Advanced Wildland Fire Behavior Calculations, S-490

Pre-Course Study Material

Part 4: Manual Methods of Fire Behavior Prediction

<u>Materials Needed:</u>

Fire Behavior Work Sheets from Appendix B
Fire Behavior Nomograms
Current BehavePlus Version (available at https://www.frames.gov/partner-sites/behaveplus/home/)
Straight edge ruler

<u>Introduction:</u>
There are many different ways to derive fire behavior predictions. There are several software programs to use on computers and even on personal digital assistants (PDA) such as Palm Pilots. There are also tables and nomograms that can be used to produce fire behavior predictions.

All of these prediction methods work in the same basic way, they take the fuels, weather and topography inputs you give and they produce outputs. The most common outputs of fire behavior are rate of spread, heat per unit area, and flame length. Other common outputs are spotting distance and probability of ignition.

Using tables and nomograms can provide insight to how the computers work, and provide you with a good understanding of the process. Tables and nomograms are also useful in displaying many outputs for a range of inputs all in one place.

Directions:

1.   Nomograms (pages 3 – 15)

      Read "Instructions for Calculating Fire Behavior with Nomograms" on the following page.
      Then work problems 1 and 2 from the Fire Behavior Worksheet. After working the
      problems, check your answers with those given. If your answers do not match the school
      solution, review the instructions and determine where you made a mistake. These
      problems will serve as the practice test for this section. It is suggested you make copies of
      the attached nomograms to keep a "clean" set to make future copies as needed.

2.   Fireline Handbook, Appendix B Look-Up Tables (pages 16 – 21)

      In Appendix B there are tables that can be used to make "calculations" on predicted fire
      behavior. Read the "Instructions for Using Fireline Handbook, Appendix B Look-Up
      Tables." Work on the two problems given and review the school solutions. If there were
      any errors, check to see where mistakes were made and redo that portion of the problem.
      These problems will serve as the practice test for this section.

3.   Calculate Proper Safety Zone Size (pages 21 – 22)

      Read the "Instructions for Calculating Safety Zone Size." Calculate the proper needed
      safety zone radius for the two problems solved in the Look-Up Table section. In general,
      the radius of the safety zone should be 4 times the flame height. The answers are given;
      review and re-work as needed. These problems will serve as the practice test for this
      section.

INSTRUCTIONS FOR CALCULATING FIRE BEHAVIOR WITH NOMOGRAMS:

A nomogram is a group of interconnecting graphs that can be used to solve a mathematical equation or series of equations. In this case, the fire model equations developed by Rothermel (1972) can be solved by constructing a series of lines on one sheet of paper.

Nomograms for predicting fire behavior were originally developed by Albini (1976). The nomograms presented here have been modified somewhat from Albini's original version. The primary change has been the adoption of midflame windspeed rather than 20-foot windspeed as an input. Albini used 20-foot windspeed with a wind time, to predict fire behavior in all conditions. To correct the over prediction of fire spread in cases where the fuels were sheltered by an overstory of trees, the method of calculating windspeed in sheltered fuel presented by Albini and Baughman (1979) was adopted.

There are two nomograms for each of the 13 fuel models: a low windspeed version and a high windspeed version. They will both give the same answers, but a better resolution can be obtained from the low windspeed version; so it should be used whenever possible. Nomograms for all fuel models are given in this envelope.

Solution of a fire spread problem on a nomogram will provide an estimate of rate of spread, fineline intensity, flame length, and heat per unit area. The fire behavior worksheet provides the input data and is used to record the outputs. It has been designed for use with nomograms, BehavePlus or other fire behavior prediction programs. Not all values are used with each system; consequently, some lines on the fire behavior worksheet will not be used. Whenever the worksheet is needed, the line number on the left-hand margin will be referenced.

For the nomograms, data on the following lines are necessary:

      1 - Fuel model number
      2 - Fine dead fuel moisture (1-hour)
      6 - Live woody fuel moisture (for some fuels)
      7 - Midflame windspeed
    10 - Slope steepness

Fuel models 2, 4, 5, 7, and 10 contain living fuel. The procedures for handling live fuel moisture are somewhat different than for the fuel models that have only dead fuel. Methods for calculating fire behavior with fuel models containing only dead fuels will be covered first.

It is assumed that a Fire Behavior Worksheet has been prepared with the required information (see Exhibit 1 on page 7).

Select the nomogram for the fuel model designated on the Fire Behavior Worksheet, line l; use the low windspeed nomogram when possible. Note that there are four parts to the nomogram. These are called quadrants and are referred to as upper and lower (meaning the top and bottom of the page) and by left and right.

Solving a fire spread problem on a nomogram requires initial preparation and then a trip through all four quadrants with a continuous line starting and finishing in the upper right quadrant. All of the answers are read in that quadrant. A diagrammatic depiction of the written instructions is given in Exhibits 2 and 3 (pages 8 and 9).

Before starting, a note on technique is worthwhile. Lay the nomogram on a flat surface. Have a narrow 10- or 12-inch straight edge available. Note that there is an underlying grid to assist you to keep your lines drawn true with the nomogram, i.e., parallel with the edges and forming right angles at intersections.

Step 1—Determine effective value of the midflame windspeed.   (This step combines wind and slope.)   Note the slope given on line 10 of the Fire Behavior Worksheet (Exhibit 1, 60% slope). In the lower left quadrant find the percent slope (Exhibit 2) and draw a vertical line to the top of the quadrant.   On the right-hand side of the lower left quadrant, find the midflame windspeed given on line 7 of the Fire Behavior Worksheet (Exhibit 1, 2.5mph). Follow the curved windspeed line to vertical line from the slope and the midflame windspeed, from where the midflame windspeed crosses the vertical slope line, draw a horizontal line to the left-hand margin. The effective windspeed is read from the margin (example shown on Exhibit 2, 5 mph). Record the effective (midflame) windspeed (EWS) on line 6 of the Fire Behavior Worksheet (OUTPUT) section.

