of more than 15 research joint venture agreements with the Forest Service. He has specialized in the development and application of climatology to fire management problems and has authored several nationally available computer programs in the field.

ACKNOWLEDGMENTS

This research was supported in part by funds provided by the Intermountain Research Station, Forest Service, U.S. Department of Agriculture (Agreement No. INT-87263-COA), and by the Bureau of Land Management, U.S. Department of the Interior (Agreement No. AA851-IAO-77).

CONTENTS

Page

Introduction 1
BEHAVE System Overview 1
Prescription Windows 2
Models in RXWINDOW 4
  Rate of Spread and Intensity 4
  Crown Scorch Height and Tree Mortality 4
Basis of the Program 4
Variables in RXWINDOW 6
  Wind 6
  Spread Direction 6
  Fuel 6
  Moisture 6
  Tree Description 9
  Symbiotic Relationships 9
Operation of the Program 9
  Example 1 10
  Example 2 12
  Example 3 25
Summary 30
References 31
Appendix: Annotated Run of the RXWINDOW Program of the BEHAVE System 32

Intermountain Research Station
324 25th Street
Ogden, UT 84401

RXWINDOW: Defining Windows of Acceptable Burning Conditions Based on Desired Fire Behavior

Patricia L. Andrews
Larry S. Bradshaw

INTRODUCTION

Prescribed burning can be defined as fire applied in a knowledgeable manner to forest and range fuels on a specific land area under selected weather conditions to accomplish predetermined, well-defined management objectives (USDA FS 1989). Prescribed fire is used to accomplish a variety of resource management objectives such as regenerating trees, increasing wildlife habitat, and protecting resources from wildfire (Brown 1985). A fire prescription is used to document the resource objectives and the methods by which those objectives will be achieved. Among other things, the prescription defines the conditions under which the burn can be successfully conducted. The computer program RXWINDOW will help fire managers develop prescription windows based on desired fire behavior.

Although the primary use of RXWINDOW will be for prescribed fire planning, it has applications in other fire management activities where there is a need to relate potential fire behavior to environmental conditions. For example, RXWINDOW can be used on a wildfire to determine appropriate conditions for burnout and backfire.

RXWINDOW is a program in the BEHAVE fire behavior prediction and fuel modeling system (Andrews 1986; Andrews and Chase 1989; Burgan and Rothermel 1984). It reverses some of the processes that are available elsewhere in BEHAVE. In the FIRE1 program of BEHAVE, you specify environmental conditions and the program calculates fire behavior. In RXWINDOW, you define acceptable ranges of fire behavior and the program determines the appropriate combinations of fuel moisture and wind. For example, if you specify a range of flame lengths, RXWINDOW will give you acceptable limits for dead and live fuel moisture and for windspeed and direction. You can also specify ranges for desired rate of spread, intensity, or the first-order fire effects, scorch heigh, or tree mortality. For simplicity in this paper we refer to all of these as fire behavior variables. The program does not include a calculation of fuel moisture from temperature and relative humidity.

The need for a program such as RXWINDOW is evidenced by the fact that many fire managers have been using BEHAVE in establishing burning prescriptions (Andrews and Bradshaw 1987; Doren and others 1987). Although the mathematical models in BEHAVE include some assumptions that limit their use for certain prescribed fire applications, skilled users are able to use the prediction with some confidence.

In this paper we describe the approach of basing prescription windows on fire behavior and explain where the RXWINDOW program fits into the prescribed fire planning process. The assumptions and limitations of the predictive models used in the program are discussed. Operation of the program is described, and an appendix contains a detailed annotated example run. We assume that you are familiar with the BEHAVE system. References will be made to previous BEHAVE documents rather than repeating all of that information here.

The RXWINDOW program is not a magic box into which anyone can blindly enter numbers and come up with a valid fire prescription. Its effectiveness depends on skillful and thoughtful judgments by conscientious fire managers who thoroughly understand how the program works. Therefore, before we describe the program using specific examples, we will explain the models, variables, assumptions, and simplifications in RXWINDOW.

BEHAVE SYSTEM OVERVIEW

RXWINDOW is the fifth program in the BEHAVE fire behavior prediction and fuel modeling system. The BEHAVE system design is shown in figure 1. There are two subsystems, FUEL and BURN. The FUEL subsystem consists of the two programs, NEWMDL and TSTMDL, which are used to develop custom fuel models (Burgan and Rothermel 1984). A description of the fuel is an important input requirement for the calculation of fire behavior. The FUEL programs are used if none of the 13 standard fire behavior fuel models (Anderson 1982) describe the area to be burned. For example, live fuel might be added to one of the logging slash models.

The BURN subsystem is the fire behavior prediction part of BEHAVE (Andrews 1986; Andrews and Chase 1989). The FIRE1 and FIRE2 programs include the fire prediction modules as shown in figure 1. The RXWINDOW program includes the same calculations as the DIRECT, SCORCH, and MORTALITY modules of FIRE1.

In the DIRECT module, rate of spread and intensity are calculated from fuel model, fuel moisture, slope, and wind. In the SCORCH module, lethal scorch height is calculated from flame length, windspeed, and ambient air temperature. In the MORTALITY module, percentage of tree mortality is calculated from scorch height and tree description.

In the RXWINDOW program, the user specifies site description (fuel model, slope, tree description, etc.) and

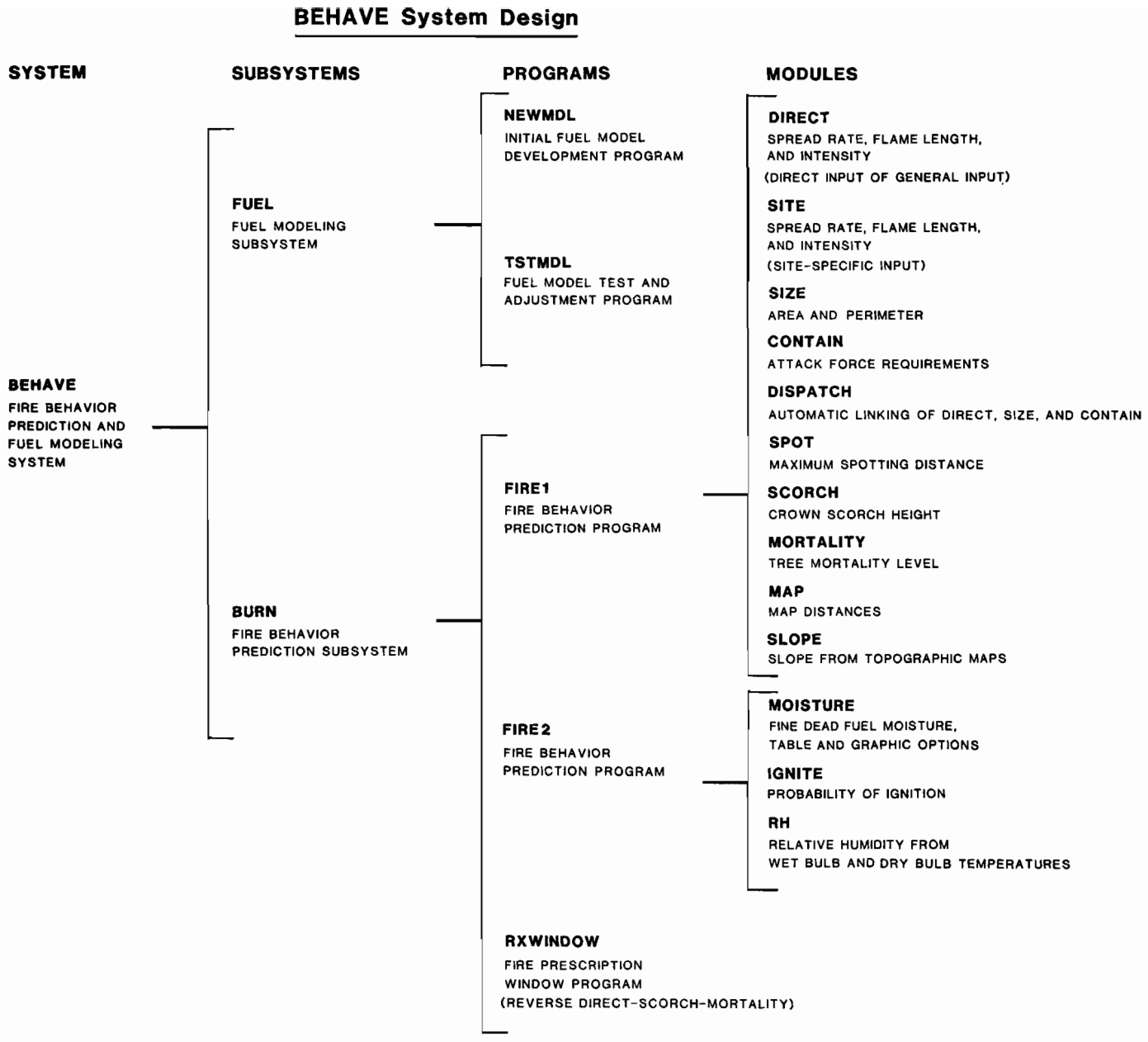


Figure 1—BEHAVE system design. RXWINDOW is a program in the BURN subsystem. It reverses the DIRECT-SCORCH-MORTALITY modules of the FIRE1 program.

desired fire behavior (flame length, scorch height, etc.). The program provides combinations of fuel moistures, windspeeds, and directions, and spread directions that satisfy the fire behavior constraints.

PRESCRIPTION WINDOWS

A prescription window defines a range of conditions under which a burn can be conducted. Prescription windows are often specified by ranges of several environmental parameters (for example, 1-h fuel moisture 6 to 12 percent, windspeed 5 to 12 mi/h).

There are problems with "square" windows like this. Consider the case where one condition is out on the "hot" side (wind greater than 12) and another is out on the "cool" side (1-h moisture greater than 12). Rather than being two reasons *not* to burn, opposing window corner values that are "out of prescription" may actually balance one another and lead to an acceptable fire. A square prescription window can either be too restrictive or include conditions that should actually be out of prescription (Raybould and Roberts 1983).

In order to achieve the burn objective, it is necessary to have the right kind of fire, both in terms of control and first-order fire effects. So we suggest defining the prescription in terms of acceptable fire behavior, using the prediction models to determine related environmental

conditions. This eliminates the square window problem, and all combinations of environmental values that result in the specified fire behavior are then "in prescription." Defining a prescription window based on fire behavior has been called "backing into the prescription."

Figure 2 is a table from the DIRECT module of FIRE1, illustrating tradeoffs between dead fuel moisture and midflame windspeed. The table shows conditions that lead to flame lengths from 2 to 5 feet. Low fuel-moisture contents are acceptable at low windspeeds but are out of prescription at high windspeeds. A "square" window based on 1-h fuel moisture and midflame windspeed would either miss some valuable burning conditions or include fires with flame lengths either too low or too high to meet the objectives.

If all situations were this simple, the FIRE1 program would be adequate for designing prescriptions. But fuel model 1 is short dead grass; there is only one category of fuel. In this example calculations are for a head fire on flat ground. Midflame windspeed and 1-h fuel moisture content are, therefore, the only variables involved. Other fuel models contain live and dead fuels and have multiple size classes. The area to be burned may be on a slope, causing wind direction to be a consideration. There is also the possibility that backing or flanking fire may be required. It is cumbersome to make multiple FIRE1 runs to define additional variables.

```
DIRECT
 1--FUEL MODEL ------------      1 -- SHORT GRASS, 1 FT (30 CM)
 2--1-HR FUEL MOISTURE, % --    4.0   5.0   6.0   7.0   8.0   9.0  10.0
 7--MIDFLAME WINDSPEED, MI/H     .0   1.0   2.0   3.0   4.0   5.0   6.0
 8--TERRAIN SLOPE, % -------     .0
 9--DIRECTION OF WIND VECTOR     .0
10--DIRECTION OF SPREAD ----     .0  (DIRECTION OF MAX SPREAD)
    CALCULATIONS
     DEGREES CLOCKWISE
      FROM THE WIND VECTOR
```

FLAME LENGTH, FT (V4.1)

1-HR MOIS (%)	MIDFLAME WIND, MI/H .0	1.0	2.0	3.0	4.0	5.0	6.0
4.0	1.2	1.6	2.3	3.2	4.1	5.0	5.9
5.0	1.1	1.5	2.2	3.0	3.9	4.8	5.6
6.0	1.1	1.4	2.1	2.9	3.8	4.6	5.4
7.0	1.1	1.4	2.0	2.8	3.6	4.4	5.2
8.0	1.0	1.3	1.9	2.6	3.4	4.1	4.9
9.0	.9	1.1	1.7	2.3	3.0	3.7	4.3
10.0	.7	.9	1.3	1.9	2.4	2.9	3.2*

* MEANS YOU HIT THE WIND LIMIT.

Figure 2—Table from the DIRECT module of the FIRE1 program illustrating the combinations of 1-h fuel moisture and midflame windspeed that result in flame length predictions of 2 to 5 ft.

MODELS IN RXWINDOW

The mathematical models used in the RXWINDOW program are the same as those used in the DIRECT, SCORCH, and MORTALITY modules of the FIRE1 program. DIRECT calculates rate of spread, intensity, and flame length as described by Andrews (1986, pp. 8-17). SCORCH and MORTALITY and their link to DIRECT are described by Andrews and Chase (1989, pp. 5-14). It is important that you be familiar with the limitations and assumptions of the models in order to properly apply them. Refer to those papers for a better understanding of the models because only a summary is given here.

Rate of Spread and Intensity

Rate of spread, heat per unit area, flame length, fireline intensity, reaction intensity, and direction of maximum spread are calculated in the DIRECT module of the FIRE1 program. The input values are fuel model, moisture content for each size class, slope, windspeed and direction, and direction of fire spread. The models are based on physical properties of fuel and fire and on laboratory experiments. They are not designed for any particular part of the world.

The model includes the assumption that the fire is burning in uniform and continuous surface fuel. The model will not work for ground fuel (duff), nor does it account for burnout of large fuel after the flaming front has passed. The uniform, continuous fuel assumption can be compensated for by the description of the fuel. If none of the 13 standard fire behavior fuel models is appropriate, a custom fuel model can be developed.

Flame length, which is directly related to fireline intensity, is an important fire behavior variable in designing prescriptions because it influences mortality of aboveground vegetation. But flame length is a poor indicator of belowground fire effects. Flame length and fireline intensity might be evaluated to plan for mortality of shrubs and trees, but fuel consumption (not in RXWINDOW) must be evaluated to plan for site preparation, fuel reduction, or plant regeneration (Brown 1985).

With experience, flame length and fireline intensity can indicate whether sustained fire is likely (Brown and Simmerman 1986). Flame length, fireline intensity, and rate of spread are all indicators of control difficulty.

Crown Scorch Height and Tree Mortality

The scorch height on a tree is the maximum height at which the lethal temperature for live crown foliage is reached (140 °F, 60 °C). Scorch height is calculated from flame length, windspeed, and ambient air temperature. The model is based on the relationship of flame length (fireline intensity) to temperature above the fire and on the shape of the convection column as it is affected by light winds (Van Wagner 1973).

The scorch height model was developed for flat ground and should be used on slopes only with care. If the flames attach to the slope, scorch height will be overpredicted; if the flames do not attach, scorch height will be underpredicted (Rothermel 1985). The scorch equation is for a line fire; merging lines may increase scorch. Increased scorch may result from holes in the canopy that create chimneys of heat and by a convection column that breaks from the surface and rises high on a ridge.

The calculation of percentage of mortality is based on scorch height, tree crown conformation, and bark thickness (which can be estimated from tree description). The model is based on the assumption that trees of different species are similar in their response to a given level of injury and that the level of damage depends on the fire and on tree characteristics (bark thickness, tree height, crown ratio) (Reinhardt and Ryan 1988; Ryan and Reinhardt 1988).

The model assumes that the fire is of average duration. Thick layers of dry duff or heavy concentrations of logs near trees will result in extended duration of burning and a corresponding underprediction of mortality. On the other hand, mortality may be overpredicted if fuel is very light or patchy.

Mortality predictions can be applied either to a stand or to an individual tree. A prediction of 30 percent mortality means that if 100 similar trees are subjected to the same fire, 30 of them are expected to die. Each tree either lives or dies. There is a 30 percent probability that an individual tree will die.

Scorch height and tree mortality are the only variables in BEHAVE that are fire effects related to fire behavior. Both models are based on data gathered on prescribed fires. Care should be taken in applying the models under conditions outside of those under which the original data were gathered.

BASIS OF THE PROGRAM

Figure 3 shows the input and output variables for the DIRECT-SCORCH-MORTALITY link in FIRE1. There are 14 user-defined inputs and seven calculated values. For each set of input values there is a corresponding unique set of output values. This, however, is not the case in reverse. It is possible for many input value combinations to result in the same calculated fire behavior. Note in figure 2 that calculated flame length is 3 feet when 1-h moisture content = 5 percent and midflame windspeed = 3 mi/h and is also 3 feet when 1-h = 9 percent and wind = 4 mi/h. The goal in RXWINDOW is to find all of the input combinations that result in fire behavior within a user-specified acceptable range.

It is not feasible to do the mathematics to reverse the many complex equations used in the calculations. The approach we use in RXWINDOW is to simplify the problem by reducing the number of variables to be considered by treating some variables as constant and by taking advantage of relationships among variables in the mathematical fire model.

Site conditions are assumed to be constant for a given area (starred values in fig. 3). RXWINDOW uses a temperature of 77 °F for the ambient air temperature for scorch height estimation as was done by Albini (1976). A constant value is used because air temperature is not a critical variable in scorch height as pointed out by

INPUT	OUTPUT
* Fuel model	Rate of spread
1-h fuel moisture	Heat per unit area
10-h fuel moisture	Fireline intensity
100-h fuel moisture	Flame length
Live herbaceous fuel moisture	Reaction Intensity
Live woody fuel moisture	Scorch height
* Terrain slope	Tree mortality
Windspeed	
Wind direction	
Spread direction	
Temperature	
* Bark thickness tree species tree diameter	
* Tree height	
* Crown ratio	

Figure 3—Input and output variables for the DIRECT-SCORCH-MORTALITY link in the FIRE1 program. Starred variables are assumed to be constant for a given area.

Van Wagner (1973). In addition it is misleading to indicate that air temperature is an element in the prescription but ignore its effect on fuel moisture. (Calculation of fuel moisture is not a part of RXWINDOW.) RXWINDOW assumes a constant relationship between 10-h and 100-h fuel moisture. (For example, 100-h = 10-h + 2 percent.) These assumptions effectively eliminate seven of the 14 variables from consideration.

