SECTION 3 - USE OF FIRE IN CONTROL OPERATIONS

This section is about the use of fire as an effective management tool to control wildland fires. Pay close attention to the emphasis on using anchor points, safety zones and escape routes during firing operations.

BURNING OUT AND BACKFIRING

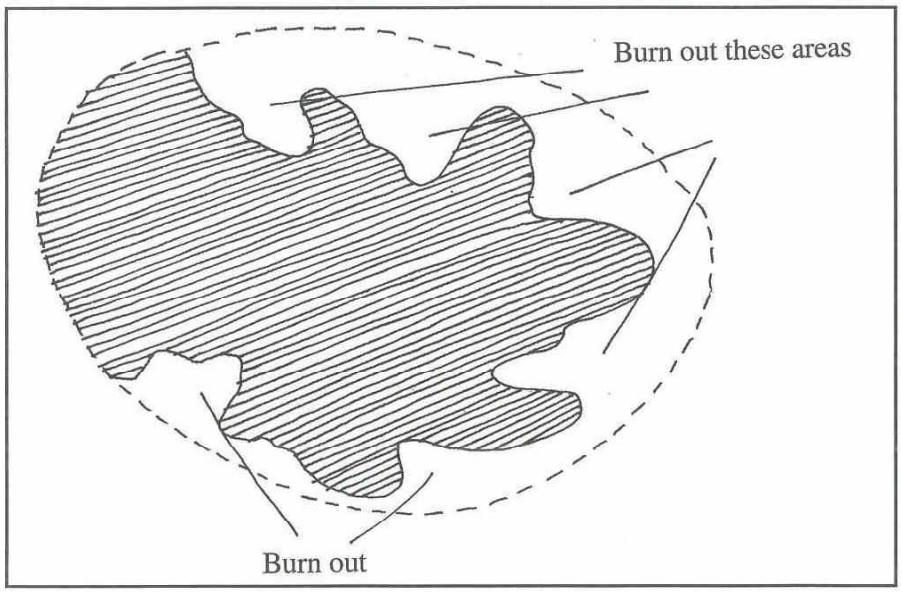
There are two general methods of using fire to fight fire. These are burning out and backfiring.

Burning Out

Burning out is used with direct and parallel attack. In direct attack a fireline is built close to the edge of a fire. Burning out is setting fire inside the fireline to consume fuel between the fireline and the edge of the fire.

Parallel attack is generally defined as a method of suppression in which fireline is constructed approximately parallel to, and just far enough from, the fire edge to enable workers and equipment to safely operate. Parallel attack can shorten the fireline by cutting across unburned fingers. The intervening strip of unburned fuel is normally burned out as the fireline proceeds, (see Figure 1) but may be allowed to bum out unassisted where this occurs without undue delay or threat to the line.

Figure 1 – Burning Out



The primary objectives of burning out are:

- Removing of unburned fuels adjacent to the line.

- Reducing mopup time.

- Incorporating unburned fingers and spot fires into the control area during fireline construction.

- Hastening construction of safe, effective fireline. A "black line" is created and firefighters can keep one foot in the black (firefighters have an escape route back into the area where fuels have been consumed).

It is generally accepted that line personnel from crew boss on up have the authority to initiate a burnout operation as long as the direct or parallel attack mode is being used. Supervisory personnel must identify to subordinates the line of responsibility and authority prior to initiating the burn out. Supervisory personnel must coordinate all burning out operations with crew members and adjoining forces.

Backfiring

Backfiring is an indirect method of attack, (see Figure 2). It is the act of setting fire along the inner edge of a fireline to:

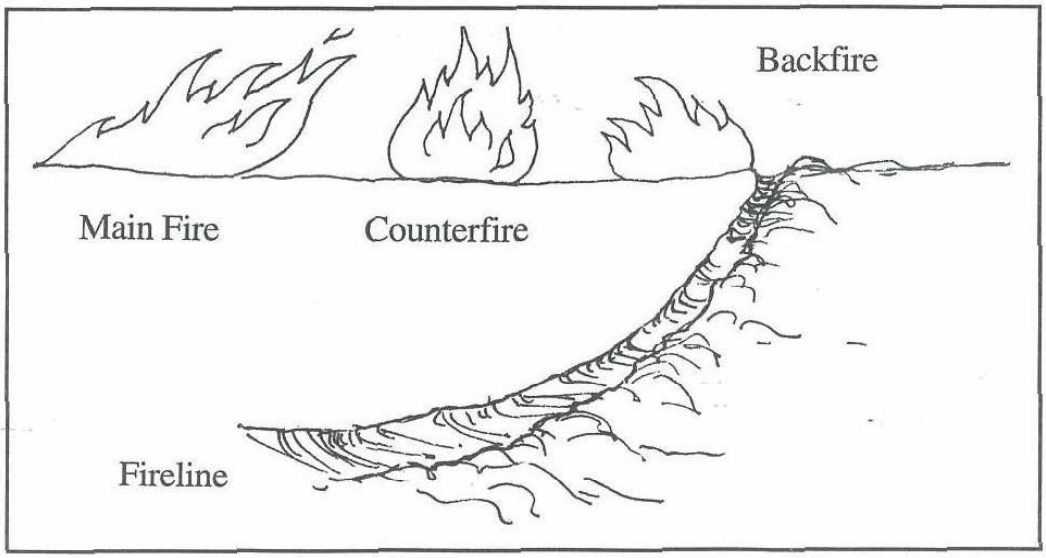
- Consume the fuel in the path of a wildland fire.

- Change the direction or force of the fire's convection column.

- Slow or change the fire's rate of spread.

Counterfires are sometimes used in conjunction with backfiring. Counterfires are set between the main fire and the backfire to hasten the spread of the backfire when large areas of unburned fuel are involved.

Page 106 Figure 2 – Backfiring



The primary objective of backfiring is:

- To eliminate fuel in advance of the fire, thus widening the fireline.

- To change the direction of the fire.

- To slow the fire's progress, allowing more time for suppression actions.

- To stop or reduce the fire's intensity and allow direct attack on the head of the fire.

The decision for backfiring is usually made by the operations section chief, based on the recommendations of other applicable personnel. It is then approved by the incident commander and put into effect at the division level.

Backfiring is an effective tactic against wildland fire, but because of the complexity, it generally requires more planning and coordination than burning out. The following items need to be evaluated before conducting a backfire operation:

- Current and expected fire behavior

- Timing

- Location of control lines

- Anchor points

- Safety zones or escape routes

- Control line preparation

- Equipment for firing and holding

- Firing methods and techniques

- Organization

- Coordination

- Communications

Remember, the distance from the fireline to the main fire is not the determining factor of whether to call it a burnout or backfire operation. The difference is the intent and the complexity of the burning operation. With burnout operations, the planning process is usually fairly rapid with immediate implementation. The complexity of backfire operations requires more thorough planning and implementation. It often is delayed until conditions warrant.