The construction lines drawn in the lower-left quadrant are not used again. The turning line for the lower-left quadrant is always the "pre-drawn" diagonal line.

Step 2—Prepare the lower right quadrant by locating a ray (line from the origin) that represents the effective windspeed. Such lines are already in the quadrant to guide you. Interpolate, if necessary, to establish a ray for the effective windspeed determined in Step 1 (see Exhibit 2). This line will be used later as a turning line when taking the trip around the nomogram.

Fuel Models with No Living Fuel Component

Step 3—This step prepares the upper left quadrant. Find the dead fuel moisture value, given on line 2 of the Fire Behavior Worksheet (example shown on Exhibit 2, 10%), on the upper edge of the quadrant. Interpolate, if necessary, and construct a new ray for the fuel moisture value (see Exhibit 2).

All preparations have been made and you can begin your trip around the nomogram.

Fuel Models with Living Fuels

Fuel models 2, 4, 5, 7, and 10 have 1iving fuels requiring a different procedure in Step 3. Do not be discouraged; the genius of Albini's nomograms is that they can handle this extra variable without requiring two pages for the solution. (See Exhibit 3 example.)

Step 3—With Live Fuels—Find the dead fuel moisture on the right side of the upper-right quadrant and on the left side of the upper-left quadrant. Draw a line across both quadrants at the designated dead fuel moisture (see Exhibit 3). In the upper-left quadrant, find the intersection of the horizontal line just drawn with a slightly curved line representing the live fuel moisture given on line 5 or 6 of the Fire Behavior Worksheet. Lay your straight edge between the intersection just found and the origin and draw a ray from the origin up through the intersection just found and edge of the quadrant (see Exhibit 3). This line will be the turning line in the upper-left quadrant when you make your trip around the nomogram (Exhibit 3).   Note that for some fuel models and some conditions, the slightly curved lines are so straight that this step provides little correction.

Starting the trip on a nomogram with live fuel moisture.   The trip is started in the upper-right quadrant at the intersection of the horizontal dead fuel moisture line with the S-shaped curve that is closest to the live fuel moisture. You can interpolate between these lines if desired. The trip will end at the intersection of this vertical line. All other steps are the same as used for dead fuel.

Continue With All Fuel Models

Step 4—Begin in the upper-right quadrant. In the margin, locate the dead fuel moisture from line 2 of the Fire Behavior Worksheet. Draw a horizontal line across the upper-right quadrant until it intercepts the S-shaped curve. At the interception, draw a vertical line all the way from the top of the upper-right quadrant through the intersection just found and into the lower-right quadrant until it hits the ray designating the effective windspeed (Exhibit 2).

NOTE: The lower-right quadrant contains a curved dashed line. There is a note in this quadrant that reads: "Wind-driven fire of low intensity may behave erratically. If the vertical line from the chart above intersects effective windspeed line to the left of the dashed line, rate of spread and fireline intensity may be overstated."

The correct procedure to follow if the vertical line from the upper-right quadrant intersects the curved dashed line above the effective windspeed line is to stop at the intersection with the dashed line and construct the next line into the lower-left quadrant from that intersection. This will produce a lower rate of spread and fire intensity than would result if you continued and used the effective windspeed line.

Step 5—Note the diagonal line in the lower-left quadrant. This is the next turning line. From the intercept of the effective windspeed in the lower-right quadrant, draw a horizontal line into the lower-left quadrant where it intercepts the diagonal line (Pay no attention to the previously constructed lines from Step 1 in the lower-left quadrant).

Step 6—From the lower-left quadrant, draw a vertical line into the upper-left quadrant until it intercepts the appropriate ray for the fuel moisture marked from Step 3 (see Exhibit 2).

Step 7—At the intercept in the upper-left quadrant, draw a horizontal line into the upper-right quadrant extending it until it intercepts the vertical line constructed at the beginning of your trip in Step 4. Draw a small circle at this intercept (see Exhibit 2).

You have completed the trip; line construction is complete, and you can read the answers.

Rate of spread is taken from the left-hand margin of the upper-right quadrant where the horizontal line from Step 7 enters the quadrant (see Exhibit 2). Record rate of spread on line 1 of the Fire Behavior Worksheet (OUTPUT) section.

Fireline intensity is found at the small circle drawn in Step 7 in the upper- right quadrant. The fireline intensity numbers are indicated on each curved line running through the quadrant. Interpolate between lines (see Exhibit 2). Record on line 3 of the Fire Behavior Worksheet (OUTPUT) section.

Flame length is found on the upper-horizontal axis of the upper-right quadrant. Start at the small circle drawn in Step 7, interpolating where necessary, and staying parallel, follow the curved lines upward to the upper horizontal axis. Record on line 4 of the Fire Behavior Worksheet (OUTPUT) section.

Heat per unit area. Read on the lower horizontal axis of the upper right quadrant where it is crossed by the vertical line drawn in Step 4.   Record on line 2 of the Fire Behavior Worksheet.

NOTE: When you have had some practice, you will find that it is not necessary to draw 1ines all around the nomogram when you make the trip; tic marks at each intersection are sufficient. The starting point in the upper-right quadrant usually requires a line so you will not miss it at the completion of the trip.

Interpretation and use of the answers obtained from the nomograms are discussed in other lessons.

Study the examples shown on Exhibits 1-3. When you understand the procedure, work through the examples.