The remaining seven variables are 1-h, 10-h, live herbaceous, and live woody fuel moistures, windspeed, wind direction, and spread direction. A further simplification is based on the fact that, as shown in figure 4, the 10 basic input values in DIRECT are reduced to three intermediate values before the final calculations are done.

The RXWINDOW base table includes acceptable combinations of weighted dead fuel moisture, weighted live fuel moisture, windspeed, and wind direction. A separate table is given for each spread direction: head, flanking, and backing. Secondary tables show the relationship between weighted fuel moisture contents and moisture content of the individual size classes.

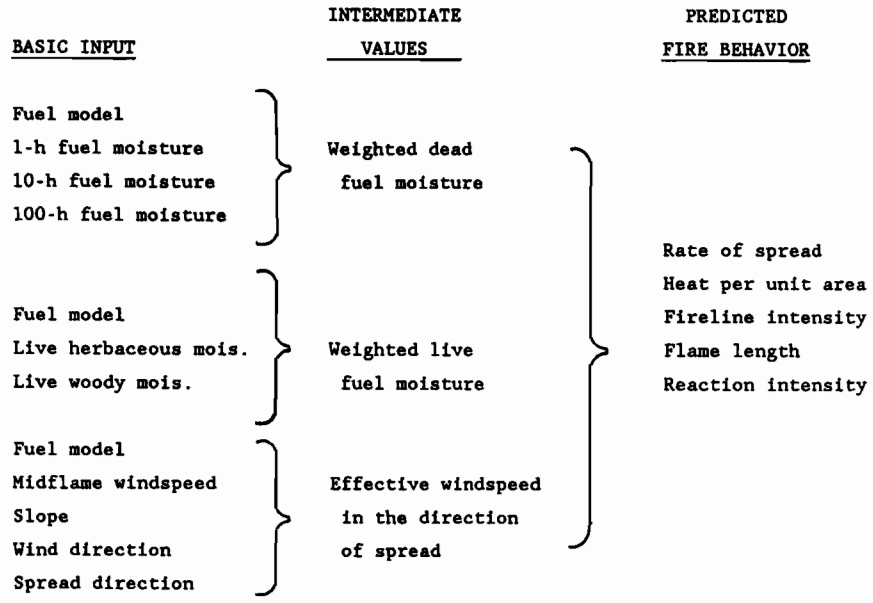


Figure 4—The structure of the RXWINDOW program is based on the fact that the 10 basic input values required by the DIRECT module of the FIRE1 program are reduced to three intermediate values before the final calculations are done.

VARIABLES IN RXWINDOW

The worksheet for RXWINDOW is shown in figure 5. There are four sections: fire behavior constraints, site conditions, preset environmental constraints, and output table configuration. A range of acceptable values must be set for at least one of the seven fire behavior variables (lines 1-7), although more than one variable may be constrained. Site conditions are assumed to be constant for an area to be burned; a single value is assigned to each (lines 8-14).

Preset environmental constraints (lines 15-22) provide the option to use information that is not a function of calculated fire behavior. For example, if the burn is to be conducted in the spring, live fuel moisture may be preset to be from 200 to 300 percent. There is no need to consider low live moisture contents. Or, based on experience, you may decide that you want a backing fire with at least a 10 mi/h 20-ft wind. RXWINDOW will not evaluate values outside of these preset conditions. It is worthwhile to narrow the options as much as possible ahead of time. This will save computing time and simplify the resulting output tables.

The final section of the input worksheet is used to specify output table configurations: the variable that is to be printed in the basic prescription table (line 23) and the format of the associated moisture tables (lines 24-25). Any *one* of the fire behavior variables (lines 1-7) can be printed on the final prescription table, whether that variable is constrained or not. The basic prescription table is based on weighted moisture content of dead fuels and live fuels. Fuel moisture tables are available when more than one size class of dead or live fuel is in a fuel model. Further explanation of the fuel moisture table options will be given with the examples.

The values on the RXWINDOW worksheet (fig. 5) are not just a rearrangement of the FIRE1 program's DIRECT-SCORCH-MORTALITY values given in figure 3. The descriptions below specifically define variables as they are used in RXWINDOW.

Wind

Reference for wind direction (line 21) is different in RXWINDOW than in FIRE1. FIRE1 requests that the direction of the wind vector be specified in degrees clockwise from upslope. In RXWINDOW, wind direction is specified as upslope, quarter upslope, cross-slope, quarter downslope, or downslope as illustrated in figure 6.

Windspeed in FIRE1 is at midflame height. Because weather forecasts and climatic summaries usually give wind at 20-ft height, RXWINDOW uses both windspeed references (lines 19-20). Wind at 20 ft multiplied by a wind adjustment factor gives midflame windspeed. Wind adjustment factor is determined by fuel exposure to the wind (line 9) and, if the fuel is fully exposed, fuel model (line 8).

Spread Direction

In FIRE1, spread direction is in degrees clockwise from upslope. Fire spread direction in RXWINDOW is specified as head, flanking, or backing (line 22). The direction of a head fire (direction of maximum spread) is automatically calculated for each combination of windspeed and wind direction. The directions of flanking and backing fires are calculated using the direction of the head fire as a reference. Spread direction in degrees from upslope is given only upon request (line 23, choice 8).

Fuel

Either a standard fire behavior fuel model or a static custom fuel model can be used (line 8). RXWINDOW does not allow dynamic custom fuel models (where fuel loads are transferred between live herbaceous and 1-h dead classes as a function of live fuel moisture). In addition, RXWINDOW does not offer the two-fuel-model concept as an option.

Moisture

The design of RXWINDOW is based on the fact that weighted moisture contents are an intermediate calculation in the fire model (fig. 4). The weighting factors are a function of the diameter class of the fuel, with the most emphasis put on fine fuel (Rothermel 1972). The weighting factors for 1-h, 10-h, and 100-h moisture contents for the standard 13 fire behavior fuel models are shown in table 1. In addition, the weighting factors are given with the RXWINDOW moisture table output.

As an example of the calculation of weighted dead fuel moisture, assume that for fuel model 13, 1-h moisture = 4 percent, 10-h moisture = 6 percent, and 100-h moisture = 8 percent. Then the weighted dead fuel moisture = 4(0.76) + 6(0.18) + 8(0.06) = 4.6 percent. This illustrates that, even in the case of heavy logging slash, the weighted dead fuel moisture is very close to the moisture content of the 1-h fuel.

Table 1—Weighting factors for each dead fuel size class for the 13 standard fire behavior fuel models

Fuel model	Dead fuel size class		
	1-h	10-h	100-h
1—Short grass	1.00	0.0	0.0
2—Timber, grass, and understory	.98	.018	.002
3—Tall grass	1.00	.0	.0
4—Chaparral	.95	.04	.01
5—Brush	.97	.03	.0
6—Dormant brush; hardwood slash	.89	.09	.02
7—Southern rough	.89	.09	.02
8—Closed timber litter	.94	.03	.03
9—Hardwood litter	.99	.008	.002
10—Timber, litter, and understory	.94	.04	.02
11—Light logging slash	.77	.17	.06
12—Medium logging slash	.75	.19	.06
13—Heavy logging slash	.76	.18	.06

RXWINDOW Worksheet

	UNITS English	Metric			
FIRE BEHAVIOR CONSTRAINTS: (must constrain at least one)					
1 Rate of spread	ch/h	m/min	_____	to	_____
2 Heat per unit area	Btu/ft²	kJ/m²	_____	to	_____
3 Fireline intensity	Btu/ft/s	kW/m	_____	to	_____
4 Flame length	ft	m	_____	to	_____
5 Reaction intensity	Btu/ft²/min	kW/m²	_____	to	_____
6 Scorch height	ft	m	_____	to	_____
7 Tree mortality	percent	percent	_____	to	_____
SITE CONDITIONS:					
8 Fuel model (1-13 for standard models, 14-99 for custom models)			_____		
9 Fuel exposure to the wind 1=exposed 2=partially sheltered 3=fully sheltered, open stand 4=fully sheleterd, closed stand 5=direct entry of wind adjustment factor			_____		
10 Terrain slope (units set using keywords PERCENT or DEGREES)	percent or degree	percent or degree	_____		
11 Relationship between 100-h and 10-h moisture content (100-h mois = 10-h mois + ?)	percent	percent	_____		
12 Tree height	ft	m	_____		
13 Crown ratio (ratio of crown length to tree height)					
14 Bark thickness Direct input	in	cm	_____		
or from: Tree species 1=western larch, Douglas-fir 2=western hemlock 3=Engelmann spruce, western redcedar 4=lodgepole pine, subalpine fir			_____		
Tree diameter, d.b.h.	in	cm	_____		

(Continued)

Figure 5—RXWINDOW worksheet.

RXWINDOW Worksheet
(continued)

PRESET ENVIRONMENTAL CONSTRAINTS:

15	1-h fuel moisture	percent	percent	_____	to	_____
16	10-h fuel moisture	percent	percent	_____	to	_____
17	Live herbaceous fuel moisture	percent	percent	_____	to	_____
18	Live woody fuel moisture	percent	percent	_____	to	_____
19	20-ft windspeed	mi/h	km/h	_____	to	_____
20	Midflame windspeed	mi/h	km/h	_____	to	_____
21	Wind direction 1=upslope 2=quarter upslope 3=cross-slope 4=quarter downslope 5=downslope			_____	to	_____
22	Fire spread direction 1=head 2=flanking 3=backing			_____	to	_____

OUTPUT TABLE CONFIGURATION:

23	RXWINDOW fire behavior table variable 1=rate of spread 2=heat per unit area 3=fireline intensity 4=flame length 5=reaction intensity 6=scorch height 7=mortality 8=spread direction	_____
24	Dead fuel moisture table variable 1=1-h 2=10-h	_____
25	Live fuel moisture table variable 1=herbaceous 2=woody	_____

Figure 5 (Con.)

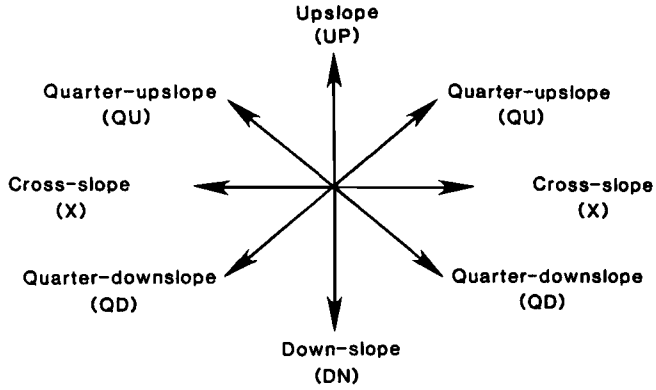


Figure 6—Diagram of the five wind directions as they are referenced in RXWINDOW. (This differs from the FIRE1 program of BEHAVE, in which direction of the wind vector is specified as degrees clockwise from upslope.)

Tree Description

A description of the tree is required only when a constraint is put on tree mortality (line 7) or when mortality is requested to be printed on the final table (line 23, choice 7).

The seven western conifer species that were used in the model development are included as choices in line 14. You can choose the species with the bark thickness relationship that best fits the species that you are concerned with, or you can enter bark thickness directly.

Symbiotic Relationships

There are relationships between some of the variables which we call "symbiotic relationships." That means that if one value is known, the other can be calculated (given some constant site descriptions). It is very possible that you will give the program conflicting constraints. When you have completed all the input prompts, the program checks to see if there are inconsistencies, then asks for clarification as illustrated in the annotated run in the appendix. The four such relationships in RXWINDOW are as follows:

1. Fireline intensity (line 3) and flame length (line 4).
2. Heat per unit area (line 2) and reaction intensity (line 5), for a given fuel model (line 8).
3. Scorch height (line 6) and tree mortality (line 7), for a given set of tree descriptors (lines 12-14).
4. Midflame windspeed (line 20) and 20-ft windspeed (line 19), for a given fuel exposure to wind (line 9) and fuel model (line 8) if fuel is fully exposed to the wind.

OPERATION OF THE PROGRAM

Operation of RXWINDOW is based on the use of keywords and is similar to other BEHAVE system programs. A list of the RXWINDOW keywords and a brief description of each is given in figure 7. A "mode" keyword is used to set a switch that remains in effect until you change it. Starred keywords are the defaults at program startup. "Action" keywords cause something to happen; most of them are used to enter input and display results.

The keyword hierarchy in figure 8 shows that the program is structured into two levels. The VIEW keywords are used after RUN is entered in the main level of RXWINDOW. KEY, HELP, COMMENT, STATUS, and the mode keywords can be entered at any time.

The FIRE1 and FIRE2 programs use the keyword RUN alone to obtain output. The RXWINDOW program offers additional options in viewing results through the keywords REDO, REPLAY, ZOOM, and NEXT.

Like other BEHAVE programs, RXWINDOW is designed for standard terminals, so a limited number of

Mode Keywords

*	WORDY	Sets full prompting.
	TERSE	Sets limited prompting.
*	PAUSE	Limits display to at most 24 lines at a time for a video display terminal.
	NOPAUSE	No pause in display.
	LOG	Writes results of COMMENT, LIST, and RUN to a file to be printed at a later time.
*	NOLOG	Turns off the LOG option.
*	ENGLISH	Sets units to English.
	METRIC	Sets units to metric.
*	PERCENT	Sets slope units to percent.
	DEGREES	Sets slope units to degrees.

Action Keywords

INPUT	Asks for all input.
LIST	Lists current input values.
CHANGE	Changes individual input values by line number.
RUN	Does calculations and presents results. Offers various display options (controlled by keywords REDO, REPLAY, ZOOM, and NEXT).
REDO	Displays the original table without recalculating. Negates ZOOM limits.
REPLAY	Instant replay of the last viewed table.
ZOOM	Allows you to expand or condense any section of a table.
NEXT	Continue with the next table in the sequence of outputs.
QUIT	Gets out of view mode or terminates the run.
KEY	Displays the keywords that are allowed at the current point along with a brief description of each.
HELP	Tells you where you are in the program and what you can do next. HELP may be used with an argument (e.g. HELP ZOOM) to display information on a specific keyword.
COMMENT	Allows you to annotate a run in a log file.
STATUS	Gives the status of the mode keywords and the names of the fuel model file and the log file.

Figure 7—RXWINDOW keyword summary. Starred values are default mode at program startup.

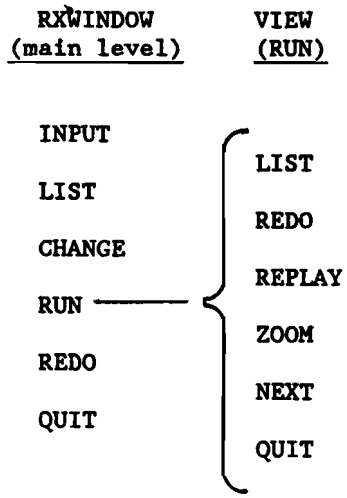


Figure 8—RXWINDOW keyword hierarchy. The VIEW keywords can be entered after RUN is entered in the MAIN program. KEY, HELP, COMMENT, STATUS, and the mode keywords are allowed at any time.

columns of an output table can be displayed on a terminal at a time. Because RXWINDOW tables may contain up to 30 columns of information, initially fewer columns that cover the range of the entire table are shown. The ZOOM keyword allows you to display portions of tables at other resolutions.

Some runs take quite a while, especially if you do not specify preset environmental constraints and if the fuel model contains live fuel. Sometimes you might want to type RUN and get a cup of coffee (or the metric equivalent, tea). The keywords REPLAY and REDO allow you to quickly redisplay tables without redoing the calculations. REPLAY is an "instant replay" of the table that was last displayed. This feature is useful when tables fill more than one screen. REPLAY can also be used after changing the units option with keywords METRIC or ENGLISH. REDO displays the original table without recalculating the results. It cancels table display limits that were set using ZOOM.

You will better understand the format of RXWINDOW tables and the use of the VIEW keywords through the example run in the appendix.

Example 1

Figure 9 is the input listing for the RXWINDOW run that corresponds to the run of the DIRECT module of FIRE1 in figure 2. We specified an acceptable flame length of 2 to 5 ft (line 4), fuel model 1 (line 8), exposed to the wind (line 9), flat ground (line 10), and head fire (line 22). We also constrained the 1-h fuel moisture to 4 to 10 percent (line 15) and midflame windspeed to less than 6 mi/h (line 20), the same values as used in figure 2.

We chose flame length to be printed on the table (line 23) so that you can better understand the relationship to figure 2. Because fuel model 1 has only one size class of dead fuel, weighted dead fuel moisture is equal to 1-h fuel moisture, and a dead fuel moisture table is not produced (line 24). Fuel model 1 has no live fuel, so a live fuel moisture table is not produced (line 25). Lines 24 and 25 are listed for information; the program did not request input.

The symbiotic relationships are also listed with the input. In this example, although 20-ft windspeed was not directly constrained, it is constrained through its relationship to midflame windspeed. Midflame windspeed is 20-ft windspeed multiplied by the wind adjustment factor (determined by the fuel model and exposure to the wind, lines 8 and 9). Fireline intensity is constrained through its relationship to flame length. There is a direct relationship in the mathematical model.

Figure 10 is the RXWINDOW prescription table that results from the input listed in figure 9. Remember that we preset the ranges for 1-h moisture and midflame windspeed in lines 15 and 20. Output table columns are for windspeeds: 20-ft wind on the top line (5.0, 7.5, 10.0, 12.5, 15.0) and midflame wind on the next line (2, 3, 4, 5, 6). Table rows are weighted dead fuel moistures (4, 5, 6, 7, 8, 9, 10), which in this case are equal to 1-h fuel moisture.

Blank cells within the table indicate combinations of moisture and wind that result in fire behavior out of prescription, in this example flame length less than 2 ft or greater than 5 ft.

