

UNIT X--FIRE BEHAVIOR AFFECTS FIRELINE TACTICS

Fire behavior affects fireline tactics. After you have read the instructions to students on page 1, please read the unit objectives on page 2. Return to this text when you have finished.

Please turn to page 3. In Unit 1, we identified a need for fire behavior knowledge and predictions as an aid to managers in decision making to achieve fire management objectives. Some of these objectives are the protection of high values with reasonable losses due to wildfires, the cost effectiveness of suppression forces, the accurate assessment of hazards and safety practices followed, and the safe containment of management fires.

Wildfires and the control actions taken to suppress them can be very costly. Resource managers and the general public take a justifiably critical view of poor tactical decisions that escalate fire costs. At the same time, losses of life and property due to fire trigger investigations to determine whether neglect or poor tactical judgments were responsible.

In addition to discussing the numerous factors making up the fire environment, the first nine units of this course have taken you through many of the steps required for making fire behavior calculations and predictions. Input values needed for such calculations have been covered. This is a complex process which will be continued in Unit 11 on fire behavior predictions.

Fire personnel must continually assess potential fire behavior, but not everyone will be making fire behavior calculations using mathematical models. Nevertheless it is important for fire personnel to recognize the value and utility of these calculations. In this unit, we will apply both fire behavior predictions made using models and general fire behavior assessments to fire management decisions, including fire suppression tactics.

What do we mean by fire suppression tactics? Well, our definition is the science and art of deploying and maneuvering forces against wildfire. Tactics are often used in a military sense, for intelligence and strategic planning are usually vital to successful combat operations. The same holds true in combating wildfires.

Item A states that fire behavior considerations must play an important role in tactical decisions made to manage or control wildland fires. Some of these decisions involve the following factors: Locations of control lines, standards for fireline construction, use of direct or indirect attack, limitations on use of forces, identification of hazardous fire conditions, and timing of control actions. These are the areas on which this unit will concentrate, since fire behavior has direct implications for each of them.

In this unit, we want to tie outputs from the fire behavior model to fire control planning and to give you practice in working with these values. In figure 1 on page 4, we have diagrammed the relationships of fire behavior inputs, outputs, and various tactical planning needs. Notice how the four primary inputs of fuel model, fuel moisture, windspeed, and slope percent are tied to fire behavior outputs. Rate of spread, flame length, fireline intensity, and probability of ignition have been discussed in previous units. These four output values, plus the basic input values, are all used in the fire control planning process. Each of the segments of planning involves

consideration of each of the fire behavior input and output values. This planning, and subsequent field operations, will determine success in meeting fire management objectives.

The first planning segment we will discuss, starting on page 5, is the location of control lines. First of all, we should clarify some commonly used terminology. Although firelines and control lines are frequently used interchangeably, they have a slightly different meaning. Fireline is defined as the part of a control line that is scraped or dug to mineral soil. Firelines are constructed by hand tools or mechanical means. Control lines usually include firelines but also can consist of artificial and natural barriers, retardant lines, and noncombustible fuels.

Several considerations are given to the locations of control lines. These are the accessibility and safety for control forces; resource values at risk from the fire and from control actions; the general shape of terrain and available barriers; current weather and weather forecasts; fuel characteristics over time and space; and direct and indirect attack methods used. All of these affect tactical decisions on fire control line locations. You will want to come back to these later.

Figure 2 illustrates the basic tactics of flanking a fire burning on a slope or driven by wind. Firelines, starting from the rear of the fire, are located and constructed along either flank as close to the fire as possible. As fireline construction progresses, the line is burned out or the main fire is allowed to burn clean to the constructed line. Eventually, line construction will catch up with the head and pinch it off at an advantageous time. It's essential to have firelines anchored to a safety zone, or to create safety zones as work progresses along the flanks.

Please turn to page 6. Flanking fires, especially those that are spreading rapidly in one direction, is common practice for several very good reasons. In item B please list the following: The rate of spread on flanks is less, forces can work closer due to less heat, it's easier to anchor lines and plan escape routes, narrower firelines are required to stop spread, and flanks may be the only safe areas to work direct attack. Come back and study these reasons later, as you will be required to know them.

Now do question 1; mark your choice or choices.

In question 1, you should have marked all the choices. Generally speaking, these are all acceptable and recommended fireline practices for most areas. Number 4 states, "Keep one foot in the burn in light fuels." This is an expression sometimes used by firefighters meaning burn out light fuels as you construct fireline, since the burned out area can provide a safety zone if needed.

Figure 3 illustrates locating firelines where fuels are lightest. This is good practice where heavy fuels make line construction difficult; the fire intensity is too great for working the fire perimeter; some acreage can be sacrificed to expedite line construction; and control lines can be made safer. Generally, these tactics reduce the amount of effort required to construct fireline, although this particular situation would require a longer fireline.