Exhibit 1

PROJECTION AREA INFORMATION

Name of Event: **Example 1 & 2**   Fire Behavior Specialist: _____

Current: Date: _____ Time: _____ Projection: Date: _____ Time: _____

SURFACE WORKSHEET FOR NOMOGRAMS

	INPUT PARAMETERS		INPUT VALUES	
			Example 1	**Example 2**
0	Projection Point	------------		
1	FBPS Fuel Model	(1-99)	6	2
2	1-H Fuel Moisture	[1-60%]	10	8
3	10-H Fuel Moisture	[1-60%]		
4	100-H Fuel Moisture	[1-60%]		
5	Live Herb Moisture	[30-300%]		50
6	Live Woody Moisture	[30-300%]		
7a	20-ft Wind Speed	[0-99 mph]		
7b	Wind Red. Factor	(0 – 1)		
7c	Midflame Windspeed	[0-99 mph]	2.5	5
7d	Effective Wind Spd	MPH		
8	Dir.of Wind Vector	[0-360°]		
	Spread at Max?	(Y / N)		
9	Spread Direction	[0-360°]		
10	Slope Steepness	[0-100%] or [0-45°]	60	40
11	Elapsed Time	[0.5 - 8.0 hrs]		
12	Rep. Fraction	(1,080 - 1,013,670)		

	OUTPUT PARAMETERS		OUTPUT VALUES
1	Rate of Spread	Chains / Hour	
2	Heat per Unit Area	BTUs / Ft^2	
3	Fireline Intensity	BTUs / Ft. / Sec	
4	Flame Length	Feet	
5	Reaction Intensity	BTU / Ft^2 / Min	
6	Effective Wind Spd	MPH	
7	Dir. Of Max. Spread	Degrees	
8	For. Spread Dist.	Chains	
9	For. Spr. Map Dist.	Inches	

Exhibit 2, Nomogram, Example 1, Fuel Model 6, Low Wind Speed

6. DORMANT BRUSH, HARDWOOD SLASH – LOW WINDSPEEDS

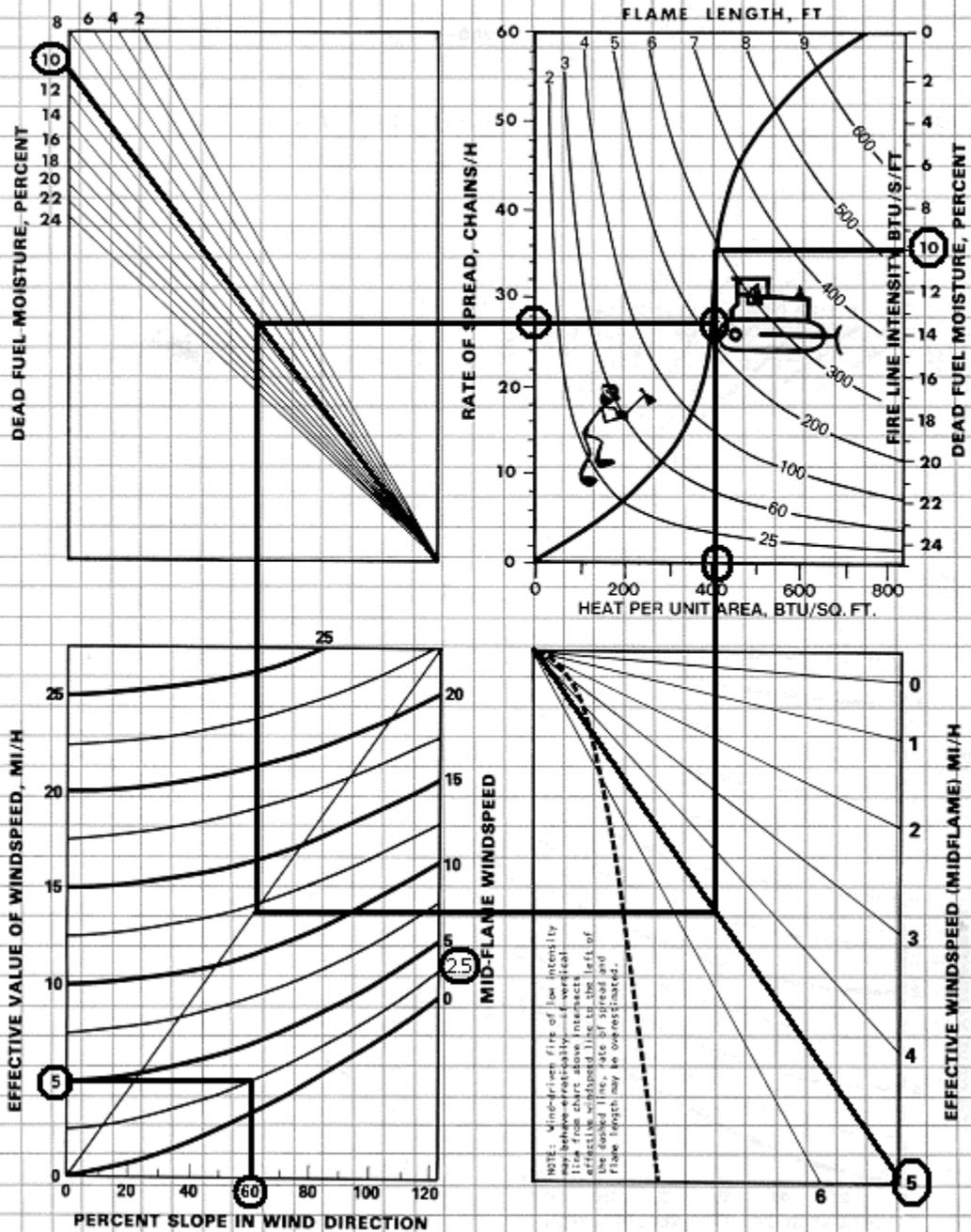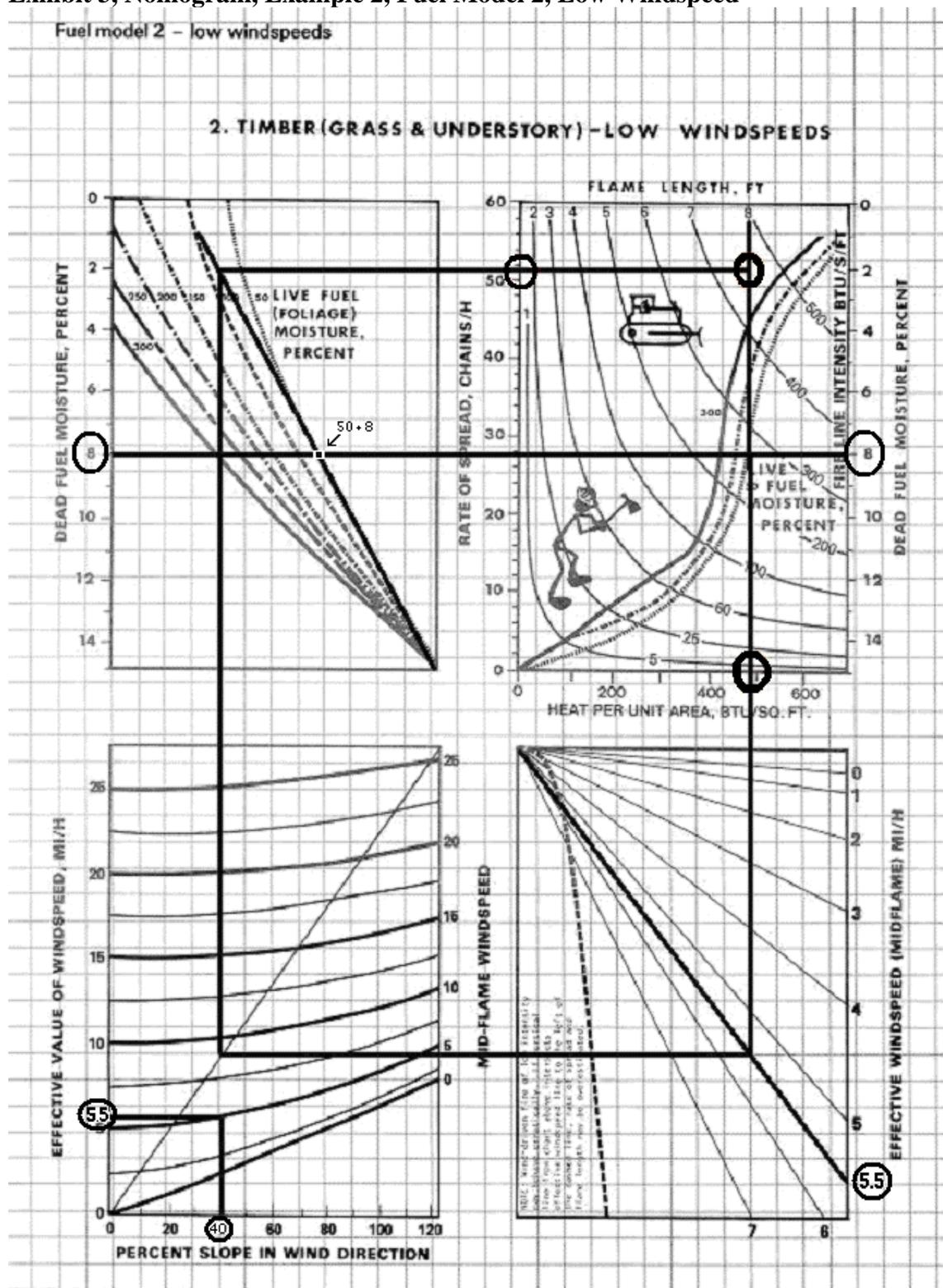**Exhibit 3, Nomogram, Example 2, Fuel Model 2, Low Windspeed**