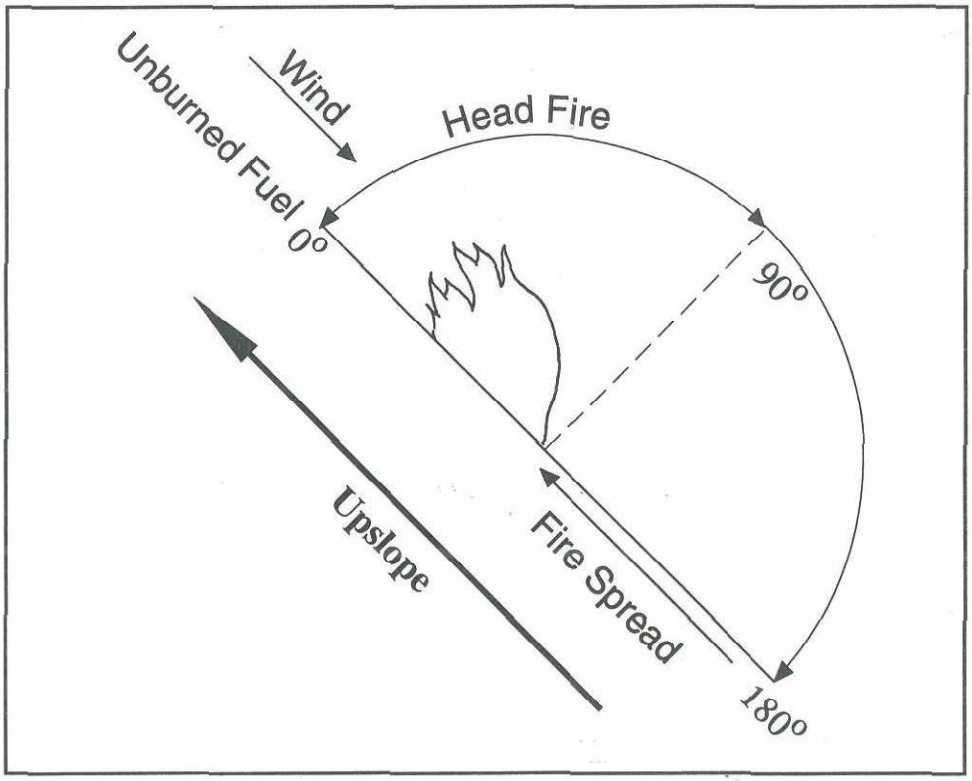
TYPES OF FIRE SPREAD

A key element one must consider prior to conducting a firing operation is the type of fire spread that needs to be created or sustained to safely accomplish the assignment. There are three types of fire spread: head fire, backing fire and flank fire. These terms describe the behavior and spread of wildland fire, as well as the type of fire spread necessary to complete a burnout and/or backfire.

Head Fire

A head fire is generally a fire front spreading with the wind. However, a fire front spreading uphill against the wind could also be termed a head fire if the angle of the flames, with respect to the unburned fuels, is less than 90 degrees (see Figure 3). Head fire spread may develop rapid and intense runs, strong convection columns, and consume large amounts of fuel in a short period of time. **Do not confuse head fire with head firing** (see Figure 13).

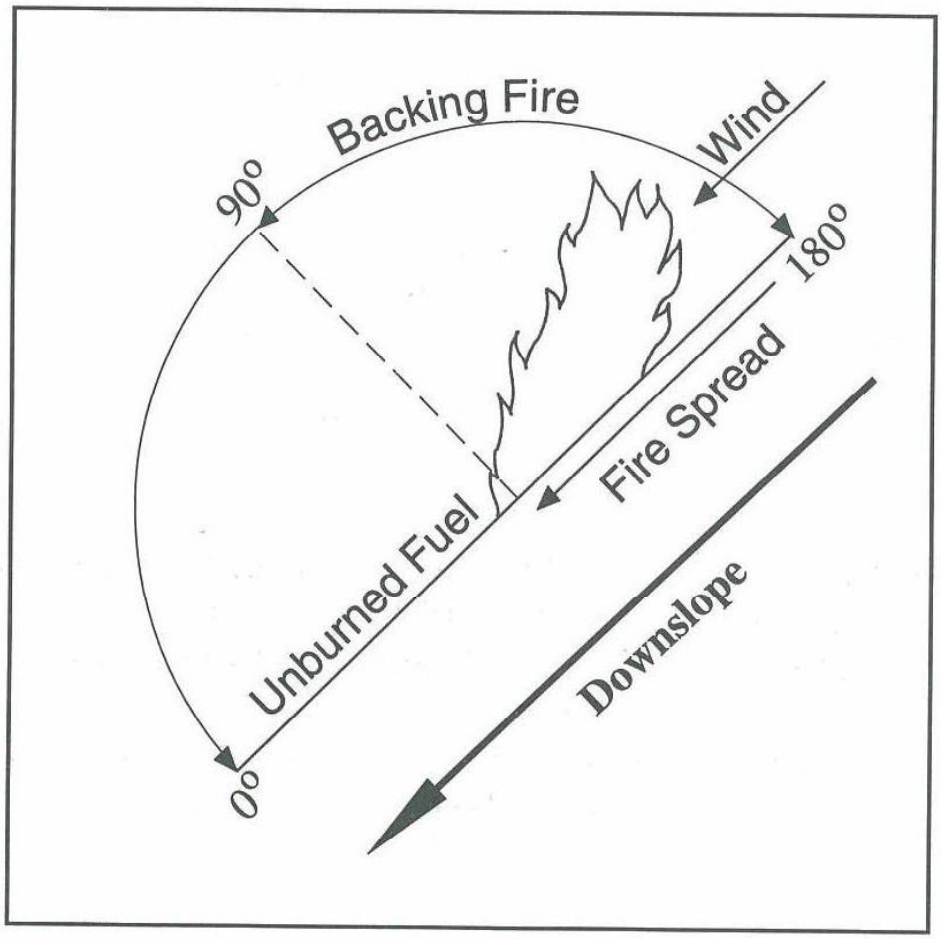
Figure 3 – Head Fire.