Common and naturally advantageous locations for firelines are ridgetops. See page 7. Some reasons why ridgetops are often selected to locate and construct firelines are that access and

mobility are usually better for both ground and air attack; a pause in fire spread usually will result from converging daytime slope winds; the hazard from rolling embers and rocks is less; fuels availability often changes with terrain changes; and ridgetop winds can be more favorable for burning out or backfiring. Generally, we can say that ridgetops present less severe fire behavior problems, and they are safer for control forces.

Figure 4 illustrates a control line placed a short distance down the back side of a ridge. This, too, is common practice. Why is it better than placing the line on the highest point of a ridge?

Now do question 2; mark your choice or choices.

In question 2, you should have marked all four choices. These are all worthy considerations when locating ridgetop firelines.

On page 8, we will examine constructing firelines in canyons. Here we have some different conditions that must be considered. For example, under item C, please note the following considerations when building control lines in deep, narrow canyons: Radiated heat can preheat and dry fuels, spotting can occur across a canyon, there are usually heavier concentrations of fuels present, access and escape routes usually are more difficult, visibility often is more limited by smoke and heavy fuels, and use of heavy equipment and air attack can be limited. These are important safety and tactical factors and you will be required to know them.

Figure 5 illustrates a fire burning on the lower slope of a canyon. Near the bottom, the slope is very steep and is a hazardous place to build fireline. The illustration suggests placing the line on the other side, but a short distance up from the bottom. This would certainly be safer and more secure from rolling firebrands, falling snags, and spotting and radiated heat across the canyon.

How about fireline around the rest of the fire? Well, flanking the fire seems reasonable if safety zones can be established. What about working the head? This can be extremely hazardous if the flanks are not yet secure, and safety zones are not readily available.

Do question 3; mark your choice or choices.

In question 3, you should have marked all of the choices. The time of day or night can give you entirely different burning conditions. Safety is affected by the nature of the fuels, anchor points, and escape routes. If the fire is small and not very active, attacking the head may be the best plan.

Once we have decided where control lines should be established, we need to determine just how they will be built to effectively stop the fire. We call these determinations the standards for control line construction. On page 9, figure 6 illustrates chances for heat transfer across a control line. If we can anticipate how the heat transfer processes will threaten a control line, we can then establish standards to make the line more secure.

Let's review the problems related to heat transfer that affect the standards for control line construction. Under item D, list the following: Radiation across control line, spotting across line,

crowning originating from surface fire, rolling firebrands, and fire creeping through subsurface organic fuels. Fire can cross a fireline in all of these ways. You will be required to know these items.

In figure 7, on the next page, we have illustrated the "black line concept." Many firefighters contend that the only safe fireline is a black line. The concept requires, for safety and security, that we burn out fuels remaining between the constructed line and the main fire to insure that the fireline is not threatened by active fire. This should be normal procedure in line construction.

There will be times when burning out is not possible or practical. What should be done in these situations? We'll discuss these, but first please do question 4; mark your choice or choices.

In question 4, you should have marked choice 3. To clarify, we'll discuss each of the four choices. In the first situation, fire may not carry through the fuels now, but could they burn later? Many firelines have been lost when fuels started burning inside and spotted across an unattended line.

The second choice can threaten firelines should a reburn occur later in the aerial fuels. Depending on the fuels situation, surface fires can dry out aerial fuels, and if weather conditions become severe enough, a crown fire might travel through the same area.

Number 3 is generally accepted as a safe practice when the fire perimeter is nearly cold. By carefully feeling out the hot spots on the perimeter, fireline need not be constructed where the fire is dead out.

In number 4, if firing out firelines is too hot and dangerous for firefighters, this obviously will not be a safe and secure fireline until some further action is taken. Two solutions to this situation might be to wait for more favorable conditions under which to burn, or to back away and place the control line in a more favorable location.

If you cannot get fuels to burn out, the usual practice is to cold trail inside the fireline, or to move the fireline to the fire perimeter. Remember, any fire burning inside a fireline remains a potential threat to that line.

On page 11, figure 8 illustrates handline constructed in brush. Here we are concerned about how wide the fireline needs to be. If fuel concentrations are reduced near the line, the actual fireline to mineral soil can be relatively narrow, 1- to 3-feet wide. Reducing the amount of fuels near the line, thus reducing fire intensity, is a reasonable practice and is generally preferred to wide firelines cut to mineral soil. Line construction is generally easier, and less environmental damage is done to the site.

Here is a rule of thumb that can be used as a guide. In low fuel types, the vegetation should be cleared to one and one-half times the height of the fuels, and a trench cut to mineral soil, usually much less in width. This should suffice on the flanks of a fire, and possibly even the head, depending on wind and other factors.