2. TIMBER (GRASS & UNDERSTORY) – LOW WINDSPEEDS

Nomogram Example 1 & 2 Answers

PROJECTION AREA INFORMATION

Name of Event: <u>Example 1 & 2</u>   Fire Behavior Specialist: _____

Current: Date: _____ Time: Projection: Date: _____ Time: _____

SURFACE WORKSHEET FOR NOMOGRAMS

	INPUT PARAMETERS		Example 1	Example 2
			INPUT VALUES	
0	Projection Point	------------		
1	FBPS Fuel Model	(1-99)	6	2
2	1-H Fuel Moisture	[1-60%]	10	8
3	10-H Fuel Moisture	[1-60%]		
4	100-H Fuel Moisture	[1-60%]		
5	Live Herb Moisture	[30-300%]		50
6	Live Woody Moisture	[30-300%]		
7a	20-ft Wind Speed	[0-99 mph]		
7b	Wind Red. Factor	(0 – 1)		
7c	Midflame Windspeed	[0-99 mph]	2.5	5
7d	Effective Wind Spd	MPH		
8	Dir.of Wind Vector	[0-360°]		
	Spread at Max?	(Y / N)		
9	Spread Direction	[0-360°]		
10	Slope Steepness	[0-100%] or [0-45°]	60	40
11	Elapsed Time	[0.5 - 8.0 hrs]		
12	Rep. Fraction	(1,080 - 1,013,670)		

	OUTPUT PARAMETERS		Example 1	Example 2
			OUTPUT VALUES	
1	Rate of Spread	Chains / Hour	22-28	45-55
2	Heat per Unit Area	BTUs / Ft^2	400-450	450-500
3	Fireline Intensity	BTUs / Ft. / Sec	200-250	425-475
4	Flame Length	Feet	4.5-5.5	7-8
5	Reaction Intensity	BTU / Ft^2 / Min		
6	Effective Wind Spd	MPH	5	5.5
7	Dir. Of Max. Spread	Degrees		
8	For. Spread Dist.	Chains		
9	For. Spr. Map Dist.	Inches		