Backing Fire

A backing fire is generally a fire front spreading against the wind. However, a fire front spreading downhill with the wind would also be termed a backing fire if the angle of the flames, with respect to the unburned fuels, is more than 90 degrees (see Figure 4).

Figure 4 – Backing Fire



A fire spreading on level or downward sloping ground with no wind is also a backing fire. This type of fire spread involves backing fire downhill (see Figure 5) or into the wind (see Figure 6). Fire is started along a natural or constructed barrier such as a road or fireline and is allowed to back into the wind or down a slope. Using this type of fire spread results in a low intensity fire and minimum scorch height, and provides maximum safety for fire personnel. A disadvantage is that it is time consuming. **Do not confuse this type of fire spread with back firing.**

Figure 5 – Backing Fire (Slope Condition).

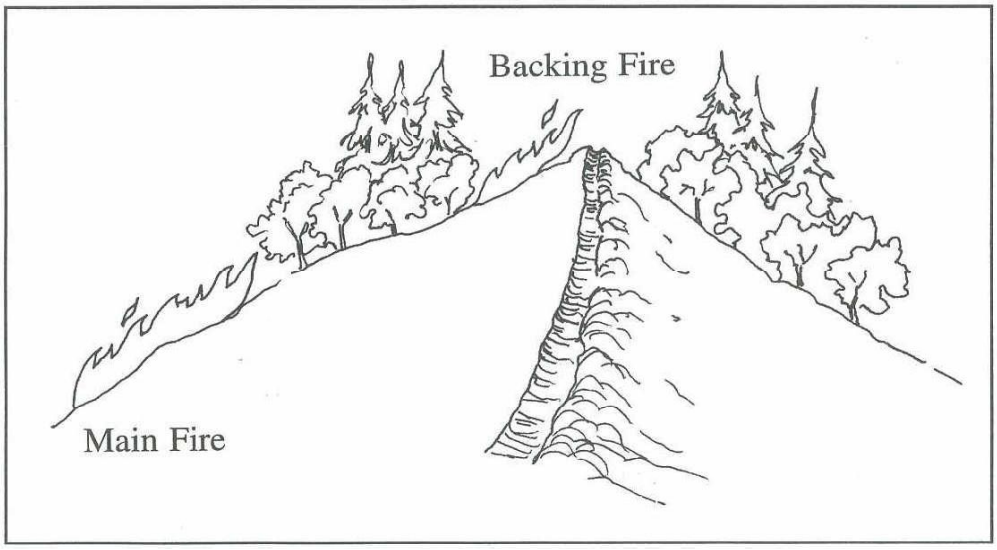
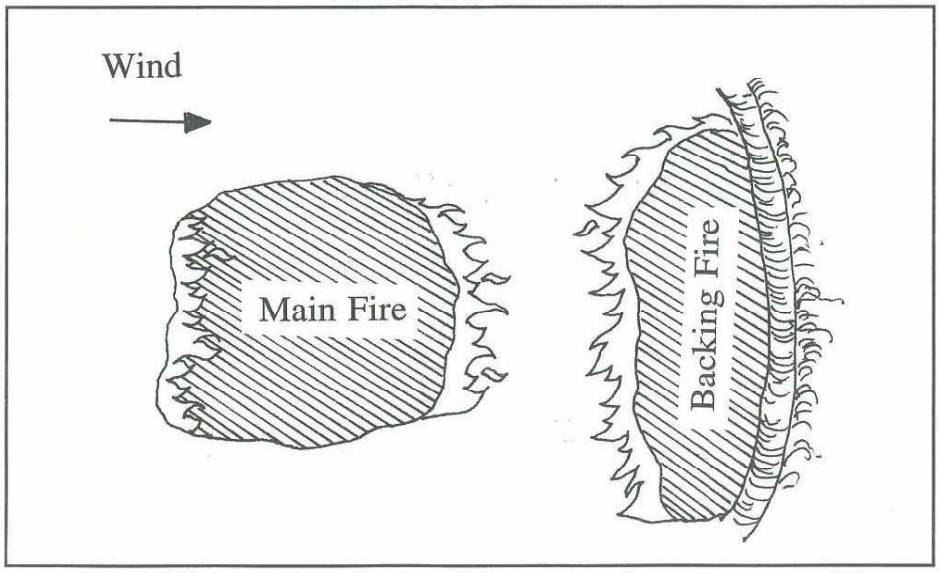