Nonblank cells indicate fire behavior within prescription limits. The first line is always the range of wind directions (W-DIR). In this example, wind direction in any direction (ANY) is acceptable because there is no slope. A second value in the cell is the range of values for the variable specified in input line 23, in this case flame length (FLAME). In comparing figure 2 to figure 10, keep in mind that table variable values are rounded to whole numbers for display. Comparisons used to determine whether a fire behavior value is in or out of prescription are done internally to one decimal place.

```
 INPUT LIST FOR RXWINDOW

 FIRE BEHAVIOR CONTRAINTS:

 1--RATE OF SPREAD, CH/H                      *** NOT CONSTRAINED ***
 2--HEAT PER UNIT AREA, BTU/SQFT              *** NOT CONSTRAINED ***
 3--FIRELINE INTENSITY, BTU/FT/S              *** NOT CONSTRAINED ***
 4--FLAME LENGTH, FT                           2.0 TO    5.0
 5--REACTION INTENSITY, BTU/SQFT/M            *** NOT CONSTRAINED ***
 6--SCORCH HEIGHT, FT                         *** NOT CONSTRAINED ***
 7--TREE MORTALITY, %                         *** NOT CONSTRAINED ***

 SITE CONDITIONS:

 8--FUEL MODEL:                          1 -- SHORT GRASS, 1 FT (30 CM)
 9--FUEL EXPOSURE TO WIND:              EXPOSED
                                        (WIND ADJUSTMENT FACTOR =  .40)
10--TERRAIN SLOPE, %                            .0

 PRESET ENVIRONMENTAL CONSTRAINTS:

15--1-H FUEL MOISTURE, %                       4.0 TO   10.0
19--20-FOOT WINDSPEED, MI/H                   *** NOT CONSTRAINED ***
20--MIDFLAME WINDSPEED, MI/H                    .0 TO    6.0
22--FIRE SPREAD DIRECTION                     HEAD

 OUTPUT TABLE CONFIGURATIONS:

23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  FLAME LENGTH, FEET
24--DEAD FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL  1.
25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL  1.

 SYMBIOTIC RELATIONSHIPS:

 CONSTRAINED MIDFLAME WINDSPEED FROM       .0 TO      6.0 MI/H
 CONSTRAINS   20-FOOT WINDSPEED FROM       .0 TO     15.0 MI/H
 RELATIONSHIP:  FUEL MODEL & FUEL EXPOSURE TO WIND (LINES 8-9).

 CONSTRAINED       FLAME LENGTH FROM      2.0 TO      5.0 FEET
 CONSTRAINS  FIRELINE INTENSITY FROM     25.5 TO    185.9 BTU/FT/S
 RELATIONSHIP:  MATHEMATICAL FIRE MODEL.
```

Figure 9—RXWINDOW input that corresponds with the FIRE1 DIRECT run in figure 2.

```
   WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
   WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE ***            (FULL WINDOW)                (VER 3.5)
--------- I --- 20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H ---
WEIGHTED  I    5.0     7.5     10.0    12.5    15.0
DEAD FM % I    2.0     3.0      4.0     5.0     6.0
--------- I ------- ------- ------- ------- -------
 4 W-DIR  I   ANY     ANY     ANY     ANY
   FLAME  I   2- 2   3- 3    4- 4    5- 5
--------- I ------- ------- ------- ------- -------
 5 W-DIR  I   ANY     ANY     ANY     ANY
   FLAME  I   2- 2   3- 3    4- 4    5- 5
--------- I ------- ------- ------- ------- -------
 6 W-DIR  I   ANY     ANY     ANY     ANY
   FLAME  I   2- 2   3- 3    4- 4    5- 5
--------- I ------- ------- ------- ------- -------
 7 W-DIR  I   ANY     ANY     ANY     ANY
   FLAME  I   2- 2   3- 3    4- 4    4- 4
--------- I ------- ------- ------- ------- -------
 8 W-DIR  I           ANY     ANY     ANY     ANY
   FLAME  I           3- 3    3- 3    4- 4    5- 5
--------- I ------- ------- ------- ------- -------
 9 W-DIR  I           ANY     ANY     ANY     ANY
   FLAME  I           2- 2    3- 3    4- 4    4- 4
--------- I ------- ------- ------- ------- -------
10 W-DIR  I                   ANY     ANY     ANY
   FLAME  I                   2- 2    3- 3    3- 3
--------- I ------- ------- ------- ------- -------
UNITS/CODES FOR TABLE VALUES ARE:
     W-DIR  - WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS,
              QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
     FLAME  - FLAME LENGTH, FEET
```

Figure 10—RXWINDOW output (prescription table) that results from the input in figure 9. Blank cells in the table indicate conditions that are out of prescription.

Example 2

Example 1 was a simple starting place in understanding the RXWINDOW prescription tables. We now use fuel model 5 (short brush), which has both live and dead fuel. Figure 11 shows a FIRE1 DIRECT run where 1-h moisture and midflame windspeed vary, 10-h moisture is 6 percent, and live fuel moisture is 75 percent. Indicated on the table are flame lengths of 2 to 5 ft. Figure 12 is for the same conditions, except live fuel moisture is 175 percent. The window of 2- to 5-ft flame lengths has shifted over significantly. Adding another variable (live fuel moisture) makes it very difficult to define the prescription window using the FIRE1 program.

The RXWINDOW run in figure 13 corresponds to the DIRECT run in figure 11, with live moisture set at 75 percent. Similarly figure 14 corresponds to figure 12, with live moisture 175 percent. Note that there is a new line in each cell (LV-FM). These values define the range of weighted live fuel moisture within each cell. Fuel model 1 (figures 9 and 10) has no live fuel. Because there is only one class of live fuel in fuel model 5, weighted live fuel moisture is equal to the live fuel moisture. There is therefore no additional table for live fuel moisture (line 25).

We produced figures 13 and 14 only to help you understand the RXWINDOW output. The program is really designed to let live moisture be anything from 75 to 175 percent as is done in figure 15. Now the table shows all combinations of dead fuel moisture, windspeed, and live fuel moisture that are in prescription. Note where the circled values, 75 percent, are compared to those in figure 13, and where the boxed values, 175 percent, are compared to figure 14. Also note that live fuel moisture content and flame length now vary within each cell. Figure 16 is based on the same input as figure 15, but rate of spread is printed as the table variable. (Line 23 was changed to option 1, rate of spread.)

There were many preset environmental constraints in figures 15 and 16. In figure 17, we constrain only flame length to 2 to 5 ft and let RXWINDOW find all of the combinations of wind, spread direction, and fuel moistures that result in fire behavior within prescription. The prescription table shows the many windspeed and fuel moisture combinations that satisfy the flame length constraints. The table variable was changed back to flame length. Only the head fire table is shown in figure 17. Similar tables were generated for flanking and backing fires.

```
DIRECT
 1--FUEL MODEL ------------      5 -- BRUSH, 2 FT (60 CM)
 2--1-HR FUEL MOISTURE, % --    4.0   5.0   6.0   7.0   8.0   9.0  10.0
 3--10-HR FUEL MOISTURE, % -    6.0
 6--LIVE WOODY MOISTURE, % -   75.0
 7--MIDFLAME WINDSPEED, MI/H     .0   1.0   2.0   3.0   4.0   5.0   6.0
 8--TERRAIN SLOPE, % -------     .0
 9--DIRECTION OF WIND VECTOR     .0
10--DIRECTION OF SPREAD ----     .0  (DIRECTION OF MAX SPREAD)
    CALCULATIONS
     DEGREES CLOCKWISE
      FROM THE WIND VECTOR
```

FLAME LENGTH, FT (V4.1)

1-HR MOIS (%)	MIDFLAME WIND, MI/H .0	1.0	2.0	3.0	4.0	5.0	6.0
4.0	1.8	3.1	4.4	5.5	6.5	7.5	8.4
5.0	1.8	3.0	4.3	5.4	6.4	7.3	8.1
6.0	1.7	2.9	4.2	5.2	6.2	7.1	7.9
7.0	1.7	2.9	4.0	5.1	6.0	6.9	7.7
8.0	1.6	2.8	3.9	4.9	5.8	6.7	7.5
9.0	1.5	2.6	3.7	4.6	5.5	6.3	7.0
10.0	1.4	2.3	3.3	4.1	4.9	5.6	6.3

Figure 11—FIRE1 DIRECT run for fuel model 5 and live fuel moisture 75 percent showing 1-h fuel moisture and midflame windspeeds that give flame length predictions of 2 to 5 ft.

```
DIRECT
 1--FUEL MODEL ------------      5 -- BRUSH, 2 FT (60 CM)
 2--1-HR FUEL MOISTURE, % --    4.0   5.0   6.0   7.0   8.0   9.0  10.0
 3--10-HR FUEL MOISTURE, % -    6.0
 6--LIVE WOODY MOISTURE, % -  175.0
 7--MIDFLAME WINDSPEED, MI/H     .0   1.0   2.0   3.0   4.0   5.0   6.0
 8--TERRAIN SLOPE, % -------     .0
 9--DIRECTION OF WIND VECTOR     .0
10--DIRECTION OF SPREAD ----     .0  (DIRECTION OF MAX SPREAD)
    CALCULATIONS
     DEGREES CLOCKWISE
      FROM THE WIND VECTOR
```

FLAME LENGTH, FT (V4.1)

1-HR MOIS (%)	MIDFLAME WIND, MI/H .0	1.0	2.0	3.0	4.0	5.0	6.0
4.0	.6	.9	1.3	1.7	2.0	2.3	2.5
5.0	.5	.9	1.3	1.6	1.9	2.1	2.4
6.0	.5	.9	1.2	1.5	1.8	2.1	2.3
7.0	.5	.8	1.2	1.5	1.7	2.0	2.2
8.0	.5	.8	1.1	1.4	1.7	1.9	2.2
9.0	.5	.8	1.1	1.4	1.7	1.9	2.1
10.0	.5	.8	1.1	1.4	1.7	1.9	2.1

Figure 12—FIRE1 DIRECT run that is the same as that in figure 10 except that live fuel moisture is 175 percent. The window of 2- to 5-ft flame lengths has shifted significantly.

```
INPUT LIST FOR RXWINDOW

FIRE BEHAVIOR CONTRAINTS:

1--RATE OF SPREAD, CH/H                          *** NOT CONSTRAINED ***
2--HEAT PER UNIT AREA, BTU/SQFT                  *** NOT CONSTRAINED ***
3--FIRELINE INTENSITY, BTU/FT/S                  *** NOT CONSTRAINED ***
4--FLAME LENGTH, FT                               2.0 TO    5.0
5--REACTION INTENSITY, BTU/SQFT/M                *** NOT CONSTRAINED ***
6--SCORCH HEIGHT, FT                             *** NOT CONSTRAINED ***
7--TREE MORTALITY, %                             *** NOT CONSTRAINED ***

SITE CONDITIONS:

8--FUEL MODEL:                          5 -- BRUSH, 2 FT (60 CM)
9--FUEL EXPOSURE TO WIND:              EXPOSED
                                       (WIND ADJUSTMENT FACTOR =  .40)
10--TERRAIN SLOPE, %                          .0

PRESET ENVIRONMENTAL CONSTRAINTS:

15--1-H FUEL MOISTURE, %                       4.0 TO   10.0
16--10-H FUEL MOISTURE, %                      6.0
18--LIVE WOODY MOISTURE, %                    75.0
19--20-FOOT WINDSPEED, MI/H                   *** NOT CONSTRAINED ***
20--MIDFLAME WINDSPEED, MI/H                    .0 TO    6.0
22--FIRE SPREAD DIRECTION                     HEAD

OUTPUT TABLE CONFIGURATIONS:

23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  FLAME LENGTH, FEET
24--DEAD FUEL MOISTURE TABLE VARIABLE    :  10-H FUEL MOISTURE, %
25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL  5.

SYMBIOTIC RELATIONSHIPS:

CONSTRAINED MIDFLAME WINDSPEED FROM       .0 TO      6.0 MI/H
CONSTRAINS   20-FOOT WINDSPEED FROM       .0 TO     15.0 MI/H
RELATIONSHIP:  FUEL MODEL & FUEL EXPOSURE TO WIND (LINES 8-9).

CONSTRAINED       FLAME LENGTH FROM      2.0 TO      5.0 FEET
CONSTRAINS  FIRELINE INTENSITY FROM     25.5 TO    185.9 BTU/FT/S
RELATIONSHIP:  MATHEMATICAL FIRE MODEL.
```

(Continued)

Figure 13—RXWINDOW run corresponding to the FIRE1 DIRECT run in figure 11.

WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE *** (FULL WINDOW) (VER 3.5)

WEIGHTED DEAD FM %		20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H			
		2.5 / 1.0	5.0 / 2.0	7.5 / 3.0	10.0 / 4.0
4	W-DIR	ANY	ANY		
	LV-FM	75- 75	75- 75		
	FLAME	3- 3	4- 4		
5	W-DIR	ANY	ANY		
	LV-FM	75- 75	75- 75		
	FLAME	3- 3	4- 4		
6	W-DIR	ANY	ANY		
	LV-FM	75- 75	75- 75		
	FLAME	3- 3	4- 4		
7	W-DIR	ANY	ANY		
	LV-FM	75- 75	75- 75		
	FLAME	3- 3	4- 4		
8	W-DIR	ANY	ANY	ANY	
	LV-FM	75- 75	75- 75	75- 75	
	FLAME	3- 3	4- 4	5- 5	
9	W-DIR	ANY	ANY	ANY	
	LV-FM	75- 75	75- 75	75- 75	
	FLAME	3- 3	4- 4	5- 5	
10	W-DIR	ANY	ANY	ANY	ANY
	LV-FM	75- 75	75- 75	75- 75	75- 75
	FLAME	2- 2	3- 3	4- 4	5- 5

UNITS/CODES FOR TABLE VALUES ARE:
W-DIR - WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS, QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
LV-FM - LIVE WEIGHTED MOISTURE, PERCENT
FLAME - FLAME LENGTH, FEET

Figure 13 (Con.)

```
INPUT LIST FOR RXWINDOW

FIRE BEHAVIOR CONTRAINTS:

1--RATE OF SPREAD, CH/H                          *** NOT CONSTRAINED ***
2--HEAT PER UNIT AREA, BTU/SQFT                  *** NOT CONSTRAINED ***
3--FIRELINE INTENSITY, BTU/FT/S                  *** NOT CONSTRAINED ***
4--FLAME LENGTH, FT                               2.0 TO    5.0
5--REACTION INTENSITY, BTU/SQFT/M                *** NOT CONSTRAINED ***
6--SCORCH HEIGHT, FT                             *** NOT CONSTRAINED ***
7--TREE MORTALITY, %                             *** NOT CONSTRAINED ***

SITE CONDITIONS:

8--FUEL MODEL:                          5 -- BRUSH, 2 FT (60 CM)
9--FUEL EXPOSURE TO WIND:              EXPOSED
                                       (WIND ADJUSTMENT FACTOR =  .40)
10--TERRAIN SLOPE, %                          .0

PRESET ENVIRONMENTAL CONSTRAINTS:

15--1-H FUEL MOISTURE, %                       4.0 TO   10.0
16--10-H FUEL MOISTURE, %                      6.0
18--LIVE WOODY MOISTURE, %                   175.0
19--20-FOOT WINDSPEED, MI/H                  *** NOT CONSTRAINED ***
20--MIDFLAME WINDSPEED, MI/H                   .0 TO    6.0
22--FIRE SPREAD DIRECTION                    HEAD

OUTPUT TABLE CONFIGURATIONS:

23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  FLAME LENGTH, FEET
24--DEAD FUEL MOISTURE TABLE VARIABLE    :  10-H FUEL MOISTURE, %
25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL  5.

SYMBIOTIC RELATIONSHIPS:

CONSTRAINED MIDFLAME WINDSPEED FROM       .0 TO      6.0 MI/H
CONSTRAINS   20-FOOT WINDSPEED FROM       .0 TO     15.0 MI/H
RELATIONSHIP:  FUEL MODEL & FUEL EXPOSURE TO WIND (LINES 8-9).

CONSTRAINED       FLAME LENGTH FROM      2.0 TO      5.0 FEET
CONSTRAINS  FIRELINE INTENSITY FROM     25.5 TO    185.9 BTU/FT/S
RELATIONSHIP:  MATHEMATICAL FIRE MODEL.
```

(Continued)

Figure 14—RXWINDOW run corresponding to the FIRE1 DIRECT run in figure 12.

WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE *** (FULL WINDOW) (VER 3.5)

WEIGHTED DEAD FM %		20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H		
		10.0	12.5	15.0
		4.0	5.0	6.0
4	W-DIR	ANY	ANY	ANY
	LV-FM	175-175	175-175	175-175
	FLAME	2- 2	2- 2	3- 3
5	W-DIR		ANY	ANY
	LV-FM		175-175	175-175
	FLAME		2- 2	2- 2
6	W-DIR		ANY	ANY
	LV-FM		175-175	175-175
	FLAME		2- 2	2- 2
7	W-DIR		ANY	ANY
	LV-FM		175-175	175-175
	FLAME		2- 2	2- 2
8	W-DIR			ANY
	LV-FM			175-175
	FLAME			2- 2
9	W-DIR			ANY
	LV-FM			175-175
	FLAME			2- 2
10	W-DIR			ANY
	LV-FM			175-175
	FLAME			2- 2

UNITS/CODES FOR TABLE VALUES ARE:
W-DIR = WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS, QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
LV-FM = LIVE WEIGHTED MOISTURE, PERCENT
FLAME = FLAME LENGTH, FEET

Figure 14 (Con.)

```
 INPUT LIST FOR RXWINDOW

 FIRE BEHAVIOR CONTRAINTS:

 1--RATE OF SPREAD, CH/H                          *** NOT CONSTRAINED ***
 2--HEAT PER UNIT AREA, BTU/SQFT                  *** NOT CONSTRAINED ***
 3--FIRELINE INTENSITY, BTU/FT/S                  *** NOT CONSTRAINED ***
 4--FLAME LENGTH, FT                               2.0 TO    5.0
 5--REACTION INTENSITY, BTU/SQFT/M                *** NOT CONSTRAINED ***
 6--SCORCH HEIGHT, FT                             *** NOT CONSTRAINED ***
 7--TREE MORTALITY, %                             *** NOT CONSTRAINED ***

 SITE CONDITIONS:

 8--FUEL MODEL:                        5 -- BRUSH, 2 FT (60 CM)
 9--FUEL EXPOSURE TO WIND:            EXPOSED
                                      (WIND ADJUSTMENT FACTOR =  .40)
10--TERRAIN SLOPE, %                        .0

 PRESET ENVIRONMENTAL CONSTRAINTS:

15--1-H FUEL MOISTURE, %                     4.0 TO   10.0
16--10-H FUEL MOISTURE, %                    6.0
18--LIVE WOODY MOISTURE, %                  75.0 TO  175.0
19--20-FOOT WINDSPEED, MI/H                 *** NOT CONSTRAINED ***
20--MIDFLAME WINDSPEED, MI/H                  .0 TO    6.0
22--FIRE SPREAD DIRECTION                   HEAD

 OUTPUT TABLE CONFIGURATIONS:

23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  FLAME LENGTH, FEET
24--DEAD FUEL MOISTURE TABLE VARIABLE    :  10-H FUEL MOISTURE, %
25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL  5.

 SYMBIOTIC RELATIONSHIPS:

 CONSTRAINED MIDFLAME WINDSPEED FROM       .0 TO      6.0 MI/H
 CONSTRAINS   20-FOOT WINDSPEED FROM       .0 TO     15.0 MI/H
 RELATIONSHIP:  FUEL MODEL & FUEL EXPOSURE TO WIND (LINES 8-9).

 CONSTRAINED       FLAME LENGTH FROM      2.0 TO      5.0 FEET
 CONSTRAINS  FIRELINE INTENSITY FROM     25.5 TO    185.9 BTU/FT/S
 RELATIONSHIP:  MATHEMATICAL FIRE MODEL.                    (Continued)
```

Figure 15—RXWINDOW run like those in figures 13 and 14, but with live fuel moisture allowed to be anything from 75 to 175 percent. Compare the location of the circled values (75 percent) to those in figure 13 and the boxed values (175 percent) to those in figure 14. Flame length is printed as a table variable.

WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE *** (FULL WINDOW) (VER 3.5)

WEIGHTED DEAD FM %		20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H					
		2.5	5.0	7.5	10.0	12.5	15.0
		1.0	2.0	3.0	4.0	5.0	6.0
4	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	(75)-125	(75)-135	95-145	115-[175]	125-[175]	135-[175]
	FLAME	2- 3	2- 4	2- 5	2- 5	2- 5	3- 5
5	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	(75)-115	(75)-125	95-135	115-155	125-[175]	125-[175]
	FLAME	2- 3	2- 4	2- 5	2- 4	2- 4	2- 5
6	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	(75)-105	(75)-115	85-125	105-135	115-[175]	115-[175]
	FLAME	2- 3	3- 4	2- 5	2- 5	2- 4	2- 5
7	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	(75)- 95	(75)-105	85-115	95-125	105-[175]	115-[175]
	FLAME	2- 3	3- 4	2- 5	2- 5	2- 5	2- 4
8	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	(75)- 95	(75)-105	(75)-105	95-115	95-165	105-[175]
	FLAME	2- 3	2- 4	3- 5	2- 4	2- 5	2- 4
9	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	(75)- 85	(75)- 95	(75)- 95	85-105	95-165	95-[175]
	FLAME	2- 3	2- 4	3- 5	2- 5	2- 4	2- 4
10	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	(75)- (75)	(75)- 85	(75)- 85	(75)-105	85-155	85-[175]
	FLAME	2- 2	2- 3	3- 4	2- 5	2- 4	2- 5

UNITS/CODES FOR TABLE VALUES ARE:
W-DIR = WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS, QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
LV-FM = LIVE WEIGHTED MOISTURE, PERCENT
FLAME = FLAME LENGTH, FEET

Figure 15 (Con.)

WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE *** (FULL WINDOW) (VER 3.5)

WEIGHTED DEAD FM %		20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H					
		2.5 / 1.0	5.0 / 2.0	7.5 / 3.0	10.0 / 4.0	12.5 / 5.0	15.0 / 6.0
4	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	75-125	75-135	95-145	115-175	125-175	135-175
	ROS	3- 5	4- 11	5- 14	5- 16	7- 18	9- 18
5	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	75-115	75-125	95-135	115-155	125-175	125-175
	ROS	3- 5	5- 10	5- 14	5- 14	6- 15	8- 19
6	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	75-105	75-115	85-125	105-135	115-175	115-175
	ROS	3- 5	5- 10	5- 15	6- 15	6- 16	8- 21
7	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	75- 95	75-105	85-115	95-125	105-175	115-175
	ROS	3- 5	5- 10	6- 14	6- 17	6- 18	7- 15
8	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	75- 95	75-105	75-105	95-115	95-165	105-175
	ROS	3- 4	4- 9	7- 15	6- 15	6- 19	7- 16
9	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	75- 85	75- 95	75- 95	85-105	95-165	95-175
	ROS	3- 4	4- 9	7- 14	6- 16	6- 14	7- 18
10	W-DIR	ANY	ANY	ANY	ANY	ANY	ANY
	LV-FM	75- 75	75- 85	75- 85	75-105	85-155	85-175
	ROS	4- 4	5- 8	8- 13	6- 18	6- 16	7- 21

UNITS/CODES FOR TABLE VALUES ARE:
W-DIR - WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS,
QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
LV-FM - LIVE WEIGHTED MOISTURE, PERCENT
ROS - RATE OF SPREAD, CHAINS/H

Figure 16—RXWINDOW output where the input is the same as for figure 15 except that the table variable is chosen to be rate of spread (ROS).

```
 INPUT LIST FOR RXWINDOW

 FIRE BEHAVIOR CONTRAINTS:

 1--RATE OF SPREAD, CH/H                          *** NOT CONSTRAINED ***
 2--HEAT PER UNIT AREA, BTU/SQFT                  *** NOT CONSTRAINED ***
 3--FIRELINE INTENSITY, BTU/FT/S                  *** NOT CONSTRAINED ***
 4--FLAME LENGTH, FT                               2.0 TO    5.0
 5--REACTION INTENSITY, BTU/SQFT/M                *** NOT CONSTRAINED ***
 6--SCORCH HEIGHT, FT                             *** NOT CONSTRAINED ***
 7--TREE MORTALITY, %                             *** NOT CONSTRAINED ***

 SITE CONDITIONS:

 8--FUEL MODEL:                          5 -- BRUSH, 2 FT (60 CM)
 9--FUEL EXPOSURE TO WIND:              EXPOSED
                                        (WIND ADJUSTMENT FACTOR =  .40)
10--TERRAIN SLOPE, %                              .0

 PRESET ENVIRONMENTAL CONSTRAINTS:

15--1-H FUEL MOISTURE, %                          *** NOT CONSTRAINED ***
16--10-H FUEL MOISTURE, %                         *** NOT CONSTRAINED ***
18--LIVE WOODY MOISTURE, %                        *** NOT CONSTRAINED ***
19--20-FOOT WINDSPEED, MI/H                       *** NOT CONSTRAINED ***
20--MIDFLAME WINDSPEED, MI/H                      *** NOT CONSTRAINED ***
22--FIRE SPREAD DIRECTION                         *** NOT CONSTRAINED ***

 OUTPUT TABLE CONFIGURATIONS:

23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  FLAME LENGTH, FEET
24--DEAD FUEL MOISTURE TABLE VARIABLE    :  1-H FUEL MOISTURE, %
25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL  5.

 SYMBIOTIC RELATIONSHIPS:

 CONSTRAINED       FLAME LENGTH FROM      2.0 TO      5.0 FEET
 CONSTRAINS  FIRELINE INTENSITY FROM     25.5 TO    185.9 BTU/FT/S
 RELATIONSHIP:  MATHEMATICAL FIRE MODEL.
```

(Continued)

Figure 17—RXWINDOW run with no preset environmental conditions (as was done in figures 15 and 16). Flame length is constrained to 2 to 5 ft. In the interest of saving space, only the head fire table is shown here. This run also produced similar tables for flanking and backing fires.

WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE *** (FULL WINDOW) (VER 3.5)

		20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H							
WEIGHTED		.0	4.0	8.0	12.0	16.0	20.0	24.0	28.0
DEAD FM %		.0	1.6	3.2	4.8	6.4	8.0	9.6	11.2
1 W-DIR		ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM		30- 80	60-170	140-260	160-300	170-300	180-300	180-300	190-300
FLAME		2- 3	2- 5	2- 5	2- 5	3- 5	3- 4	4- 5	4- 5
2 W-DIR		ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM		30- 70	50-160	120-200	150-300	160-300	170-300	170-300	170-300
FLAME		2- 3	2- 5	2- 5	2- 5	3- 5	3- 4	3- 4	4- 5
3 W-DIR		ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM		30- 60	50-150	110-160	140-290	150-300	160-300	160-300	160-300
FLAME		2- 3	2- 5	2- 5	2- 5	2- 4	3- 4	3- 4	3- 4
4 W-DIR		ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM		30- 60	40-130	100-140	130-240	140-300	140-300	150-300	150-300
FLAME		2- 3	2- 5	3- 5	2- 5	2- 4	2- 5	3- 4	3- 4
5 W-DIR		ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM		30- 50	40-120	100-130	120-210	130-300	130-300	140-300	140-300
FLAME		2- 2	2- 5	3- 5	2- 5	2- 4	2- 5	3- 3	3- 4
6 W-DIR		ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM		30- 50	40-110	90-120	110-180	120-290	120-300	130-300	130-300
FLAME		2- 2	2- 5	3- 5	2- 5	2- 4	2- 5	2- 3	3- 4
7 W-DIR		ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM		30- 40	30-100	80-110	100-170	110-270	110-300	120-300	120-300
FLAME		2- 2	3- 5	3- 5	2- 5	2- 4	2- 5	2- 3	3- 4
8 W-DIR		ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM		30- 40	30- 90	80-100	90-160	100-250	100-300	110-300	110-300
FLAME		2- 2	3- 5	3- 5	2- 5	2- 4	2- 5	2- 3	2- 4
9 W-DIR		ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM		30- 40	30- 80	70- 90	80-150	90-240	90-300	90-300	100-300
FLAME		2- 2	3- 5	3- 5	2- 5	2- 4	2- 4	2- 5	2- 4
10 W-DIR		ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM		30- 40	30- 70	70- 80	80-150	80-240	80-300	80-300	90-300
FLAME		2- 2	3- 5	2- 4	2- 3	2- 4	2- 4	2- 5	2- 4

Figure 17 (Con.)

(Continued)

11 W-DIR	I	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM	I	30- 30	30- 60	60- 70	70-140	70-230	70-300	70-300	80-300
FLAME	I	2- 2	3- 4	2- 4	2- 3	2- 4	2- 4	2- 5	2- 4
12 W-DIR	I	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM	I	30- 30	30- 50	50- 60	60-130	60-220	60-300	60-300	60-300
FLAME	I	2- 2	3- 4	2- 5	2- 3	2- 3	2- 4	2- 4	2- 4
13 W-DIR	I	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM	I	30- 30	30- 40	40- 50	50-120	50-200	50-290	50-300	50-300
FLAME	I	2- 2	3- 4	2- 5	2- 3	2- 3	2- 3	2- 4	2- 4
14 W-DIR	I		ANY	ANY	ANY	ANY	ANY	ANY	ANY
LV-FM	I		30- 30	40- 40	40-100	40-180	40-260	40-300	40-300
FLAME	I		4- 4	2- 2	2- 3	2- 3	2- 3	2- 4	2- 4
15 W-DIR	I				ANY	ANY	ANY	ANY	ANY
LV-FM	I				30- 80	30-140	30-210	30-230	30-230
FLAME	I				2- 2	2- 3	2- 3	2- 3	2- 3
16 W-DIR	I				ANY	ANY	ANY	ANY	ANY
LV-FM	I				30- 50	30-100	30-130	30-130	30-130
FLAME	I				2- 2	2- 3	2- 3	2- 3	2- 3
17 W-DIR	I					ANY	ANY	ANY	ANY
LV-FM	I					30- 40	30- 40	30- 40	30- 40
FLAME	I					2- 2	2- 2	2- 2	2- 2

UNITS/CODES FOR TABLE VALUES ARE:
W-DIR - WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS, QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
LV-FM - LIVE WEIGHTED MOISTURE, PERCENT
FLAME - FLAME LENGTH, FEET

Figure 17 (Con.)

Example 3

In this final example we illustrate the use of the ZOOM keyword and show the two format options for the dead fuel moisture table. In figure 18 we use fuel model 12 (medium logging slash), which has three sizes of dead fuel and no live fuel. The burn will be on a 5 percent slope, partially sheltered from the wind. The prescription is based on constraining flame length to 4 to 8 ft and scorch height to 10 to 30 ft. We restrict 1-h fuel moisture to 4 to 24 percent (not much of a constraint) and plan to use a head fire. There are no preset constraints on wind direction.

The prescription table shows a 20-ft windspeed range of 2 to 30 mi/h (0.6 to 9.0 mi/h at midflame height) and a weighted dead fuel moisture range of 4 to 17 percent. Notice that weighted dead fuel moisture skips from 5 to 9 percent. This is a result of condensation of the table to fit on the screen. Rows with only blank cells are not displayed. The range of 20-ft windspeed is from 2 to 30 mi/h. Only every fourth column is displayed on the initial table. Figure 19 illustrates a view of a selected portion of the table using the ZOOM keyword. Twenty-foot windspeed was set to 2 to 6 mi/h in increments of 1 mi/h and weighted dead moisture from 4 to 9 percent in 1 percent increments. The circled values in figure 19 correspond to those displayed in figure 18.

A dead fuel moisture table is available whenever the fuel model has more than one class of dead fuel. In this example, fuel model 12 has 1-h, 10-h, and 100-h fuel. The moisture table shows combinations of 1-h and 10-h that result in the same weighted dead fuel moisture. Line 24 of figure 18 shows the dead fuel moisture table variable chosen to be 10-h fuel moisture. The resulting table is in figure 20. The row values (WGHTED DEAD) are the weighted dead moistures for the same range as the base table: 4 to 17 percent in figure 18. The column values are 1-h dead fuel moisture contents. Table values are ranges of 10-h dead fuel moisture content. For example, 8 percent weighted dead moisture can be obtained by various combinations of 1-h and 10-h moisture contents: 10-h = 17 to 20 percent when 1-h = 4 percent; 10-h = 8 to 11 percent when 1-h = 7 percent; and so on. The ZOOM keyword can be used with moisture tables to view 1-h fuel moisture ranges in smaller increments as illustrated in figure 21.

Figure 22 shows the alternate format for the dead moisture tables in which the table variable is 1-h moisture. Reading from the table, an 8 percent weighted fuel moisture can be obtained by 10-h = 4 percent and 1-h = 9 percent, 10-h = 16 percent and 1-h = 5 percent, and so on.

A live fuel moisture table is generated for custom fuel models that contain both live herbaceous and live woody fuel. Row values are weighted live fuel moisture content. Depending on the table format chosen (line 25), the table variable is either live herbaceous or live woody fuel moisture.

```
 INPUT LIST FOR RXWINDOW

 FIRE BEHAVIOR CONTRAINTS:

 1--RATE OF SPREAD, CH/H                          *** NOT CONSTRAINED ***
 2--HEAT PER UNIT AREA, BTU/SQFT                  *** NOT CONSTRAINED ***
 3--FIRELINE INTENSITY, BTU/FT/S                  *** NOT CONSTRAINED ***
 4--FLAME LENGTH, FT                               4.0 TO    8.0
 5--REACTION INTENSITY, BTU/SQFT/M                *** NOT CONSTRAINED ***
 6--SCORCH HEIGHT, FT                             10.0 TO   30.0
 7--TREE MORTALITY, %                             *** NOT CONSTRAINED ***

 SITE CONDITIONS:

 8--FUEL MODEL:                        12 -- MEDIUM LOGGING SLASH
 9--FUEL EXPOSURE TO WIND:             PARTIALLY SHELTERED
                                       (WIND ADJUSTMENT FACTOR =  .30)
10--TERRAIN SLOPE, %                          5.0
11--100-H MOISTURE = 10-H MOISTURE PLUS        5. %

 PRESET ENVIRONMENTAL CONSTRAINTS:

15--1-H FUEL MOISTURE, %                       4.0 TO   24.0
16--10-H FUEL MOISTURE, %                     *** NOT CONSTRAINED ***
19--20-FOOT WINDSPEED, MI/H                   *** NOT CONSTRAINED ***
20--MIDFLAME WINDSPEED, MI/H                  *** NOT CONSTRAINED ***
21--WIND DIRECTION                            *** NOT CONSTRAINED ***
22--FIRE SPREAD DIRECTION                     HEAD

 OUTPUT TABLE CONFIGURATIONS:

23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  FLAME LENGTH, FEET
24--DEAD FUEL MOISTURE TABLE VARIABLE    :  10-H FUEL MOISTURE, %
25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL 12.

 SYMBIOTIC RELATIONSHIPS:

 CONSTRAINED       FLAME LENGTH FROM      4.0 TO      8.0 FEET
 CONSTRAINS  FIRELINE INTENSITY FROM    114.6 TO    515.5 BTU/FT/S
 RELATIONSHIP:  MATHEMATICAL FIRE MODEL.                    (Continued)
```

Figure 18—RXWINDOW run with two fire behavior constraints, flame length 4 to 8 ft and scorch height 10 to 30 ft. The boxed portion of the table is expanded in figure 19.

WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE *** (FULL WINDOW) (VER 3.5)

WEIGHTED DEAD FM %		20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H							
		2.0 .6	6.0 1.8	10.0 3.0	14.0 4.2	18.0 5.4	22.0 6.6	26.0 7.8	30.0 9.0
4	W-DIR	ANY							
	FLAME	4- 4							
5	W-DIR	UP- X							
	FLAME	4- 4							
9	W-DIR		QU- DN						
	FLAME		5- 5						
10	W-DIR		ANY						
	FLAME		5- 5						
11	W-DIR		ANY						
	FLAME		4- 5						
12	W-DIR		ANY						
	FLAME		4- 4						
13	W-DIR		ANY						
	FLAME		4- 4						
14	W-DIR			ANY					
	FLAME			5- 5					
15	W-DIR			ANY	ANY				
	FLAME			4- 4	5- 5				
16	W-DIR				ANY	ANY	ANY	ANY	ANY
	FLAME				4- 4	5- 5	5- 5	6- 6	6- 6
17	W-DIR						ANY	ANY	ANY
	FLAME						4- 4	5- 5	5- 5

UNITS/CODES FOR TABLE VALUES ARE:
W-DIR - WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS, QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
FLAME - FLAME LENGTH, FEET
SCORCH HEIGHTS ARE BASED ON A 77 DEG (F) DAY.

Figure 18 (Con.)

WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE *** (ZOOMED VIEW) (VER 3.5)

	20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H				
WEIGHTED DEAD FM %	2.0 .6	3.0 .9	4.0 1.2	5.0 1.5	6.0 1.8
4 W-DIR	ANY	QD- DN			
FLAME	4- 4	5- 5			
5 W-DIR	UP- X	ANY			
FLAME	4- 4	4- 4			
6 W-DIR		ANY	ANY		
FLAME		4- 4	5- 5		
7 W-DIR		UP- QD	ANY	ANY	
FLAME		4- 4	4- 4	5- 5	
8 W-DIR			ANY	ANY	
FLAME			4- 4	5- 5	
9 W-DIR			ANY	ANY	QU- DN
FLAME			4- 4	4- 4	5- 5

UNITS/CODES FOR TABLE VALUES ARE:
W-DIR - WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS, QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
FLAME - FLAME LENGTH, FEET
SCORCH HEIGHTS ARE BASED ON A 77 DEG (F) DAY.