Now do question 5; mark your choice or choices.

In question 5, you should have marked choice number 3. In number 1, not always; it might be much more efficient to move the fireline back into lighter fuels and straighten the line. In number 2, wider than necessary firelines cost time and expense and can result in more damage to the environment. In number 4, fuels need not be burned out if the fire perimeter is cold trailed. Number 3, then, seems to be a reasonable practice and presents a challenge to firemen to determine how wide a line is really needed.

Now let's consider some more fireline situations. In figure 9 on page 12, we see a handline constructed through timber. The actual fireline to mineral soil can be relatively narrow if the adjacent areas are brushed out, trees limbed up, and surface fuels reduced. On the left, or inside the fireline, we scatter and reduce fuels for a reasonable distance to control fire intensity as it burns near the fireline or is burned out from the line. This can be done by removing unburned fuels from the inside and disposing of them outside the fireline. Note that it's advisable to leave enough light fuels inside the fireline to get a clean burn. The object is to keep burnout fire intensity low and to reduce the threat to a narrow fireline.

In figure 10, we are dealing with a different threat to a fireline, that of rolling firebrands from slopes above, but inside the line. The steeper the slope, the greater the problem. Burning cones and chunks of logs easily respond to gravity and can scatter fire for considerable distance downslope. The yucca plant in the Southwest, which is round and burns off at the roots, has been known to scatter fire up to 1/4-mile downslope from the fire. So you see it's possible for the rear or flank of a fire on a slope to present greater control problems than the head.

What can we do about the problem of rolling firebrands? Well, firefighters have found that cup trenches are generally effective. The steeper the slope, the deeper the cup trench, it's still advisable to patrol these areas frequently, as some firebrands may evade capture.

We have discussed a number of threats or hazards to firelines which require precautionary measures to insure their security. Exercise 1 on page 13 also deals with fireline hazards. You should be able to recognize the impacts of fire behavior on line construction. Please read the instructions; then do this exercise. When you have finished, return to the text.

You should have checked your answers for exercise 1 with those on page 26.

On page 14, exercise 2 relates to both fireline location and standards. This should provide a good review of materials presented up to this time. Please read the instructions and do the exercise.

The next portion of this unit will concentrate on planning attack on wildfires. Fire attack methods generally fall into one of two broad categories. See item E on page 16 and note the following: First is direct attack. This is a method of suppression in which the fire perimeter or burning edge is treated by wetting, cooling, smothering, or chemically quenching the fire, or by mechanically separating the fire from unburned fuel. Direct attack if possible, most often is the best policy, as fewer acres may be burned and less fireline needs to be constructed.

The second is indirect attack. This is a method of suppression in which the control line is located away from the fire's edge, perhaps a considerable distance, to take advantage of natural firebreaks or favorable breaks in fuels and topography, and the intervening fuel is burned out or backfired.

We're going to consider various attack methods that fall into one or the other category. First let's look at an indirect attack method that is well known, but seldom used. This is the backfire. Figure 11 illustrates backfiring from a ridgetop, which is one of the better locations to place a control line. Backfires are used to slow the advance of a hot running head of a fire and to reduce the heat energy at the control lines. Remember that this attack is always indirect; control lines are selected on the firefighters' terms; timing and experience are very important when starting the draft fire; and the strategic decision to backfire is usually made at the command level.

When direct attack on the head of the fire is not feasible, backfiring might be a consideration. Backfiring can be dangerous and is sometimes done in desperation; however, it is a viable suppression tactic that is sometimes necessary to stop a fire. Planning and carrying out a backfire require the best fire weather and fire behavior inputs you can acquire.

On page 17, exercise 3 deals with more fire attack methods used by firefighters. Read the instructions; then do the exercise.

Now we'll move on to more aspects of planning attack and control of wildfires. On page 18, we have outlined four primary considerations essential to the planning process:

1. Where will the fire perimeter or projected perimeter be, by time periods. This can be estimated by determining probable rates of spread at various points and by anticipating fire spread due to spotting and crowning.
2. What will be the degree of fire activity by time of day. Fire activity will change due to diurnal weather changes and fuel moisture changes. Certain times of day or night will be better than other times for various fire control activities.
3. Identify the hazards to, and limitations of, control forces. This can vary by time of the day or night, but we are concerned with hazardous fuels and terrains, extreme or unusual fire behavior, and with fireline intensity or flame length.
4. Assess and consider other environmental and management factors that may be unique to the fire area. These include agency and local fire control policies and resource management objectives.

We must try to relate each of these four primary considerations to the various planning activities.

One step in the planning process that we have not discussed is the evaluation of factors affecting fire control. This is the evaluation of all existing factors pertinent to probable future behavior of an ongoing fire, and of the potential ability of available forces to carry out control operations on

a given time schedule. Note that the two primary considerations are probable fire behavior and ability of available forces to accomplish the job.