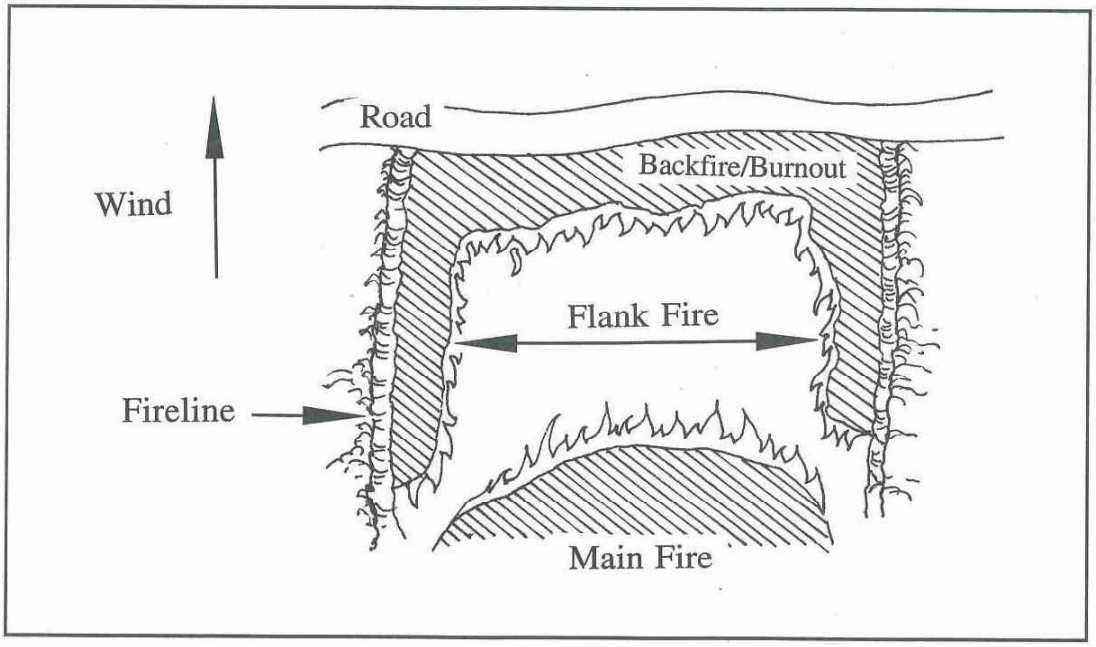
Figure 6 – Backing Fire (Wind Condition)



Flank Fire

A flank fire is a fire spreading perpendicular to the direction of the wind. However, a flanking fire is generally associated with a firing operation (burnout and/or backfire). Fire is set along a control line parallel to the wind and allowed to spread at right angles, toward the main fire. A principle use of flanking fire is to secure the flanks of a head fire or backing fire as they progress. Utilizing this kind of fire spread allows for very little variation in wind direction and requires coordination and timing to get the ignited flanking fire to burn into the main fire (see Figure 7).

Figure 7 – Flank Fire



IGNITION TECHNIQUES

There are six ignition techniques and many variations commonly used in conjunction with the three fire spread types (head, backing, flank**).** The ignition techniques include strip firing, blowhole firing, spot firing, ring/perimeter firing, chevron firing, and burn strip. These ignition techniques are used in both burning out and backfiring. Remember, it is the method of attack (direct, parallel, indirect) and complexity that determines whether a firing operation is a burnout or backfire. The ignition technique and fire spread type used primarily control the rate of ignition, intensity, and spread direction of a firing operation. In most ignition techniques the fireline becomes the escape route for the firing personnel. **In all firing operations adequate anchor points, escape routes, and safety zones must be established and identified prior to beginning firing operations.**

Strip Firing

This is the most commonly used ignition technique. It involves setting fire to one or more strips of fuel and allowing the strips to burn together. Lighting numerous strips allows fast area ignition. By varying the width of the strips and their location in relation to the slope and/or wind direction a means of regulating the fire's intensity can be provided (see Figures 8-1 1).