Work through Problem 1 and 2 on the following page. Make photocopies of your blank nomograms; this will ensure that you keep a "clean" and complete set. <u>Do not look at the solutions</u> until after you have worked the problems. If you have time, make up your own problems and practice solving them until you feel confident that you understand nomogram solution techniques and can work them without instructions.
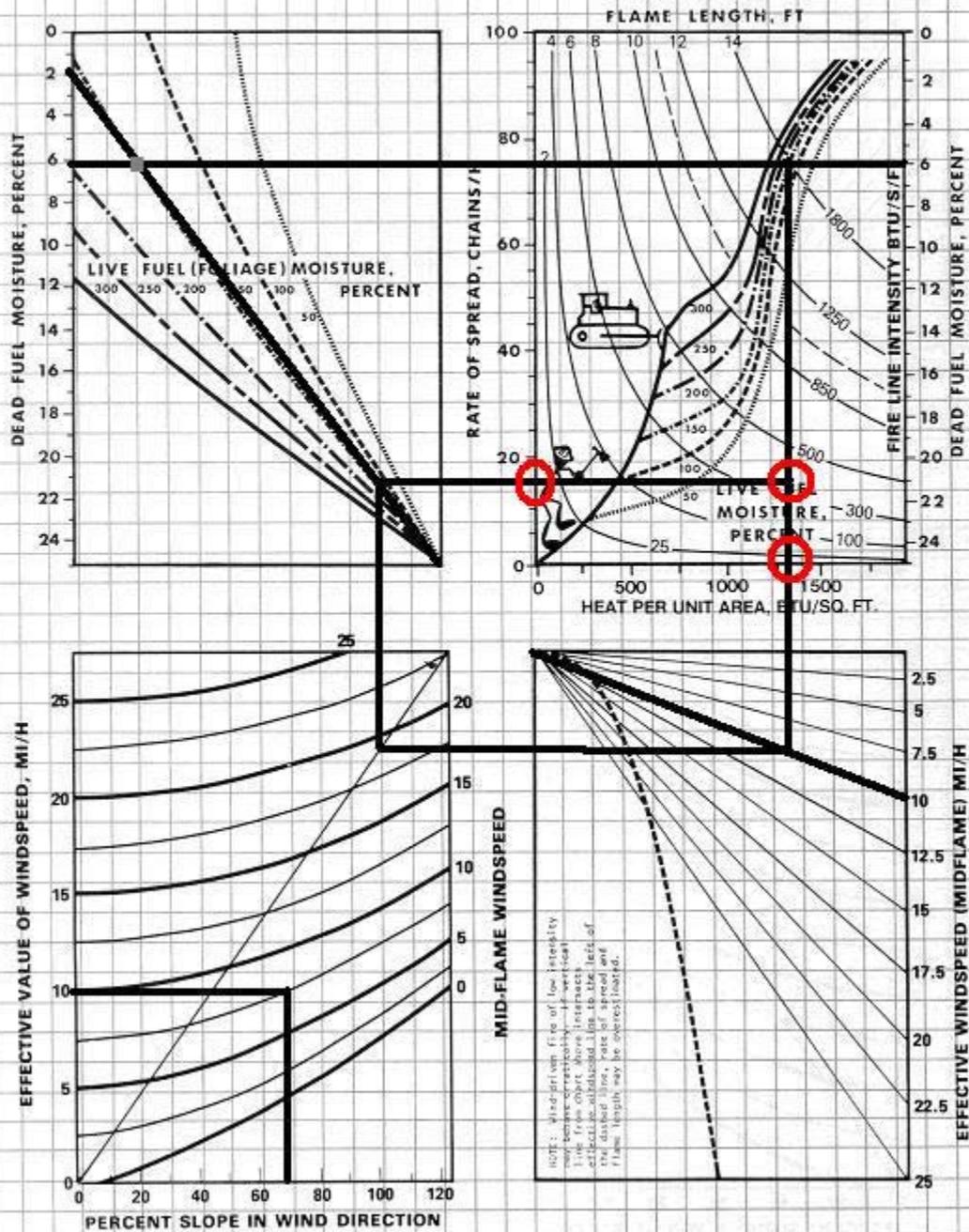
Nomogram Problem 1 & 2

PROJECTION AREA INFORMATION

Name of Event: **Problem 1 & 2**   Fire Behavior Specialist: _____

Current: Date: _____ Time: _____ Projection: Date: _____ Time: _____

SURFACE WORKSHEET FOR NOMOGRAMS

INPUT PARAMETERS			INPUT VALUES	
			Problem 1	**Problem 2**
0	Projection Point	------------		
1	FBPS Fuel Model	(1-99)	10	11
2	1-H Fuel Moisture	[1-60%]	6	9
3	10-H Fuel Moisture	[1-60%]		
4	100-H Fuel Moisture	[1-60%]		
5	Live Herb Moisture	[30-300%]		
6	Live Woody Moisture	[30-300%]	150	
7a	20-ft Wind Speed	[0-99 mph]		
7b	Wind Red. Factor	(0 – 1)		
7c	Midflame Windspeed	[0-99 mph]	7.5	4
7d	Effective Wind Spd	MPH		
8	Dir.of Wind Vector	[0-360°]		
	Spread at Max?	(Y / N)		
9	Spread Direction	[0-360°]		
10	Slope Steepness	[0-100%] or [0-45°]	70	50
11	Elapsed Time	[0.5 - 8.0 hrs]		
12	Rep. Fraction	(1,080 - 1,013,670)		

OUTPUT PARAMETERS			OUTPUT VALUES
1	Rate of Spread	Chains / Hour	
2	Heat per Unit Area	BTUs / Ft^2	
3	Fireline Intensity	BTUs / Ft. / Sec	
4	Flame Length	Feet	
5	Reaction Intensity	BTU / Ft^2 / Min	
6	Effective Wind Spd	MPH	
7	Dir. Of Max. Spread	Degrees	
8	For. Spread Dist.	Chains	
9	For. Spr. Map Dist.	Inches	