Fire planners have another term which they use in the planning of control. It is resistance to control. This refers to the relative difficulty of constructing and holding a control line, as affected by physical problems related to line construction and fire behavior. In resistance to control, the two primary considerations are fire behavior and the terrain and/or fuels which can make line construction difficult.

The next step in planning control is to determine line construction rates. These rates will depend on resistance to control and the type of forces available.

An important consideration can be the accomplishment of control actions on a given time schedule. This often requires that priorities of attack are set, and timing is right, to accomplish the various fireline activities.

Fire behavior predictions play an important part in the setting of priorities and in timing of fireline activities. Priorities must be given to fireline location, attack methods, and the distribution of forces. Timing can be important to determining control line standards, burning out and backfiring activities, and certain potentially hazardous situations. For example, certain times of day and the accompanying weather conditions might make one portion of the fire perimeter very hazardous, but several hours later it may be safe for personnel to work.

Timing affects other fireline activities. See item G on page 19. Proper timing, weather, and fuel moisture conditions are important to having a successful burning out or backfiring operation. For either, we must have the following: Adequate fuel loadings, suitable fuel moistures, favorable winds and slope, and tolerable flame lengths. These are all very important factors and you will be required to know these.

Now do question 6; mark your choice or choices.

In question 6, you should not have marked any of the choices. All five planning activities definitely do require fire behavior assessments.

Next, we want to cover in more detail how fire behavior outputs are used in fire control planning. Two of the outputs are fireline intensity and flame length. Flame length is directly related to fireline intensity and is a more observable aspect of fire behavior. We noted earlier that these outputs are very important to determining standards for line construction and the success of various control forces. In figure 12 on page 20, we have prepared a chart that can be used as a guide when planning attack methods on a fire. Four ranges of fireline intensity and average flame lengths are given in the left hand columns. Fire suppression interpretations of these ranges are given as guides for fire planning purposes. For example, a flame length of 4 feet produces approximately 100 BTUs per second per foot of fire front. Up to these intensities, fires can generally be attacked at the head or flanks by persons using hand tools.

Read through the rest of the chart and note how fire control forces may be limited by various fireline intensities. When you finish, return to the text.

Now, move on to exercise 4, page 21, on initial attack planning. Here you are given a fire situation and are asked to assess potential fire behavior and to plan how you would use the available control forces. When you have finished, return to the text.

On page 23, figure 13, we would like to introduce you to the fire activity planning chart. This chart might be prepared by a Fire Behavior Officer from fire weather forecasts and site data he has collected. The application of this chart should become evident as we discuss it.

On the bottom portion, fine dead fuel moisture has been plotted by a dashed line, using predicted temperatures and relative humidity data for each hour during a 24-hour period. Forecasted wind speeds for the same times are also plotted on the bottom portion by a solid line. Note that the moisture of extinction has been specified at 15 percent fuel moisture content for fuel model 2.

In the top portion, three outputs have been plotted by time--flame length, rate of spread, and probability of ignition, all of which were calculated from wind speed, fuel moisture content, temperature, slope, and fuel model. You will see some interesting and significant relationships between the inputs in the bottom portion and the outputs on the top.

Rate of spread, which is the upper solid line, is very much influenced by wind speed, which is the lower dashed line. The minimum rate of spread is predicted to occur about 0600 hours and is 0 chains per hour. The maximum rate of spread is predicted to occur about 1700 hours, and is 57 chains per hour.

The dot-dashed line above represents flame length. It, too, is influenced by windspeed, but fuel moisture content has a very strong effect on flame length. Note the opposite curves of flame length on top and fuel moisture content below. The minimum flame length will occur about 0600 hours at 0 feet, and the maximum at 1700 hours at 9 feet. The points at which manual and mechanical forces are limited are also noted on the chart. Calculations for both flame length and rate of spread indicate 0 values at 0600. Does this mean that the fire will go out? Well, obviously not, but the fire will stop spreading and for the most part burn only in the larger fuels that have lower fuel moistures at this time of morning.

The third output value, probability of ignition, is noted for certain hours only but can be estimated for any hour of the day. Note that the highest probability of ignition is 100 at 1700 hours. Probability of ignition figures can be used to help predict spotting.

This chart can be valuable when a fire lasts several days, and especially when the weather pattern is persistent. It can be used to plan burnout operations and to position various control forces. Take a few moments to study the chart in more detail; then move on to exercise S on page 24. In this exercise, you will be interpreting information from the fire activity planning chart. This is a very important exercise, as it demonstrates_ the uses of various fire behavior input and output values that have been described in earlier units.

When you have finished this exercise, check your answers; then review the entire unit and prepare yourself for the unit test.