Figure 19—The keyword ZOOM was used to expand a section of the output table in figure 18. Circled values correspond to those shown in figure 18.

```
   DEAD FUEL MOISTURE TABLE:  TABLE RANGES ARE VALID 10-H MOISTURE RANGES.
                FUEL MODEL:  12 -- MEDIUM LOGGING SLASH

  MOISTURE WEIGHTING FACTORS ARE:   1 HOUR ( 74.8 %)
                                   10 HOUR ( 19.0 %)
                                  100 HOUR (  6.2 %)
(VER 3.5)
WGHTED I                1-HOUR FUEL MOISTURE, %
 DEAD  I    (4)     (7)     10      13      16      19      22
------ I ------ ------ ------ ------ ------ ------ ------
  4 %  I  4- 1
  5 %  I  8- 5
  6 %  I 12- 9   3- 1
  7 %  I 16-13   7- 4
  8 %  I 20-17  11- 8   2- 1
  9 %  I 24-21  15-12   6- 3
 10 %  I 28-25  19-16  10- 7   1- 1
 11 %  I 30-29  23-20  14-11   5- 2
 12 %  I        27-24  18-15   9- 6
 13 %  I        30-28  22-19  13-10   4- 1
 14 %  I               26-23  17-14   8- 5
 15 %  I               30-27  21-18  12- 9   3- 1
 16 %  I                      25-22  16-13   7- 4
 17 %  I                      29-26  20-17  11- 8   2- 1
------ I ------ ------ ------ ------ ------ ------ ------
```

Figure 20—Dead fuel moisture table for the RXWINDOW run in figure 18. The dead fuel moisture table variable was chosen to be 10-h.

```
  DEAD FUEL MOISTURE TABLE:  TABLE RANGES ARE VALID 10-H MOISTURE RANGES.
               FUEL MODEL:  12 -- MEDIUM LOGGING SLASH

 MOISTURE WEIGHTING FACTORS ARE:   1 HOUR ( 74.8 %)
                                  10 HOUR ( 19.0 %)
                                 100 HOUR (  6.2 %)
(VER 3.5)
WGHTED I              1-HOUR FUEL MOISTURE, %
 DEAD  I    4       5       6       7       8       9      10      11      12      13
------ I ------ ------ ------ ------ ------ ------ ------ ------ ------ ------
  4 %  I  4- 1   1-1
  5 %  I  8- 5   5- 2   2- 1
  6 %  I 12- 9   9- 6   6- 3   3- 1
  7 %  I 16-13  13-10  10- 7   7- 4   4- 1   1- 1
  8 %  I 20-17  17-14  14-11  11- 8   8- 5   5- 2   2- 1
  9 %  I 24-21  21-18  18-15  15-12  12- 9   9- 6   6- 3   3- 1
------ I ------ ------ ------ ------ ------ ------ ------ ------ ------ ------
```

Figure 21—The keyword ZOOM was used to expand a section of the moisture table in figure 20.

DEAD FUEL MOISTURE TABLE: TABLE VALUES ARE VALID 1-H MOISTURE RANGES.
FUEL MODEL: 12 -- MEDIUM LOGGING SLASH

MOISTURE WEIGHTING FACTORS ARE: 1 HOUR (74.8 %)
10 HOUR (19.0 %)
100 HOUR (6.2 %)

(VER 3.5)

WGHTED DEAD	I	10-HOUR FUEL MOISTURE, % 1	4	7	10	13	16	19	22	25	28
4 %	I	5- 4	4- 4								
5 %	I	6- 6	5- 5	4- 4							
6 %	I	7- 7	6- 6	5- 5	4- 4						
7 %	I	9- 8	8- 7	7- 6	6- 5	5- 4	4- 4				
8 %	I	10-10	9- 9	8- 8	7- 7	6- 6	5- 5	4- 4			
9 %	I	11-11	10-10	9- 9	8- 8	7- 7	6- 6	5- 5	4- 4		
10 %	I	13-12	12-11	11-10	10- 9	9- 8	8- 7	7- 6	6- 5	5- 4	4- 4
11 %	I	14-14	13-13	12-12	11-11	10-10	9- 9	8- 8	7- 7	6- 6	5- 5
12 %	I	15-15	14-14	13-13	12-12	11-11	10-10	9- 9	8- 8	7- 7	6- 6
13 %	I	17-16	16-15	15-14	14-13	13-12	12-11	11-10	10- 9	9- 8	8- 7
14 %	I	18-18	17-17	16-16	15-15	14-14	13-13	12-12	11-11	10-10	9- 9
15 %	I	19-19	18-18	17-17	16-16	15-15	14-14	13-13	12-12	11-11	10-10
16 %	I	21-20	20-19	19-18	18-17	17-16	16-15	15-14	14-13	13-12	12-11
17 %	I	22-22	21-21	20-20	19-19	18-18	17-17	16-16	15-15	14-14	13-13

Figure 22—Dead fuel moisture table for the RXWINDOW run in figure 18, but with the table variable chosen to be 1-h.

SUMMARY

RXWINDOW is a prescribed fire planning tool that allows incorporation of mathematical fire behavior and fire effects models into the process. RXWINDOW is not a comprehensive fire prescription development system. Prediction models are not available for all aspects of prescribed fire behavior and effects; and not all available models have been included in the program. RXWINDOW reformulates models that are already in use through the FIRE1 program in BEHAVE. Development of future prescribed fire planning systems may well be influenced by experiences gained through use of this program.

A fire prescription is a statement of objectives for the fire and a description of the required fire and environmental conditions under which the objectives can be met. The process of planning for prescribed fire is described by Fischer (1978), Martin and Dell (1978), and Brown (1985). The four steps are:

1. Specify resource management objectives, such as regenerate trees, increase capacity of wildlife habitat, or protect resources from wildfire.
2. Determine fire objectives required to meet the resource management objectives. The fire objectives can be stated in terms of both fire effects and fire control, such as desired ranges of fuel consumption and plant mortality, and acceptable amount of smoke production. Getting the fire to spread might also be a fire objective.
3. Determine what kind of fire treatment will result in the specified fire objectives. One aspect of fire treatment is fire behavior, such as desired flame length, intensity, and scorch height.
4. Determine how the specified fire treatment can be attained, possibly based on a range of weather and fuel moisture conditions.

A range of weather and fuel moisture conditions are specified that can be expected to result in the desired fire treatment, which in turn results in desired fire effects that best meet management objectives for the particular site. RXWINDOW can be used in step 4.

A comprehensive system for designing fire prescriptions would address all of these steps, recognizing conflicting goals. Such a system is described by Reinhardt and others (1989). At this time that system is at a prototype stage and needs formal testing and evaluation. Potential delivery to users is unresolved.

For now we add RXWINDOW to the prescribed fire planner's "tool box." RXWINDOW might be used in conjunction with other available systems. For example, the MOISTURE module of the FIRE2 program in BEHAVE calculates fine dead fuel moisture from environmental conditions, including temperature, relative humidity, and shade. And the RXWTHR and RXBURN programs (Bradshaw and Fischer 1981) generate climatological summaries of fire weather variables and cooccurrences of ranges of those variables.

Successful use of the RXWINDOW program in developing fire prescriptions depends on the experience and professionalism of prescribed fire managers.

REFERENCES

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

Anderson, Hal E. 1982. Aids to determining fuel models for estimating fire behavior. Gen. Tech. Rep. INT-122. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 22 p.

Andrews, Patricia L. 1986. BEHAVE: fire behavior prediction and fuel modeling system—BURN subsystem, Part 1. Gen. Tech. Rep. INT-194. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 130 p.

Andrews, Patricia L.; Bradshaw, Larry S. 1987. A system for defining windows of acceptable burning conditions for prescribed fire based on desired fire behavior. In: Proceedings, ninth conference on fire and forest meteorology; 1987 April 21-24; San Diego, CA. Boston, MA: American Meteorological Society: 49-56.

Andrews, Patricia L.; Chase, Carolyn H. 1989. BEHAVE: fire behavior prediction and fuel modeling system—BURN subsystem, Part 2. Gen. Tech. Rep. INT-260. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 93 p.

Bradshaw, Larry S.; Fischer, William C. 1981. A computer system for scheduling fire use. Part I: The system. Gen. Tech. Rep. INT-91. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 63 p.

Brown, James K. 1985. A process for designing fire prescriptions. In: Proceedings, prescribed fire by aerial ignition; 1984 October 30-November 1; Missoula, MT. Missoula, MT: Intermountain Fire Council: 17-30.

Brown, James K.; Simmerman, Dennis G. 1986. Appraising fuels and flammability in western aspen: a prescribed fire guide. Gen. Tech. Rep. INT-205. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 48 p.

Burgan, Robert E.; Rothermel, Richard C. 1984. BEHAVE: fire behavior prediction and fuel modeling system—FUEL subsystem. Gen. Tech. Rep. INT-167. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 126 p.

Doren, Robert F.; Richardson, Donald R.; Roberts, Richard E. 1987. Prescribed burning of the sand pine scrub community: Yamato scrub, a test case. Florida Scientist. 50(3): 184-192.

Fischer, William C. 1978. Planning and evaluating prescribed fires—a standard procedure. Gen. Tech. Rep. INT-43. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 19 p.

Martin, Robert E.; Dell, J. D. 1978. Planning for prescribed fire in the inland Northwest. Gen. Tech. Rep. PNW-76. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 67 p.

Raybould, Steven; Roberts, Tom. 1983. A matrix approach to fire prescription writing. Fire Management Notes. 44(4): 7-10.

Reinhardt, Elizabeth; Ryan, Kevin. 1988. Estimating tree mortality resulting from prescribed fire. Fire Management Notes. 49(4): 30-36.

Reinhardt, Elizabeth; Wright, Alden H.; Jackson, David H. 1989. An advisory expert system for designing fire prescriptions. Ecological Modelling. 46: 1-13.

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

Rothermel, Richard C. 1985. Fire behavior considerations of aerial ignition. In: Proceedings, prescribed fire by aerial ignition; 1984 October 30-November 1; Missoula, MT. Missoula, MT: Intermountain Fire Council: 143-158.

Ryan, Kevin C.; Reinhardt, Elizabeth. 1988. Predicting post-fire mortality of seven western conifers. Canadian Journal of Forest Research. 18: 1291-1297.

U.S. Department of Agriculture, Forest Service. 1989. A guide for prescribed fire in southern forests. Tech. Publ. R8-TP 11. Atlanta, GA: U.S. Department of Agriculture, Forest Service. 56 p.

Van Wagner, C. E. 1973. Height of crown scorch in forest fires. Canadian Journal of Forest Research. 3: 373-378.

APPENDIX: ANNOTATED RUN OF THE RXWINDOW PROGRAM OF THE BEHAVE SYSTEM

This appendix provides a complete user session with the RXWINDOW program of the BEHAVE system, with all of the interaction between the computer and the user. Basic operation is similar to the FIRE1 and FIRE2 programs. Features unique to RXWINDOW are emphasized here.

Lines that begin with a > (the prompt symbol) were typed by the user. All others were printed by the computer. The prompt symbol may be different on another computer. (The Forest Service Data General system does not provide a prompt.)

Gaining access to the BEHAVE programs and printing log files are functions of the computer being used and therefore are not described in this manual.

```
WELCOME to the BEHAVE system
  BURN subsytem
    RXWINDOW program:  Version 3.5 -- May 1990

Developed by:  The Fire Behavior Research Work Unit
               Intermountain Fire Sciences Laboratory
               In Cooperation with
               Systems for Environmental Mgmt.
               Missoula, Montana

 Operation of the program,
 assumptions and limitations of the models,
 and proper application of RXWINDOW are in:

      Andrews, Patricia L., and Bradshaw, Larry S.  "RXWINDOW:
      Defining Windows of Acceptable Burning Conditions Based
      on Desired Fire Behavior," INT-GTR-000, 1990.

 PRESS ENTER TO CONTINUE....
>
 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>input

 INPUT OF FIRE BEHAVIOR CONSTRAINTS...
  CONSTRAIN AT LEAST ONE OF LINES 1 - 7

  1--DO YOU WANT TO CONSTRAIN RATE OF SPREAD ? Y-N
>n

  2--DO YOU WANT TO CONSTRAIN HEAT PER UNIT AREA ? Y-N
>n

  3--DO YOU WANT TO CONSTRAIN FIRELINE INTENSITY ? Y-N
>n

  4--DO YOU WANT TO CONSTRAIN FLAME LENGTH ? Y-N
>y

 ENTER MINIMUM VALUE, FT ? 0 TO 100
>4

 ENTER MAXIMUM VALUE, FT ? 4 TO 100
>8

  5--DO YOU WANT TO CONSTRAIN REACTION INTENSITY ? Y-N
>b
 b IS NOT A VALID ANSWER.
 TYPE Y FOR YES  OR  N FOR NO.
>n

  6--DO YOU WANT TO CONSTRAIN SCORCH HEIGHT ? Y-N
>n

  7--DO YOU WANT TO CONSTRAIN TREE MORTALITY ? Y-N
>n

 INPUT OF SITE PARAMETERS...

  8--FUEL MODEL ? (1-99 OR ?)
       (ENTER 1 TO 13 FOR STANDARD MODELS,
              14 TO 99 FOR CUSTOM MODELS, OR
              ? FOR A LIST OF STANDARD MODELS.)
>12
      FUEL MODEL: 12 -- MEDIUM LOGGING SLASH
```

Both upper and lower case are allowed in RXWINDOW. (Upper case is required in the other BEHAVE programs.)

Specify 4 to 8 ft. flame lengths as acceptable.

Input is checked as it is entered.

A single value must be entered for each of lines 8-14.

```
 9--EXPOSURE OF FUELS TO THE WIND ? 1-5
      1=EXPOSED
      2=PARTIALLY SHELTERED
      3=FULLY SHELTERED--OPEN STAND
      4=FULLY SHELTERED--DENSE STAND
      5=ENTER YOUR OWN WIND REDUCTION FACTOR
>2

       WIND ADJUSTMENT FACTOR =   .3

 10--TERRAIN SLOPE, % ? 0 TO 100
>5

 11--RELATIONSHIP BEWTEEN 100-H AND 10-H MOISTURE, % ?    -10 TO 10
>5
     100-HR MOISTURE = 10-HR MOISTURE +  5. %  OK ? Y-N
>y

 INPUT OF PRESET ENVIRONMENTAL LIMITS...
  YOU MAY CONSTRAIN ANY OR NONE OF LINES 15-22

 15--DO YOU WANT TO CONSTRAIN 1-HR FUEL MOISTURE ? Y-N
>y

 ENTER MINIMUM VALUE, % ? 1 TO 40
>4

 ENTER MAXIMUM VALUE, % ? 4 TO 40
>24

 16--DO YOU WANT TO CONSTRAIN 10-HR FUEL MOISTURE ? Y-N
>n

 19--DO YOU WANT TO CONSTRAIN 20-FOOT WINDSPEED ? Y-N
>y

 ENTER MINIMUM VALUE, MI/H ? 0 TO 30
>2

 ENTER MAXIMUM VALUE, MI/H ? 2 TO 30
>8

 20--DO YOU WANT TO CONSTRAIN MIDFLAME WINDSPEED ? Y-N
>n

 21--DO YOU WANT TO CONSTRAIN WIND DIRECTION ? Y-N
>n

 22--DO YOU WANT TO CONSTRAIN FIRE SPREAD DIRECTION ? Y-N
>y

 1 = HEAD FIRE      2 = FLANK FIRE     3 = BACKING FIRE

 ENTER MINIMUM VALUE, (CODE) ? 1 TO 3
>1

 ENTER MAXIMUM VALUE, (CODE) ? 1 TO 3
>1

 SPECIFICATION OF OUTPUT TABLE DESIGN...

 23--INCLUDE A FIRE VARIABLE IN THE OUTPUT TABLE ? Y-N
>y

  WHICH ONE ? 1-8
      1=RATE OF SPREAD          2=HEAT PER UNIT AREA
      3=FIRELINE INTENSITY      4=FLAME LENGTH
      5=REACTION INTENSITY      6=SCORCH HEIGHT
      7=MORTALITY               8=SPREAD DIRECTION
>4
```

In case you didn't understand the question.

1-h = 4 to 24% will be considered.

Only head fires will be considered.

Flame length will be printed on the table.

```
 24--DEAD FUEL MOISTURE TABLE VARIABLE ? 1-2
     1 = 1-HOUR
     2 = 10-HOUR
>1

 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>list

  INPUT LIST FOR RXWINDOW

  FIRE BEHAVIOR CONTRAINTS:

  1--RATE OF SPREAD, CH/H                    *** NOT CONSTRAINED ***
  2--HEAT PER UNIT AREA, BTU/SQFT            *** NOT CONSTRAINED ***
  3--FIRELINE INTENSITY, BTU/FT/S            *** NOT CONSTRAINED ***
  4--FLAME LENGTH, FT                         4.0 TO     8.0
  5--REACTION INTENSITY, BTU/SQFT/M          *** NOT CONSTRAINED ***
  6--SCORCH HEIGHT, FT                       *** NOT CONSTRAINED ***
  7--TREE MORTALITY, %                       *** NOT CONSTRAINED ***

 PRESS ENTER TO CONTINUE....
>

  SITE CONDITIONS:

  8--FUEL MODEL:                      12 -- MEDIUM LOGGING SLASH
  9--FUEL EXPOSURE TO WIND:           PARTIALLY SHELTERED
                                      (WIND ADJUSTMENT FACTOR = .30)
 10--TERRAIN SLOPE, %                          5.0
 11--100-HR MOISTURE = 10-HR MOISTURE PLUS      5. %

 PRESS ENTER TO CONTINUE....
>

  PRESET ENVIRONMENTAL CONSTRAINTS:

 15--1-HR FUEL MOISTURE, %                   4.0 TO   24.0
 16--10-HR FUEL MOISTURE, %                 *** NOT CONSTRAINED ***
 19--20-FOOT WINDSPEED, MI/H                 2.0 TO    8.0
 20--MIDFLAME WINDSPEED, MI/H               *** NOT CONSTRAINED ***
 21--WIND DIRECTION                         *** NOT CONSTRAINED ***
 22--FIRE SPREAD DIRECTION                  HEAD

 PRESS ENTER TO CONTINUE....
>

  OUTPUT TABLE CONFIGURATIONS:

 23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  FLAME LENGTH, FEET
 24--DEAD FUEL MOISTURE TABLE VARIABLE    :  1-HR FUEL MOISTURE, %
 25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL 12.

 PRESS ENTER TO CONTINUE....
>

  SYMBIOTIC RELATIONSHIPS:

  CONSTRAINED  20-FOOT WINDSPEED FROM      2.0 TO      8.0 MI/H
  CONSTRAINS   MIDFLAME WINDSPEED FROM      .6 TO      2.4 MI/H
  RELATIONSHIP:  FUEL MODEL & FUEL EXPOSURE TO WIND (LINES 8-9).

  CONSTRAINED        FLAME LENGTH FROM      4.0 TO      8.0 FEET
  CONSTRAINS   FIRELINE INTENSITY FROM    114.6 TO    515.5 BTU/FT/S
  RELATIONSHIP:  MATHEMATICAL FIRE MODEL.
```

Pause - because the whole list won't fit on the screen. The prompt won't be in log files.