Problem 1, Answers
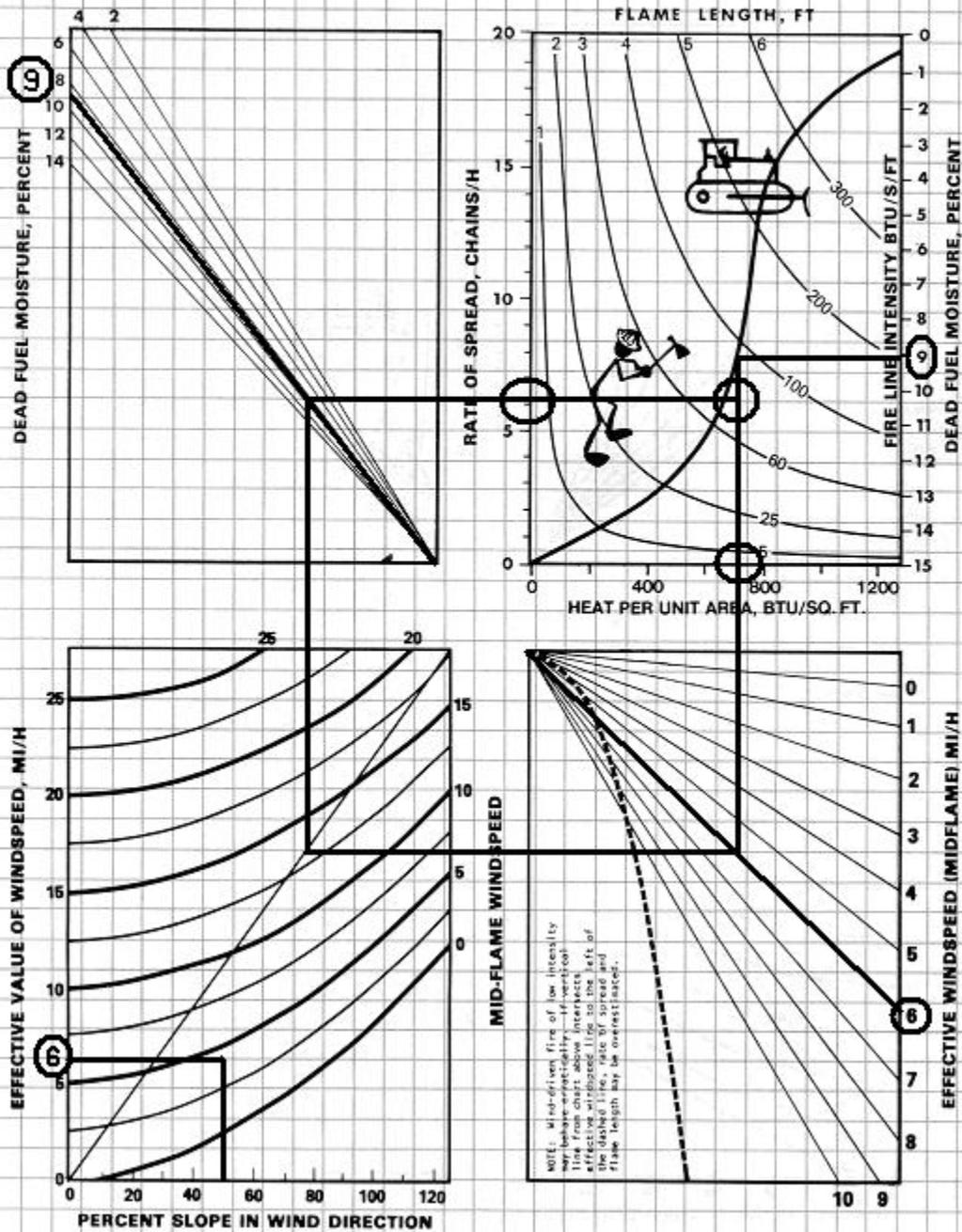

Fuel model 10 – high windspeeds

10. TIMBER (LITTER & UNDERSTORY)-HIGH WINDSPEEDS

Problem 2, Answers

Fuel model 11 – low windspeeds

11. LIGHT LOGGING SLASH-LOW WINDSPEEDS

Nomogram Problem 1 & 2 Answers

PROJECTION AREA INFORMATION

Name of Event: <u>Problem 1 & 2</u>   Fire Behavior Specialist: _____

Current: Date: _____ Time: _____ Projection: Date: _____ Time: _____

SURFACE WORKSHEET FOR NOMOGRAMS

	INPUT PARAMETERS		INPUT VALUES	
			Problem 1	Problem 2
0	Projection Point	------------		
1	FBPS Fuel Model	(1-99)	10	11
2	1-H Fuel Moisture	[1-60%]	6	9
3	10-H Fuel Moisture	[1-60%]		
4	100-H Fuel Moisture	[1-60%]		
5	Live Herb Moisture	[30-300%]		
6	Live Woody Moisture	[30-300%]	150	
7a	20-ft Wind Speed	[0-99 mph]		
7b	Wind Red. Factor	(0 – 1)		
7c	Midflame Windspeed	[0-99 mph]	7.5	4
7d	Effective Wind Spd	MPH		
8	Dir.of Wind Vector	[0-360°]		
	Spread at Max?	(Y / N)		
9	Spread Direction	[0-360°]		
10	Slope Steepness	[0-100%] or [0-45°]	70	50
11	Elapsed Time	[0.5 - 8.0 hrs]		
12	Rep. Fraction	(1,080 - 1,013,670)		

	OUTPUT PARAMETERS		OUTPUT VALUES	
1	Rate of Spread	Chains / Hour	**13-19**	**5-7**
2	Heat per Unit Area	BTUs / Ft^2	**1200-1300**	**650-750**
3	Fireline Intensity	BTUs / Ft. / Sec	**300-400**	**70-80**
4	Flame Length	Feet	**6-7.5**	**3-4**
5	Reaction Intensity	BTU / Ft^2 / Min		
6	Effective Wind Spd	MPH		
7	Dir. Of Max. Spread	Degrees		
8	For. Spread Dist.	Chains		
9	For. Spr. Map Dist.	Inches		

**INSTRUCTIONS FOR USING FIRELINE HANDBOOK, APPENDIX B
LOOK-UP TABLES:**

Fire Behavior Tables - Use of Tables
These tables, found on pages B-64 through B-144 in the October, 1993 version of the Fireline Handbook, are provided to give quick access to estimated fire behavior characteristics of rate of spread (ROS) and flame length (FL). Inputs for these tables are fuel model, slope, 1-hour fuel moisture, and midflame wind speed.