See below.

2.0 x .30 = .6

Fireline intensity can be calculated from flame length

```
 RXWINDOW KEYWORD?
 ENTER:   INPUT,LIST,CHANGE,RUN,HELP,KEY
          WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
          PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>change

 CHANGE WHICH LINE ? (0-25)
>3

  3--DO YOU WANT TO CONSTRAIN FIRELINE INTENSITY ? Y-N
>y

 ENTER MINIMUM VALUE, BTU/FT/S ? 0 TO 10000
>350

 ENTER MAXIMUM VALUE, BTU/FT/S ? 350 TO 10000
>1000

 CHANGE WHICH LINE ? (0-25)
>0

 YOU HAVE CONSTRAINED BOTH FLAME LENGTH AND FIRELINE INTENSITY.

 THERE IS A DIRECT RELATIONSHIP BETWEEN THEM.

 1.  INPUT         FLAME LENGTH FROM      4.0 TO      8.0 FEET
     EQUALS FIRELINE INTENSITY FROM    114.6 TO    515.5 BTU/FT/S

 2.  INPUT  FIRELINE INTENSITY FROM    350.0 TO   1000.0 BTU/FT/S
     EQUALS        FLAME LENGTH FROM      6.7 TO     10.8 FEET

 WHICH DO YOU WANT ? (1-2)
>1

 FIRELINE INTENSITY NO LONGER DIRECTLY CONSTRAINED...

 RXWINDOW KEYWORD?
 ENTER:   INPUT,LIST,CHANGE,RUN,HELP,KEY
          WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
          PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>list

  INPUT LIST FOR RXWINDOW

  FIRE BEHAVIOR CONTRAINTS:

  1--RATE OF SPREAD, CH/H                    *** NOT CONSTRAINED ***
  2--HEAT PER UNIT AREA, BTU/SQFT            *** NOT CONSTRAINED ***
  3--FIRELINE INTENSITY, BTU/FT/S            *** NOT CONSTRAINED ***
  4--FLAME LENGTH, FT                         4.0 TO    8.0
  5--REACTION INTENSITY, BTU/SQFT/M          *** NOT CONSTRAINED ***
  6--SCORCH HEIGHT, FT                       *** NOT CONSTRAINED ***
  7--TREE MORTALITY, %                       *** NOT CONSTRAINED ***

 PRESS ENTER TO CONTINUE....
>

  SITE CONDITIONS:

  8--FUEL MODEL:                      12 -- MEDIUM LOGGING SLASH
  9--FUEL EXPOSURE TO WIND:           PARTIALLY SHELTERED
                                      (WIND ADJUSTMENT FACTOR =  .30)
 10--TERRAIN SLOPE, %                        5.0
 11--100-HR MOISTURE = 10-HR MOISTURE PLUS    5. %

 PRESS ENTER TO CONTINUE....
>
```

You are asked to resolve conflicting constraints.

Fireline intensity is, in effect, constrained because of its relationship to flame length.

```
 PRESET ENVIRONMENTAL CONSTRAINTS:

15--1-HR FUEL MOISTURE, %                        4.0 TO   24.0
16--10-HR FUEL MOISTURE, %                      *** NOT CONSTRAINED ***
19--20-FOOT WINDSPEED, MI/H                      2.0 TO    8.0
20--MIDFLAME WINDSPEED, MI/H                    *** NOT CONSTRAINED ***
21--WIND DIRECTION                              *** NOT CONSTRAINED ***
22--FIRE SPREAD DIRECTION                       HEAD

 PRESS ENTER TO CONTINUE....
>

 OUTPUT TABLE CONFIGURATIONS:

23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  FLAME LENGTH, FEET
24--DEAD FUEL MOISTURE TABLE VARIABLE    :  1-HR FUEL MOISTURE, %
25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL 12.

 PRESS ENTER TO CONTINUE....
>

 SYMBIOTIC RELATIONSHIPS:

 CONSTRAINED  20-FOOT WINDSPEED FROM      2.0 TO      8.0 MI/H
 CONSTRAINS  MIDFLAME WINDSPEED FROM       .6 TO      2.4 MI/H
 RELATIONSHIP:  FUEL MODEL & FUEL EXPOSURE TO WIND (LINES 8-9).

 CONSTRAINED       FLAME LENGTH FROM      4.0 TO      8.0 FEET
 CONSTRAINS  FIRELINE INTENSITY FROM    114.6 TO    515.5 BTU/FT/S
 RELATIONSHIP:  MATHEMATICAL FIRE MODEL.


 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>run
 WORKING...
    WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
    WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

 *** HEAD FIRE ***           (FULL WINDOW)                (VER 3.3)
 ********** I ---  20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H ---
 WEIGHTED   I    2.0     3.0     4.0     5.0     6.0     7.0     8.0
 DEAD FM %  I     .6      .9     1.2     1.5     1.8     2.1     2.4
 ********** I ======= ======= ======= ======= ======= ======= =======
  4 W-DIR   I   ANY     ANY     ANY     ANY     ANY     ANY     ANY
    FLAME   I   4- 4   5- 5   5- 5   6- 6   6- 6   6- 6   7- 7
 ---------- I ------- ------- ------- ------- ------- ------- -------
  5 W-DIR   I  UP- X    ANY     ANY     ANY     ANY     ANY     ANY
    FLAME   I   4- 4   4- 4   5- 5   5- 5   6- 6   6- 6   6- 6
 ---------- I ------- ------- ------- ------- ------- ------- -------
  6 W-DIR   I           ANY     ANY     ANY     ANY     ANY     ANY
    FLAME   I           4- 4   5- 5   5- 5   5- 5   6- 6   6- 6
 ---------- I ------- ------- ------- ------- ------- ------- -------
  7 W-DIR   I         UP- QD   ANY     ANY     ANY     ANY     ANY
    FLAME   I           4- 4   4- 4   5- 5   5- 5   5- 5   6- 6
 ---------- I ------- ------- ------- ------- ------- ------- -------

 PRESS ENTER TO CONTINUE....
>
```

There is no live fuel in fuel model 12.

So that you know something is happening. It may take a while.

```
*** HEAD FIRE ***            (FULL WINDOW)
========= I ---  20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H ---
WEIGHTED  I    2.0     3.0     4.0     5.0     6.0     7.0     8.0
DEAD FM % I     .6      .9     1.2     1.5     1.8     2.1     2.4
========= I ======= ======= ======= ======= ======= ======= =======
 8 W-DIR  I                    ANY     ANY     ANY     ANY     ANY
   FLAME  I                    4- 4    5- 5    5- 5    5- 5    5- 5
--------- I ------- ------- ------- ------- ------- ------- -------
 9 W-DIR  I                    ANY     ANY     ANY     ANY     ANY
   FLAME  I                    4- 4    4- 4    5- 5    5- 5    5- 5
--------- I ------- ------- ------- ------- ------- ------- -------
10 W-DIR  I                    ANY     ANY     ANY     ANY     ANY
   FLAME  I                    4- 4    4- 4    5- 5    5- 5    5- 5
--------- I ------- ------- ------- ------- ------- ------- -------
11 W-DIR  I                            ANY     ANY     ANY     ANY
   FLAME  I                            4- 4    4- 5    5- 5    5- 5
--------- I ------- ------- ------- ------- ------- ------- -------
12 W-DIR  I                            ANY     ANY     ANY     ANY
   FLAME  I                            4- 4    4- 4    5- 5    5- 5
--------- I ------- ------- ------- ------- ------- ------- -------

 PRESS ENTER TO CONTINUE....
>
 *** HEAD FIRE ***            (FULL WINDOW)
 ========= I ---  20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H ---
 WEIGHTED  I    2.0     3.0     4.0     5.0     6.0     7.0     8.0
 DEAD FM % I     .6      .9     1.2     1.5     1.8     2.1     2.4
 ========= I ======= ======= ======= ======= ======= ======= =======
 13 W-DIR  I                                    ANY     ANY     ANY
    FLAME  I                                    4- 4    4- 4    5- 5
 --------- I ------- ------- ------- ------- ------- ------- -------
 14 W-DIR  I                                            ANY     ANY
    FLAME  I                                            4- 4    4- 4
 --------- I ------- ------- ------- ------- ------- ------- -------

 PRESS ENTER TO CONTINUE....
>
 UNITS/CODES FOR TABLE VALUES ARE:
      W-DIR  = WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS,
               QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
      FLAME  = FLAME LENGTH, FEET

 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
         ZOOM,REPLAY,REDO,NEXT,QUIT
>nopause
 NO-PAUSE OPTION SET.

 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
         ZOOM,REPLAY,REDO,NEXT,QUIT
>next

  DO YOU WANT TO SEE THE MOISTURE TABLES FOR THIS WINDOW ? Y-N
>y
```

Heading displayed on every screen when the PAUSE option is set (default).

20-ft wind

Midflame wind

Note.

Reminder. Not a requirement.

If the fire spread direction hadn't been constrained to "head" (line 22), tables for "backing" and "flanking" fires would be displayed here.

```
  DEAD FUEL MOISTURE TABLE:  TABLE VALUES ARE VALID 1-HR MOISTURE RANGES.
                FUEL MODEL:  12 -- MEDIUM LOGGING SLASH

 MOISTURE WEIGHTING FACTORS ARE:   1 HOUR ( 74.8 %)
                                  10 HOUR ( 19.0 %)
                                 100 HOUR (  6.2 %)
(VER 3.3)
WGHTED I           10-HOUR FUEL MOISTURE, %
 DEAD  I    1       4       7      10      13      16      19      22      25      28
------ I ------  ------  ------  ------  ------  ------  ------  ------  ------  ------
  4 %  I  5- 4    4- 4
  5 %  I  6- 6    5- 5    4- 4
  6 %  I  7- 7    6- 6    5- 5    4- 4
  7 %  I  9- 8    8- 7    7- 6    6- 5    5- 4    4- 4
  8 %  I 10-10    9- 9    8- 8    7- 7    6- 6    5- 5    4- 4
  9 %  I 11-11   10-10    9- 9    8- 8    7- 7    6- 6    5- 5    4- 4
 10 %  I 13-12   12-11   11-10   10- 9    9- 8    8- 7    7- 6    6- 5    5- 4    4- 4
 11 %  I 14-14   13-13   12-12   11-11   10-10    9- 9    8- 8    7- 7    6- 6    5- 5
 12 %  I 15-15   14-14   13-13   12-12   11-11   10-10    9- 9    8- 8    7- 7    6- 6
 13 %  I 17-16   16-15   15-14   14-13   13-12   12-11   11-10   10- 9    9- 8    8- 7
 14 %  I 18-18   17-17   16-16   15-15   14-14   13-13   12-12   11-11   10-10    9- 9
------ I ------  ------  ------  ------  ------  ------  ------  ------  ------  ------

 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
         ZOOM,REPLAY,REDO,NEXT,QUIT
>quit

 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
         REDO
change

 CHANGE WHICH LINE ? (0-25)
>8

  8--FUEL MODEL ? (1-99 OR ?)
       (ENTER 1 TO 13 FOR STANDARD MODELS,
              14 TO 99 FOR CUSTOM MODELS, OR
              ? FOR A LIST OF STANDARD MODELS.)
>14

 A FUEL MODEL FILE IS NOT CURRENTLY ATTACHED TO THIS RUN.

 DO YOU WANT TO TRY ANOTHER MODEL NUMBER ? Y-N
>y

  8--FUEL MODEL ? (1-99 OR ?)
       (ENTER 1 TO 13 FOR STANDARD MODELS,
              14 TO 99 FOR CUSTOM MODELS, OR
              ? FOR A LIST OF STANDARD MODELS.)
>12
      FUEL MODEL: 12 -- MEDIUM LOGGING SLASH

 CHANGE WHICH LINE ? (0-25)
>6

  6--DO YOU WANT TO CONSTRAIN SCORCH HEIGHT ? Y-N
>y

 ENTER MINIMUM VALUE, FT ? 0 TO 200
>0

 ENTER MAXIMUM VALUE, FT ? 0 TO 200
>30
```

Just type the custom fuel model number. The other BEHAVE programs use the keyword CUSTOM.

But we'll stick with a standard fuel model for this example.

Add another constraint. Scorch height less than 30.

```
 CHANGE WHICH LINE ? (0-25)
>0

 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>list

  INPUT LIST FOR RXWINDOW

  FIRE BEHAVIOR CONTRAINTS:

  1--RATE OF SPREAD, CH/H                      *** NOT CONSTRAINED ***
  2--HEAT PER UNIT AREA, BTU/SQFT              *** NOT CONSTRAINED ***
  3--FIRELINE INTENSITY, BTU/FT/S              *** NOT CONSTRAINED ***
  4--FLAME LENGTH, FT                           4.0 TO    8.0
  5--REACTION INTENSITY, BTU/SQFT/M            *** NOT CONSTRAINED ***
  6--SCORCH HEIGHT, FT                            .0 TO   30.0
  7--TREE MORTALITY, %                         *** NOT CONSTRAINED ***

  SITE CONDITIONS:

  8--FUEL MODEL:                        12 -- MEDIUM LOGGING SLASH
  9--FUEL EXPOSURE TO WIND:             PARTIALLY SHELTERED
                                        (WIND ADJUSTMENT FACTOR =  .30)
 10--TERRAIN SLOPE, %                          5.0
 11--100-HR MOISTURE = 10-HR MOISTURE PLUS      5. %

  PRESET ENVIRONMENTAL CONSTRAINTS:

 15--1-HR FUEL MOISTURE, %                      4.0 TO   24.0
 16--10-HR FUEL MOISTURE, %                   *** NOT CONSTRAINED ***
 19--20-FOOT WINDSPEED, MI/H                    2.0 TO    8.0
 20--MIDFLAME WINDSPEED, MI/H                 *** NOT CONSTRAINED ***
 21--WIND DIRECTION                           *** NOT CONSTRAINED ***
 22--FIRE SPREAD DIRECTION                    HEAD

  OUTPUT TABLE CONFIGURATIONS:

 23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  FLAME LENGTH, FEET
 24--DEAD FUEL MOISTURE TABLE VARIABLE    :  1-HR FUEL MOISTURE, %
 25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL 12.

  SYMBIOTIC RELATIONSHIPS:

  CONSTRAINED  20-FOOT WINDSPEED FROM      2.0 TO      8.0 MI/H
  CONSTRAINS  MIDFLAME WINDSPEED FROM       .6 TO      2.4 MI/H
  RELATIONSHIP:  FUEL MODEL & FUEL EXPOSURE TO WIND (LINES 8-9).

  CONSTRAINED       FLAME LENGTH FROM      4.0 TO      8.0 FEET
  CONSTRAINS  FIRELINE INTENSITY FROM    114.6 TO    515.5 BTU/FT/S
  RELATIONSHIP:  MATHEMATICAL FIRE MODEL.


 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>run
 WORKING...
```

```
   WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
   WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE ***           (FULL WINDOW)                (VER 3.3)
========== I --- 20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H ---
WEIGHTED   I    2.0      3.0      4.0      5.0      6.0      7.0      8.0
DEAD FM %  I     .6       .9      1.2      1.5      1.8      2.1      2.4
========== I ======= ======= ======= ======= ======= ======= =======
 4 W-DIR   I   ANY    QD- DN
   FLAME   I   4-  4   5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
 5 W-DIR   I  UP- X    ANY
   FLAME   I   4-  4   4-  4
---------- I ------- ------- ------- ------- ------- ------- -------
 6 W-DIR   I           ANY      ANY
   FLAME   I           4-  4    5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
 7 W-DIR   I          UP- QD    ANY      ANY
   FLAME   I           4-  4    4-  4    5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
 8 W-DIR   I                    ANY      ANY
   FLAME   I                    4-  4    5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
 9 W-DIR   I                    ANY      ANY     QU- DN
   FLAME   I                    4-  4    4-  4    5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
10 W-DIR   I                    ANY      ANY      ANY
   FLAME   I                    4-  4    4-  4    5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
11 W-DIR   I                             ANY      ANY     X - DN
   FLAME   I                             4-  4    4-  5    5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
12 W-DIR   I                             ANY      ANY      ANY
   FLAME   I                             4-  4    4-  4    5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
13 W-DIR   I                                      ANY      ANY      ANY
   FLAME   I                                      4-  4    4-  4    5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
14 W-DIR   I                                               ANY      ANY
   FLAME   I                                               4-  4    4-  4
---------- I ------- ------- ------- ------- ------- ------- -------
UNITS/CODES FOR TABLE VALUES ARE:
     W-DIR  = WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS,
              QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
     FLAME  = FLAME LENGTH, FEET
              SCORCH HEIGHTS ARE BASED ON A 77 DEG (F) DAY.

TYPE NEXT TO VIEW NEXT TABLE

VIEW KEYWORD?
ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
        PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
        ZOOM,REPLAY,REDO,NEXT,QUIT
>comment

NO LOG FILE CURRENTLY ACTIVE.  TO ACTIVATE, ENTER
** TO TERMINATE COMMENT, THEN ENTER LOG.

ENTER TEXT FOR DOCUMENTATION. USE A CARRIAGE RETURN AT THE END OF EACH LINE.
TO TERMINATE, ENTER (ON A NEW LINE) ** FOLLOWED BY A CARRIAGE RETURN.

*******************************************************************************
COMMENT:
>**
*******************************************************************************

TYPE NEXT TO VIEW NEXT TABLE
```

Reminder that it doesn't make much sense to type comments if they're not being saved in a log file

```
 VIEW KEYWORD?
 ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
         ZOOM,REPLAY,REDO,NEXT,QUIT
>log

 WHAT FILE NAME DO YOU WANT TO USE?
    (USE FILE NAMING CONVENTIONS FOR YOUR COMPUTER) <-
>show.log

 LOG IS ON.

 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
         ZOOM,REPLAY,REDO,NEXT,QUIT
>status

 **** RXWINDOW STATUS REQUEST ****

     ACTIVE MODULE :  VIEW
     PROMPT MODE   :  WORDY
     DISPLAY MODE  :  NOPAUSE
     LOG FILE NAME :  show.log
     LOG FUNCTIONS :  ON
     FUEL FILE NAME:  UNDECLARED
     DISPLAY UNITS :  ENGLISH
     SLOPE UNITS   :  PERCENT

 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
         ZOOM,REPLAY,REDO,NEXT,QUIT
>comment

 ENTER TEXT FOR DOCUMENTATION. USE A CARRIAGE RETURN AT THE END OF EACH LINE.
 TO TERMINATE, ENTER (ON A NEW LINE) ** FOLLOWED BY A CARRIAGE RETURN.

 ********************************************************************************
 COMMENT:
>This run corresponds to figure 18 in the text, sort of...
>**
 ********************************************************************************

 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
         ZOOM,REPLAY,REDO,NEXT,QUIT
 >list <-

   INPUT LIST FOR RXWINDOW

   FIRE BEHAVIOR CONTRAINTS:

   1--RATE OF SPREAD, CH/H                 *** NOT CONSTRAINED ***
   2--HEAT PER UNIT AREA, BTU/SQFT         *** NOT CONSTRAINED ***
   3--FIRELINE INTENSITY, BTU/FT/S         *** NOT CONSTRAINED ***
   4--FLAME LENGTH, FT                      4.0 TO    8.0
   5--REACTION INTENSITY, BTU/SQFT/M       *** NOT CONSTRAINED ***
   6--SCORCH HEIGHT, FT                       .0 TO   30.0
   7--TREE MORTALITY, %                    *** NOT CONSTRAINED ***
```

Important Note!
Every computer is different, so we can't check this. You may be able to crash the program with a bad name.