Live fuel moistures, woody and herbaceous, are listed as being between 120-90% for those fuel models that include them. The range of fire behavior outputs (flame length and rate of spread), relate to the range of live fuel moisture used as input (120%-90%). For example the rate of spread in fuel model 4 with 90% slope, dead fuel moisture of 3%, and mid-flame of wind of 4 mph gives a range of rate of spread of 150-186 ch/hr. The 150 ch/hr is for 120% live fuel moisture, and the 186 ch/hr goes with the drier 90% live fuel moisture.

To use these look up tables you need to gather the above listed input values of fuel model, slope percent, 1-hour fuel moisture and mid-flame wind.

1. Start with the appropriate fuel model and slope percent. Use this to find the proper look-up table.
2. On the proper table locate the appropriate fuel moisture down the left side, and the correct mid-flame wind across the top.
3. Where the fuel moisture and wind "cross" read the ROS on the top half, and FL on the bottom half of the table.

Table Interpolation
Fire behavior nomograms and programs found on computers or other devices allow you to use specific inputs. The look-up tables provide input values in only a limited interval. Fuel moisture inputs are for every 3%, midflame wind is for even numbers only, and the slope classes are for 0%, 30%, 45%, 60% and 90% values.

It is important that you understand that rounding your input to fit the table will result in less precise output. To achieve more accurate results you should use interpolation. When your input value falls between those listed in the tables, say 3 mph midflame wind, you should read the output values given for 2 mph and 4 mph and interpolate to the mid-point between those values' outputs. Use the same technique with slope and fuel moisture to find more precise outputs.

Perimeter and Area Estimations for Point Source Fires Tables – Use of Tables
A fire's shape varies based on effective wind speed. Low wind speeds allow fires to build in a more round shape. Fires burning under conditions of high wind speeds are "stretched out" and have a much more linear shape (see the diagram on fire shapes for various effective windspeeds on page B-47). These perimeter and area tables are found on pages B-41 through B-46. These tables can be used to estimate the perimeter of a fire in chains, or the area of fires in acres from estimates of total spread distance (rate of spread x time) and effective windspeed. Across the top of the tables is effective wind speed. These tables are usually used in conjunction with runs made using nomograms. The effective windspeed can be determined using the lower left quadrant of the nomogram of the fuel model being used. Using the effective windspeed across the top of the table and the spread distance along the left margin, find the intersection of those two numbers. When the effective windspeed is an even number or when spread distance is not broken out, estimations can be made or interpolation may be necessary.

Probability of Ignition Table – Use of Tables
The probability of ignition (PIG) is an indication of the chance that a firebrand will cause an ignition. The number of firebrands, their size, and the fuel on which they land is unknown. Use Table 12 on page B-55 with the dry bulb temperature, shading and the fine dead fuel moisture to determine the probability of ignition. After determining the fine fuel moisture for your prediction, locate that fuel moisture on the top of the PIG table. Next, determine if your site is to be considered "unshaded" or "shaded." Shading percent is the combination of cloud cover, and tree canopy and other factors that would result in the area being shaded (topography). If the site is unshaded, use the top of the table, if shaded, use the bottom half. Locate the range of temperature that includes the temperature for the site. Find where this temperature and the fine fuel moisture cross and read the resulting PIG.

Practice Test – "Look-Up" Tables
Work on the following two problems using the "look-up" tables in your Fireline Handbook, Appendix B. After working these problems and determining the flame length and rate of spread for the given inputs, check your answers with those given. Work through any errors you find.

Practice Test - Fire Behavior Lookup Tables

PROJECTION AREA INFORMATION

Name of Event: <u>Practice Test</u>   Fire Behavior Specialist: _____

Current: Date: _____ Time: _____ Projection: Date: _____ Time: _____

SURFACE WORKSHEET

	INPUT PARAMETERS		INPUT VALUES	
			Problem 1	**Problem 2**
0	Projection Point	------------	5	9
1	FBPS Fuel Model	(1-99)	3	5
2	1-H Fuel Moisture	[1-60%]		
3	10-H Fuel Moisture	[1-60%]		
4	100-H Fuel Moisture	[1-60%]		
5	Live Herb Moisture	[30-300%]		
6	Live Woody Moisture	[30-300%]	120	
7a	20-ft Wind Speed	[0-99 mph]		
7b	Wind Red. Factor	(0 – 1)		
7c	Midflame Windspeed	[0-99 mph]	6	5
7d	Effective Wind Spd	MPH		
8	Dir.of Wind Vector	[0-360°]		
	Spread at Max?	(Y / N)		
9	Spread Direction	[0-360°]		
10	Slope Steepness	[0-100%] or [0-45°]	0	30
11	Elapsed Time	[0.5 - 8.0 hrs]		
12	Rep. Fraction	(1,080 - 1,013,670)		

	OUTPUT PARAMETERS		OUTPUT VALUES
1	Rate of Spread	Chains / Hour	
2	Heat per Unit Area	BTUs / Ft^2	
3	Fireline Intensity	BTUs / Ft. / Sec	
4	Flame Length	Feet	
5	Reaction Intensity	BTU / Ft^2 / Min	
6	Effective Wind Spd	MPH	
7	Dir. Of Max. Spread	Degrees	
8	For. Spread Dist.	Chains	
9	For. Spr. Map Dist.	Inches	

Practice Test Answers - Fire Behavior Lookup Tables

PROJECTION AREA INFORMATION

Name of Event: <u>Practice Test</u>   Fire Behavior Specialist: _____

Current: Date: _____ Time: _____ Projection: Date: _____ Time: _____

SURFACE WORKSHEET

	INPUT PARAMETERS		INPUT VALUES	
			Problem 1	Problem 2
0	Projection Point	------------	5	9
1	FBPS Fuel Model	(1-99)	3	5
2	1-H Fuel Moisture	[1-60%]		
3	10-H Fuel Moisture	[1-60%]		
4	100-H Fuel Moisture	[1-60%]		
5	Live Herb Moisture	[30-300%]		
6	Live Woody Moisture	[30-300%]	120	
7a	20-ft Wind Speed	[0-99 mph]		
7b	Wind Red. Factor	(0 – 1)		
7c	Midflame Windspeed	[0-99 mph]	6	5
7d	Effective Wind Spd	MPH		
8	Dir.of Wind Vector	[0-360°]		
	Spread at Max?	(Y / N)		
9	Spread Direction	[0-360°]		
10	Slope Steepness	[0-100%] or [0-45°]	0	30
11	Elapsed Time	[0.5 - 8.0 hrs]		
12	Rep. Fraction	(1,080 - 1,013,670)		

	OUTPUT PARAMETERS		OUTPUT VALUES	
1	Rate of Spread	Chains / Hour	**28**	**11.1**
2	Heat per Unit Area	BTUs / Ft^{2}		
3	Fireline Intensity	BTUs / Ft. / Sec		
4	Flame Length	Feet	**7**	**3.36**
5	Reaction Intensity	BTU / Ft^{2} / Min		
6	Effective Wind Spd	MPH		
7	Dir. Of Max. Spread	Degrees		
8	For. Spread Dist.	Chains		
9	For. Spr. Map Dist.	Inches		

Practice Test - Perimeter and Area Lookup Tables

You have a point source fire that started 1½ hours ago. The rate of spread has been calculated at 20 chains per hour. The effective windspeed is 5 mph.

1. What is the estimated perimeter of this fire?

2. What is the estimated area of this fire?

A lightning caused fire just started burning 30 miles south east of the nearest work center in a remote area. It will take the crews 2 hours to arrive on the fire scene. Your estimates for the area of the fire indicate the effective wind speed will be 6 mph, and the rate of spread will be 30 chains per hour.

3. What is the estimated perimeter of the fire when the crews arrive?

4. What is the estimated area of the fire when the crews arrive?

Determine the Probability of Ignition for the following two questions:

Question 5	Question 6
Temperature – 89 degrees	Temperature – 72 degrees
Fine Fuel Moisture – 4%	Fine Fuel Moisture – 11
Shading – 30% shaded	Shading – 75% shaded

Using the Table on B-55:

5. What is the probability of ignition for the data in question 5?

6. What is the probability of ignition for the date in question 6?

<u>Practice Test Answers - Perimeter and Area Lookup Tables</u>

1. 74 chains
2. 35 acres
3. 144.5 chains
4. 125 acres
5. 80
6. 30

INSTRUCTIONS FOR CALCULATING SAFETY ZONE SIZE:

Read the paper "Firefighter Safety Zones: How Big Is Big Enough?" on the Student CD. The National Wildfire Coordination Group defines a "Safety Zone" as a preplanned area of sufficient size and suitable location that is expected to prevent injury to fire personnel from known hazards <u>without</u> using fire shelters. In this paper it is pointed out that firefighter safety zones should be created so they can keep firefighters at least four times (4x) the maximum flame height away from the flames.

Our fire behavior prediction models do not predict flame *height*, so we need to use flame *length*. If the fire is expected to burn all the way around the safety zone, the "4x" number should be the radius of the safety zone, and therefore the final distance across the entire safety zone will be eight times the maximum flame height. This is an accepted guideline. It is important to understand that both people and equipment take up space in the safety zone.

When calculating or checking on the size of safety zones it is important to understand that additional area to accommodate equipment and people must be included in the final size of the safety zone. BehavePlus version 2.0 and higher includes a safety zone calculator function.

For example, if the expected maximum flame height is 5 feet, the minimum distance needed to keep crews safe from burn injuries would be 20 feet. If the fire is expected to burn all the way around the safety zone, then the zone must have a diameter of 40 feet.

To account for the space that crews and equipment need to occupy the above formula needs to be added to. The separation distance = (4 x the flame length). The equation for the room occupied by crews and equipment = 20 + 4(# of 20 person crews) + (# of pieces of equipment).

So the final equation is:

Safety Zone Radius = Separation Distance + Room for Crews and Equipment
Safety Zone Radius = ((4 x Flame Length) + 20) + (4 x (# of 20 per. crews)) + (# of pieces of equipment)

An example would be:

> 6 foot flame length
> 3 – 20 person crews
> 2 – type 6 engines

Safety Zone Radius = ((4 x 6) + 20) + (4 (3)) + (2) = 24 + 20 + 12 + 2 = 58 feet

Practice Test

1. Calculate the separation distance for the fire behavior predicted using the information from the two earlier practice test questions.

2. Calculate the Safety Zone Radius if there were 2 crews and 2 engines on the fire.

<u>After</u> you have calculated the radius, check your answers on the following page.

Practice Test Answers

1. Problem 1 from the "look-up" tables practice test had a flame length of 7 feet. That means that the minimum separation distance is 28 feet.

    Problem 2 from the "look-up" tables practice test had a flame length of 3.4 feet. That means the minimum separation distance is 13.6 feet.

2. Safety Zone Radius = 13.6 + 20 + 4 (2) + 2 = 43.6 feet