This comment will be saved in the log file.

Be sure to keep a list with your output tables. We pre-list here so it will go in the log file.

```
 SITE CONDITIONS:

 8--FUEL MODEL:                          12 -- MEDIUM LOGGING SLASH
 9--FUEL EXPOSURE TO WIND:               PARTIALLY SHELTERED
                                         (WIND ADJUSTMENT FACTOR =  .30)
10--TERRAIN SLOPE, %                              5.0
11--100-HR MOISTURE = 10-HR MOISTURE PLUS          5. %

 PRESET ENVIRONMENTAL CONSTRAINTS:

15--1-HR FUEL MOISTURE, %                          4.0 TO   24.0
16--10-HR FUEL MOISTURE, %                        *** NOT CONSTRAINED ***
19--20-FOOT WINDSPEED, MI/H                        2.0 TO    8.0
20--MIDFLAME WINDSPEED, MI/H                      *** NOT CONSTRAINED ***
21--WIND DIRECTION                                *** NOT CONSTRAINED ***
22--FIRE SPREAD DIRECTION                         HEAD

 OUTPUT TABLE CONFIGURATIONS:

23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  FLAME LENGTH, FEET
24--DEAD FUEL MOISTURE TABLE VARIABLE    :  1-HR FUEL MOISTURE, %
25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL 12.

 SYMBIOTIC RELATIONSHIPS:

 CONSTRAINED  20-FOOT WINDSPEED FROM      2.0 TO      8.0 MI/H
 CONSTRAINS   MIDFLAME WINDSPEED FROM      .6 TO      2.4 MI/H
 RELATIONSHIP:  FUEL MODEL & FUEL EXPOSURE TO WIND (LINES 8-9).

 CONSTRAINED       FLAME LENGTH FROM      4.0 TO      8.0 FEET
 CONSTRAINS   FIRELINE INTENSITY FROM    114.6 TO    515.5 BTU/FT/S
 RELATIONSHIP:  MATHEMATICAL FIRE MODEL.


TYPE NEXT TO VIEW NEXT TABLE

VIEW KEYWORD?
ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
        PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
        ZOOM,REPLAY,REDO,NEXT,QUIT
>replay
   WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
   WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE ***          (FULL WINDOW)                    (VER 3.3)
========== I ---  20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H ---
WEIGHTED   I    2.0     3.0     4.0     5.0     6.0     7.0     8.0
DEAD FM %  I     .6      .9     1.2     1.5     1.8     2.1     2.4
========== I ======= ======= ======= ======= ======= ======= =======
 4 W-DIR   I   ANY    QD- DN
   FLAME   I   4-  4   5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
 5 W-DIR   I  UP- X    ANY
   FLAME   I   4-  4   4-  4
---------- I ------- ------- ------- ------- ------- ------- -------
 6 W-DIR   I           ANY     ANY
   FLAME   I           4-  4   5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
 7 W-DIR   I          UP- QD   ANY     ANY
   FLAME   I           4-  4   4-  4   5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
 8 W-DIR   I                   ANY     ANY
   FLAME   I                   4-  4   5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
 9 W-DIR   I                   ANY     ANY    QU- DN
   FLAME   I                   4-  4   4-  4   5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
10 W-DIR   I                   ANY     ANY     ANY
   FLAME   I                   4-  4   4-  4   5-  5
---------- I ------- ------- ------- ------- ------- ------- -------
```

Replay the last table without waiting for the calculations. Save it in the log file.

Note. A later example will say ZOOMED VIEW

```
11 W-DIR  I                          ANY     ANY    X - DN
   FLAME  I                          4-  4   4-  5   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
12 W-DIR  I                          ANY     ANY     ANY
   FLAME  I                          4-  4   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
13 W-DIR  I                                  ANY     ANY     ANY
   FLAME  I                                  4-  4   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
14 W-DIR  I                                          ANY     ANY
   FLAME  I                                          4-  4   4-  4
--------- I ------- ------- ------- ------- ------- ------- -------
UNITS/CODES FOR TABLE VALUES ARE:
     W-DIR  = WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS,
              QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
     FLAME  = FLAME LENGTH, FEET
              SCORCH HEIGHTS ARE BASED ON A 77 DEG (F) DAY.

TYPE NEXT TO VIEW NEXT TABLE

VIEW KEYWORD?
ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
        PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
        ZOOM,REPLAY,REDO,NEXT,QUIT
>nolog

LOG IS OFF. <-------------------------------------------

TYPE NEXT TO VIEW NEXT TABLE

VIEW KEYWORD?
ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
        PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
        ZOOM,REPLAY,REDO,NEXT,QUIT
>status <-----------------------------------------------

**** RXWINDOW STATUS REQUEST ****

    ACTIVE MODULE :  VIEW
    PROMPT MODE   :  WORDY
    DISPLAY MODE  :  NOPAUSE
    LOG FILE NAME :  show.log
    LOG FUNCTIONS :  OFF <------
    FUEL FILE NAME:  UNDECLARED
    DISPLAY UNITS :  ENGLISH
    SLOPE UNITS   :  PERCENT

TYPE NEXT TO VIEW NEXT TABLE

VIEW KEYWORD?
ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
        PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
        ZOOM,REPLAY,REDO,NEXT,QUIT
>help zoom <--------------------------------------------

RXWINDOW HELP SYSTEM -- CURRENT SECTION IS: VIEW

ZOOM    -- ALLOWS ZOOM OR PAN OF CURRENTLY VIEWED TABLE.  YOU ARE PROMPTED
           FOR THE TABLE LIMITS AND STEP SIZE BETWEEN EACH ROW AND COLUMN.
           THE ZOOM PROMPT WILL INCLUDE VALID TABLE PARAMETER RANGES.
           WHEN RESPONDING TO A ZOOM PROMPT, ENTER THE BEGINING VALUE, THE
           END VALUE, AND THE STEP SIZE SEPARATING EACH FIELD WITH A COMMA.
           E.G.  5,20,5 SHOWS VALUES AT 5,10,15, AND 20.  IN DISPLAYING
           TABLES, THE NUMBER OF COLUMNS (STEPS) IS LIMITED TO 10 IN DEAD
           MOISTURE TABLES, AND TO 8 IN THE WINDOW AND LIVE MOISTURE TABLES.
           THE ZOOM INPUT ROUTINES ALLOW YOU TO VERIFY YOUR SPECIFICATIONS.
           FOR ALL TABLE TYPES, THE NUMBER OF TABLE ROWS IS LIMITED TO 15.
```

Turn the log off until another table is to be saved.

STATUS comes in handy when you can't remember whether LOG is on or off.

RXWINDOW allows you to get help on a specific keyword.

```
 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:   WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
          PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
          ZOOM,REPLAY,REDO,NEXT,QUIT
>zoom

 ENTER 20-FOOT WIND BOUNDS AND STEP SIZE, MI/H ? 2 TO 8
>4,8,1

 THE FOLLOWING VALUES WILL BE USED
   4.0   5.0   6.0   7.0   8.0
 OK ? Y-N
>Y

 ENTER WEIGHTED DEAD MOISTURE BOUNDS AND STEP SIZE, % ? 4 TO 14
>4,10,1

 THE FOLLOWING VALUES WILL BE USED
   4.0   5.0   6.0   7.0   8.0   9.0  10.0
 OK ? Y-N
>Y
    WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
    WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

 *** HEAD FIRE ***          (ZOOMED VIEW)                (VER 3.3)
 ========== I --- 20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H ---
 WEIGHTED   I    4.0      5.0      6.0      7.0      8.0
 DEAD FM %  I    1.2      1.5      1.8      2.1      2.4
 ========== I ======= ======= ======= ======= =======
 6 W-DIR    I   ANY
    FLAME   I   5-  5
 ---------- I ------- ------- ------- ------- -------
  7 W-DIR   I   ANY      ANY
    FLAME   I   4-  4    5-  5
 ---------- I ------- ------- ------- ------- -------
  8 W-DIR   I   ANY      ANY
    FLAME   I   4-  4    5-  5
 ---------- I ------- ------- ------- ------- -------
  9 W-DIR   I   ANY      ANY     QU- DN
    FLAME   I   4-  4    4-  4    5-  5
 ---------- I ------- ------- ------- ------- -------
 10 W-DIR   I   ANY      ANY      ANY
    FLAME   I   4-  4    4-  4    5-  5
 ---------- I ------- ------- ------- ------- -------
 UNITS/CODES FOR TABLE VALUES ARE:
      W-DIR  = WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS,
               QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
      FLAME  = FLAME LENGTH, FEET
               SCORCH HEIGHTS ARE BASED ON A 77 DEG (F) DAY.

 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:   WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
          PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
          ZOOM,REPLAY,REDO,NEXT,QUIT
>redo
```

4 = starting value
8 = ending value
1 = step size

Bounds of the full table.
Bounds set for the Zoomed View

So you will know that this isn't the complete window.

Every column for the mois = 4 & 5 rows is blank, so those rows are not displayed.

REDO gives the full table without recalculation. No waiting.

```
   WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
   WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE ***          (FULL WINDOW)                (VER 3.3)
========= I --- 20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H ---
WEIGHTED  I    2.0     3.0     4.0     5.0     6.0     7.0     8.0
DEAD FM % I     .6      .9     1.2     1.5     1.8     2.1     2.4
========= I ======= ======= ======= ======= ======= ======= =======
 4 W-DIR  I   ANY    QD- DN
   FLAME  I   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
 5 W-DIR  I  UP- X    ANY
   FLAME  I   4-  4   4-  4
--------- I ------- ------- ------- ------- ------- ------- -------
 6 W-DIR  I           ANY     ANY
   FLAME  I           4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
 7 W-DIR  I          UP- QD   ANY     ANY
   FLAME  I           4-  4   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
 8 W-DIR  I                   ANY     ANY
   FLAME  I                   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
 9 W-DIR  I                   ANY     ANY    QU- DN
   FLAME  I                   4-  4   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
10 W-DIR  I                   ANY     ANY     ANY
   FLAME  I                   4-  4   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
11 W-DIR  I                           ANY     ANY    X - DN
   FLAME  I                           4-  4   4-  5   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
12 W-DIR  I                           ANY     ANY     ANY
   FLAME  I                           4-  4   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
13 W-DIR  I                                   ANY     ANY     ANY
   FLAME  I                                   4-  4   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- -------
14 W-DIR  I                                           ANY     ANY
   FLAME  I                                           4-  4   4-  4
--------- I ------- ------- ------- ------- ------- ------- -------
 UNITS/CODES FOR TABLE VALUES ARE:
      W-DIR  = WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS,
               QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
      FLAME  = FLAME LENGTH, FEET
               SCORCH HEIGHTS ARE BASED ON A 77 DEG (F) DAY.

 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
         ZOOM,REPLAY,REDO,NEXT,QUIT
>change
 CHANGE NOT ALLOWED HERE.  ENTER QUIT, THEN CHANGE IF THAT IS WHAT YOU WANT.

 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
         ZOOM,REPLAY,REDO,NEXT,QUIT
>quit

 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
         REDO
>change
```

Note.

Must get out of VIEW to change an input.

Can get back into VIEW without recalculating, i.e. without RUN.

```
 CHANGE WHICH LINE ? (0-25)
>23

 23--INCLUDE A FIRE VARIABLE IN THE OUTPUT TABLE ? Y-N
>Y

  WHICH ONE ? 1-8
       1=RATE OF SPREAD          2=HEAT PER UNIT AREA
       3=FIRELINE INTENSITY      4=FLAME LENGTH
       5=REACTION INTENSITY      6=SCORCH HEIGHT
       7=MORTALITY               8=SPREAD DIRECTION
>7

 CHANGE WHICH LINE ? (0-25)
>0

 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>run
 BECAUSE OF CHANGES YOU HAVE MADE, ADDITIONAL INFORMATION IS REQUIRED...

 12--TREE HEIGHT, FT ? 20 TO 200
>50

 13--CROWN RATIO ? .1-1
     (RATIO OF CROWN LENGTH TO TREE HEIGHT)
>.7

 14--BARK THICKNESS ? 1-2
       1=DETERMINE FROM SPECIES AND DBH
       2=DIRECT ENTRY
>2

 14--BARK THICKNESS, IN ? .1 TO 2
>.8

 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>list

  INPUT LIST FOR RXWINDOW

  FIRE BEHAVIOR CONTRAINTS:

  1--RATE OF SPREAD, CH/H                    *** NOT CONSTRAINED ***
  2--HEAT PER UNIT AREA, BTU/SQFT            *** NOT CONSTRAINED ***
  3--FIRELINE INTENSITY, BTU/FT/S            *** NOT CONSTRAINED ***
  4--FLAME LENGTH, FT                         4.0 TO    8.0
  5--REACTION INTENSITY, BTU/SQFT/M          *** NOT CONSTRAINED ***
  6--SCORCH HEIGHT, FT                          .0 TO   30.0
  7--TREE MORTALITY, %                       *** NOT CONSTRAINED ***

  SITE CONDITIONS:

  8--FUEL MODEL:                      12 -- MEDIUM LOGGING SLASH
  9--FUEL EXPOSURE TO WIND:           PARTIALLY SHELTERED
                                      (WIND ADJUSTMENT FACTOR =  .30)
 10--TERRAIN SLOPE, %                          5.0
 11--100-HR MOISTURE = 10-HR MOISTURE PLUS      5. %
 12--TREE HEIGHT, FT                           50.0
 13--CROWN RATIO                                .7
 14--BARK THICKNESS, IN                         .8
       (DIRECT ENTRY)
```

Mortality will be printed on the table. But it is still not constrained.

REDO is not an option after an input value is changed because calculations must be redone.

Tree description is used in the mortality calculation.

← Tree description.

```
 PRESET ENVIRONMENTAL CONSTRAINTS:

15--1-HR FUEL MOISTURE, %                        4.0 TO   24.0
16--10-HR FUEL MOISTURE, %                      *** NOT CONSTRAINED ***
19--20-FOOT WINDSPEED, MI/H                      2.0 TO    8.0
20--MIDFLAME WINDSPEED, MI/H                    *** NOT CONSTRAINED ***
21--WIND DIRECTION                              *** NOT CONSTRAINED ***
22--FIRE SPREAD DIRECTION                       HEAD

 OUTPUT TABLE CONFIGURATIONS:

23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  TREE MORTALITY, PERCENT  <--
24--DEAD FUEL MOISTURE TABLE VARIABLE    :  1-HR FUEL MOISTURE, %
25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL 12.

 SYMBIOTIC RELATIONSHIPS:

 CONSTRAINED  20-FOOT WINDSPEED FROM      2.0 TO      8.0 MI/H
 CONSTRAINS  MIDFLAME WINDSPEED FROM       .6 TO      2.4 MI/H
 RELATIONSHIP:  FUEL MODEL & FUEL EXPOSURE TO WIND (LINES 8-9).

 CONSTRAINED       FLAME LENGTH FROM      4.0 TO      8.0 FEET
 CONSTRAINS  FIRELINE INTENSITY FROM    114.6 TO    515.5 BTU/FT/S
 RELATIONSHIP:  MATHEMATICAL FIRE MODEL.


 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>run
 WORKING...
    WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
    WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

 *** HEAD FIRE ***            (FULL WINDOW)                (VER 3.3)
 ========== I ---  20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H ---
 WEIGHTED   I    2.0     3.0     4.0     5.0     6.0     7.0     8.0
 DEAD FM %  I     .6      .9     1.2     1.5     1.8     2.1     2.4
 ========== I ======= ======= ======= ======= ======= ======= =======
  4 W-DIR   I   ANY     QD- DN
    T-MORT  I  42- 47  66- 67  <--
 ---------- I ------- ------- ------- ------- ------- ------- -------
  5 W-DIR   I  UP- X    ANY
    T-MORT  I  32- 34  50- 53
 ---------- I ------- ------- ------- ------- ------- ------- -------
  6 W-DIR   I           ANY     ANY
    T-MORT  I          39- 42  57- 60
 ---------- I ------- ------- ------- ------- ------- ------- -------
  7 W-DIR   I          UP- QD   ANY     ANY
    T-MORT  I          32- 34  48- 51  65- 67
 ---------- I ------- ------- ------- ------- ------- ------- -------
  8 W-DIR   I                   ANY     ANY
    T-MORT  I                  41- 44  57- 60
 ---------- I ------- ------- ------- ------- ------- ------- -------
  9 W-DIR   I                   ANY     ANY     QU- DN
    T-MORT  I                  36- 39  51- 54  66- 68
 ---------- I ------- ------- ------- ------- ------- ------- -------
 10 W-DIR   I                   ANY     ANY     ANY
    T-MORT  I                  33- 35  46- 48  60- 63
 ---------- I ------- ------- ------- ------- ------- ------- -------
 11 W-DIR   I                           ANY     ANY    X - DN
    T-MORT  I                          40- 43  54- 56  67- 68
 ---------- I ------- ------- ------- ------- ------- ------- -------
 12 W-DIR   I                           ANY     ANY     ANY
    T-MORT  I                          34- 36  46- 48  58- 60
```

Now the table variable is mortality rather than flame length.

```
--------- I ------- ------- ------- ------- ------- ------- -------
13 W-DIR  I                                    ANY     ANY     ANY
   T-MORT I                                  36- 38  47- 49  58- 59
--------- I ------- ------- ------- ------- ------- ------- -------
14 W-DIR  I                                            ANY     ANY
   T-MORT I                                           33- 35  42- 43
--------- I ------- ------- ------- ------- ------- ------- -------
UNITS/CODES FOR TABLE VALUES ARE:
     W-DIR  = WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS,
              QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
     T-MORT = TREE MORTALITY, PERCENT
              SCORCH HEIGHTS ARE BASED ON A 77 DEG (F) DAY.

TYPE NEXT TO VIEW NEXT TABLE

VIEW KEYWORD?
ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
        PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
        ZOOM,REPLAY,REDO,NEXT,QUIT
>next

 DO YOU WANT TO SEE THE MOISTURE TABLES FOR THIS WINDOW ? Y-N
>n

TYPE QUIT TO RETURN OR REDO TO RESTART VIEW SEQUENCE

VIEW KEYWORD?
ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
        PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
        REDO,QUIT
>quit

RXWINDOW KEYWORD?
ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
        WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
        PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
        REDO
>quit

 DO YOU  R E A L L Y  WANT TO TERMINATE THIS RUN? Y-N
>n
 OK.......

>comment

 ENTER TEXT FOR DOCUMENTATION. USE A CARRIAGE RETURN AT THE END OF EACH LINE.
 TO TERMINATE, ENTER (ON A NEW LINE) ** FOLLOWED BY A CARRIAGE RETURN.

 ********************************************************************************
 COMMENT:
>The following tables show a more complex example of the interaction of
>wind and slope.  We increase the slope from 5 to 45 percent.
>**
 ********************************************************************************

 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>change

 CHANGE WHICH LINE ? (0-25)
>10

 10--TERRAIN SLOPE, % ? 0 TO 100
>45
```

Explanation of abbreviation.

Note.

Woops.

Note.

```
 CHANGE WHICH LINE ? (0-25)
>19

 19--DO YOU WANT TO CONSTRAIN 20-FOOT WINDSPEED ? Y-N
>y

 ENTER MINIMUM VALUE, MI/H ? 0 TO 30
>8

 ENTER MAXIMUM VALUE, MI/H ? 8 TO 30
>15

 CHANGE WHICH LINE ? (0-25)
>0

 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>list

  INPUT LIST FOR RXWINDOW

  FIRE BEHAVIOR CONTRAINTS:

  1--RATE OF SPREAD, CH/H                      *** NOT CONSTRAINED ***
  2--HEAT PER UNIT AREA, BTU/SQFT              *** NOT CONSTRAINED ***
  3--FIRELINE INTENSITY, BTU/FT/S              *** NOT CONSTRAINED ***
  4--FLAME LENGTH, FT                           4.0 TO    8.0
  5--REACTION INTENSITY, BTU/SQFT/M            *** NOT CONSTRAINED ***
  6--SCORCH HEIGHT, FT                           .0 TO   30.0
  7--TREE MORTALITY, %                         *** NOT CONSTRAINED ***

  SITE CONDITIONS:

  8--FUEL MODEL:                       12 -- MEDIUM LOGGING SLASH
  9--FUEL EXPOSURE TO WIND:            PARTIALLY SHELTERED
                                       (WIND ADJUSTMENT FACTOR =  .30)
 10--TERRAIN SLOPE, %                          45.0   <-------- steep.
 11--100-HR MOISTURE = 10-HR MOISTURE PLUS       5. %

  PRESET ENVIRONMENTAL CONSTRAINTS:

 15--1-HR FUEL MOISTURE, %                      4.0 TO   24.0
 16--10-HR FUEL MOISTURE, %                   *** NOT CONSTRAINED ***
 19--20-FOOT WINDSPEED, MI/H                    8.0 TO   15.0   <-------- windy
 20--MIDFLAME WINDSPEED, MI/H                 *** NOT CONSTRAINED ***
 21--WIND DIRECTION                           *** NOT CONSTRAINED ***
 22--FIRE SPREAD DIRECTION                    HEAD

  OUTPUT TABLE CONFIGURATIONS:

 23--RXWINDOW FIRE BEHAVIOR TABLE VARIABLE:  FLAME LENGTH, FEET
 24--DEAD FUEL MOISTURE TABLE VARIABLE    :  1-HR FUEL MOISTURE, %
 25--LIVE FUEL MOISTURE TABLE VARIABLE    :  NO TABLE FOR FUEL MODEL 12.

  SYMBIOTIC RELATIONSHIPS:

  CONSTRAINED  20-FOOT WINDSPEED FROM      8.0 TO     15.0 MI/H
  CONSTRAINS  MIDFLAME WINDSPEED FROM      2.4 TO      4.5 MI/H
  RELATIONSHIP:  FUEL MODEL & FUEL EXPOSURE TO WIND (LINES 8-9).

  CONSTRAINED       FLAME LENGTH FROM      4.0 TO      8.0 FEET
  CONSTRAINS  FIRELINE INTENSITY FROM    114.6 TO    515.5 BTU/FT/S
  RELATIONSHIP:  MATHEMATICAL FIRE MODEL.
```

```
RXWINDOW KEYWORD?
ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
        WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
        PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>run
WORKING...
   WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
   WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE ***          (FULL WINDOW)              (VER 3.3)
========= I --- 20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H ---
WEIGHTED  I    8.0     9.0     10.0    11.0    12.0    13.0    14.0    15.0
DEAD FM % I    2.4     2.7      3.0     3.3     3.6     3.9     4.2     4.5
========= I ======= ======= ======= ======= ======= ======= ======= =======
 4 W-DIR  I          DN- DN
   FLAME  I           4-  4
--------- I ------- ------- ------- ------- ------- ------- ------- -------
 5 W-DIR  I          DN- DN  DN- DN
   FLAME  I           4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- ------- -------
 6 W-DIR  I                  DN- DN
   FLAME  I                   4-  4
--------- I ------- ------- ------- ------- ------- ------- ------- -------
 7 W-DIR  I                  DN- DN  DN- DN
   FLAME  I                   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- ------- -------
 8 W-DIR  I                  DN- DN  DN- DN
   FLAME  I                   4-  4   4-  4
--------- I ------- ------- ------- ------- ------- ------- ------- -------
 9 W-DIR  I                          DN- DN  DN- DN
   FLAME  I                           4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- ------- -------
10 W-DIR  I  QD- QD                 DN- DN  DN- DN
   FLAME  I   5-  5                  4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- ------- -------
11 W-DIR  I  QD- QD  QD- QD         DN- DN  DN- DN  DN- DN
   FLAME  I   5-  5   5-  5          4-  4   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- ------- -------
12 W-DIR  I  QD- QD  QD- QD  QD- QD DN- DN  DN- DN  DN- DN
   FLAME  I   4-  4   5-  5   5-  5  4-  4   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- ------- -------
13 W-DIR  I  QD- QD  QD- QD  QD- QD QD- QD  QD- DN  DN- DN  DN- DN
   FLAME  I   4-  4   4-  4   4-  4  5-  5   4-  5   4-  4   5-  5
--------- I ------- ------- ------- ------- ------- ------- ------- -------
14 W-DIR  I  X - X   X - QD  QD- QD QD- QD  QD- QD  QD- DN  QD- DN  DN- DN
   FLAME  I   5-  5   4-  5   4-  4  4-  4   5-  5   4-  5   4-  5   5-  5
--------- I ------- ------- ------- ------- ------- ------- ------- -------
15 W-DIR  I  UP- X   UP- X   UP- X   UP- QD  QU- QD  X - QD  X - QD  X - DN
   FLAME  I   4-  5   5-  5   5-  5  4-  5   4-  5   4-  5   4-  5   4-  5
--------- I ------- ------- ------- ------- ------- ------- ------- -------
16 W-DIR  I  UP- QU  UP- QU  UP- X   UP- X   UP- X   UP- X   UP- X   UP- QD
   FLAME  I   4-  4   4-  4   4-  5  4-  5   4-  5   4-  5   4-  5   4-  5
--------- I ------- ------- ------- ------- ------- ------- ------- -------
17 W-DIR  I                                                 UP- UP  UP- QU
   FLAME  I                                                  4-  4   4-  4
--------- I ------- ------- ------- ------- ------- ------- ------- -------
UNITS/CODES FOR TABLE VALUES ARE:
     W-DIR  = WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS,
              QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
     FLAME  = FLAME LENGTH, FEET
              SCORCH HEIGHTS ARE BASED ON A 77 DEG (F) DAY.

TYPE NEXT TO VIEW NEXT TABLE

VIEW KEYWORD?
ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
        PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
        ZOOM,REPLAY,REDO,NEXT,QUIT
>comment
```

Note gaps — Due to competition between the wind and slope to determine the direction of the head fire, and due to relationship between the flame length & scorch height constraints.

```
 ENTER TEXT FOR DOCUMENTATION. USE A CARRIAGE RETURN AT THE END OF EACH LINE.
 TO TERMINATE, ENTER (ON A NEW LINE) ** FOLLOWED BY A CARRIAGE RETURN.

 ********************************************************************************
 COMMENT:
>Notice the gaps at weighted dead fm from 10 to 11 and wind speed from
>9 to 10 mph.  This is an area where the direction of the head fire
>changes from being controlled by the slope to being dominated
>by the wind.  To illustrate, we'll change the table variable to spread
>direction.
>**
 ********************************************************************************

 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
         ZOOM,REPLAY,REDO,NEXT,QUIT
>quit

 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
         REDO
>change

 CHANGE WHICH LINE ? (0-25)
>3

 23--INCLUDE A FIRE VARIABLE IN THE OUTPUT TABLE ? Y-N
>y

  WHICH ONE ? 1-8
       1=RATE OF SPREAD          2=HEAT PER UNIT AREA
       3=FIRELINE INTENSITY      4=FLAME LENGTH
       5=REACTION INTENSITY      6=SCORCH HEIGHT
       7=MORTALITY               8=SPREAD DIRECTION
>8

 CHANGE WHICH LINE ? (0-25)
>0

 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
>run
 WORKING...
```

← Note.

← To print the direction of the head fire.

WIND SPEEDS AND WEIGHTED FUEL MOISTURES THAT RESULT IN FIRE BEHAVIOR
WITHIN PRESCRIPTION CONSTRAINTS FOR A *** HEAD FIRE ***

*** HEAD FIRE *** (FULL WINDOW) (VER 3.3)

	20-FOOT WIND SPEED/MIDFLAME WIND SPEED, MI/H							
WEIGHTED DEAD FM %	8.0 2.4	9.0 2.7	10.0 3.0	11.0 3.3	12.0 3.6	13.0 3.9	14.0 4.2	15.0 4.5
4 W-DIR		DN- DN						
S-DIR		180-180						
5 W-DIR		DN- DN	DN- DN					
S-DIR		180-180	180-180					
6 W-DIR			DN- DN					
S-DIR			180-180					
7 W-DIR			DN- DN	DN- DN				
S-DIR			180-180	180-180				
8 W-DIR			DN- DN	DN- DN				
S-DIR			180-180	180-180				
9 W-DIR				DN- DN	DN- DN			
S-DIR				180-180	180-180			
10 W-DIR	QD- QD			DN- DN	DN- DN			
S-DIR	75- 75			180-180	180-180			
11 W-DIR	QD- QD	QD- QD		DN- DN	DN- DN	DN- DN		
S-DIR	75- 75	84- 84		180-180	180-180	180-180		
12 W-DIR	QD- QD	QD- QD	QD- QD	DN- DN	DN- DN	DN- DN		
S-DIR	75- 75	84- 84	91- 91	180-180	180-180	180-180		
13 W-DIR	QD- QD	QD- QD	QD- QD	QD- QD	QD- DN	DN- DN	DN- DN	
S-DIR	75- 75	84- 84	91- 91	97- 97	102-180	180-180	180-180	
14 W-DIR	X - X	X - QD	QD- QD	QD- QD	QD- QD	QD- DN	QD- DN	DN- DN
S-DIR	48- 48	52- 84	91- 91	97- 97	102-102	105-180	108-180	180-180
15 W-DIR	UP- X	UP- X	UP- X	UP- QD	QU- QD	X - QD	X - QD	X - DN
S-DIR	0- 48	0- 52	0- 55	0- 97	29-102	63-105	65-108	66-180
16 W-DIR	UP- QU	UP- QU	UP- X	UP- X	UP- X	UP- X	UP- X	UP- QD
S-DIR	0- 24	0- 25	0- 55	0- 58	0- 61	0- 63	0- 65	0-111
17 W-DIR							UP- UP	UP- QU
S-DIR							0- 0	0- 32

UNITS/CODES FOR TABLE VALUES ARE:
W-DIR = WIND DIRECTION (UP=UP-SLOPE, QU=QUARTER-UP, X=CROSS, QD=QUARTER-DOWN, DN=DOWN-SLOPE, ANY=ANY DIRECTION)
S-DIR = FIRE SPREAD DIRECTION, DEG (UP=0)
SCORCH HEIGHTS ARE BASED ON A 77 DEG (F) DAY.

TYPE NEXT TO VIEW NEXT TABLE

VIEW KEYWORD?
ENTER: WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
ZOOM,REPLAY,REDO,NEXT,QUIT

Note.

0 = upslope head fire.

180 = downslope head fire.

```
>comment

 ENTER TEXT FOR DOCUMENTATION. USE A CARRIAGE RETURN AT THE END OF EACH LINE.
 TO TERMINATE, ENTER (ON A NEW LINE) ** FOLLOWED BY A CARRIAGE RETURN.

 ********************************************************************************
 COMMENT:
>Now we'll quit for good...
>**
 ********************************************************************************

 TYPE NEXT TO VIEW NEXT TABLE

 VIEW KEYWORD?
 ENTER:  WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,LIST,HELP,KEY
         ZOOM,REPLAY,REDO,NEXT,QUIT
>quit

 RXWINDOW KEYWORD?
 ENTER:  INPUT,LIST,CHANGE,RUN,HELP,KEY
         WORDY,TERSE,PAUSE,NOPAUSE,COMMENT,ENGLISH,METRIC
         PERCENT,DEGREES,LOG,NOLOG,STATUS,QUIT
         REDO
>quit

 DO YOU  R E A L L Y  WANT TO TERMINATE THIS RUN? Y-N
>y

 PART OF THIS RUN MAY HAVE BEEN LOGGED.
 THE FILE NAME IS:  show.log

  THE WINDOW IS NOW CLOSED.
 ********************************
```

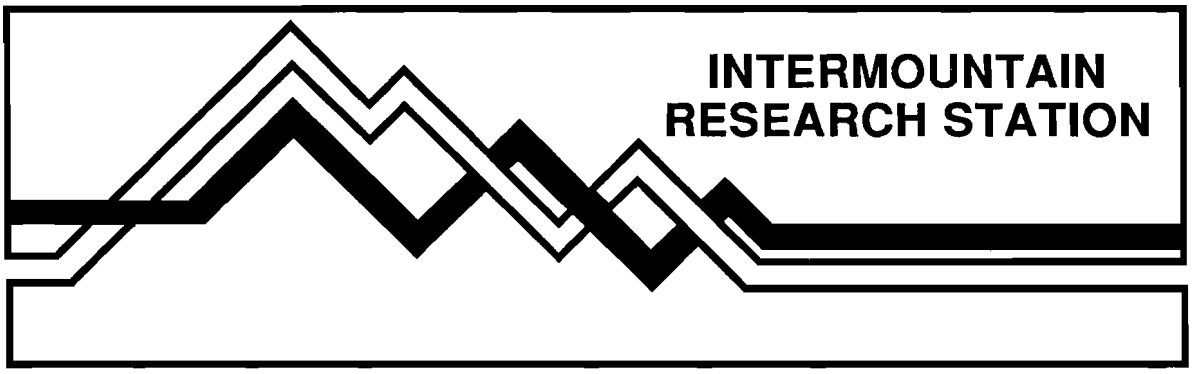
← The way that you print and delete this file depends on the computer that you're using.

☆U.S. GOVERNMENT PRINTING OFFICE: 1990-773-039/21008

Andrews, Patricia L.; Bradshaw, Larry S. 1990. RXWINDOW: defining windows of acceptable burning conditions based on desired fire behavior. Gen. Tech. Rep. INT-273. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 54 p.

The program RXWINDOW is intended to help fire managers develop prescription windows based on desired fire behavior. It is the fifth program in the BEHAVE fire behavior prediction and fuel modeling system. It reverses calculations found elsewhere in BEHAVE. In RXWINDOW, the user specifies acceptable fire behavior (rate of spread, flame length, intensity, scorch height, tree mortality) and the program determines appropriate combinations of environmental conditions (fuel moisture and wind).

KEYWORDS: wildland fire, fire management, prescribed fire, fire effects, fire behavior



The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

The Intermountain Research Station territory includes Montana, Idaho, Utah, Nevada, and western Wyoming. Eighty-five percent of the lands in the Station area, about 231 million acres, are classified as forest or rangeland. They include grasslands, deserts, shrublands, alpine areas, and forests. They provide fiber for forest industries, minerals and fossil fuels for energy and industrial development, water for domestic and industrial consumption, forage for livestock and wildlife, and recreation opportunities for millions of visitors.

Several Station units conduct research in additional western States, or have missions that are national or international in scope.

Station laboratories are located in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Ogden, Utah

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)

USDA policy prohibits discrimination because of race, color, national origin, sex, age, religion, or handicapping condition. Any person who believes he or she has been discriminated against in any USDA-related activity should immediately contact the Secretary of Agriculture, Washington, DC 20250.