Figure 8 – Strip Firing (Favorable Wind)

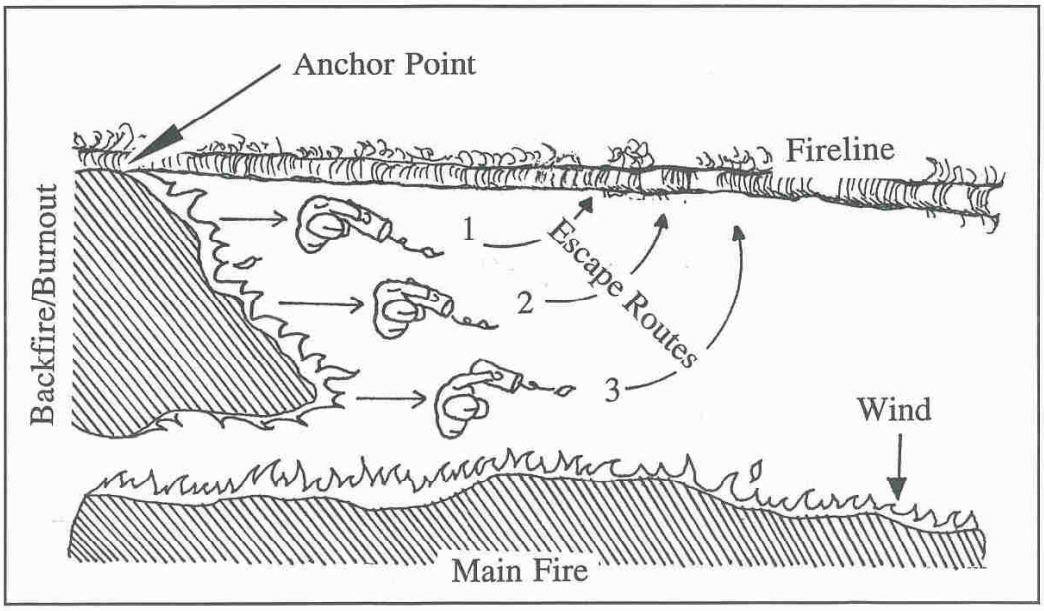


Figure 9 – Strip Firing (Favorable Slope)

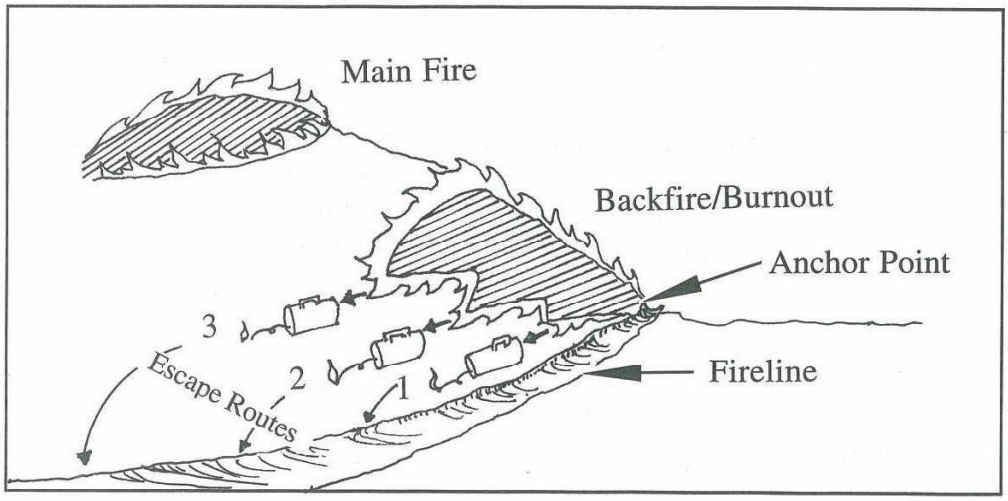


Figure 10 – S trip Firing (Adverse Wind)

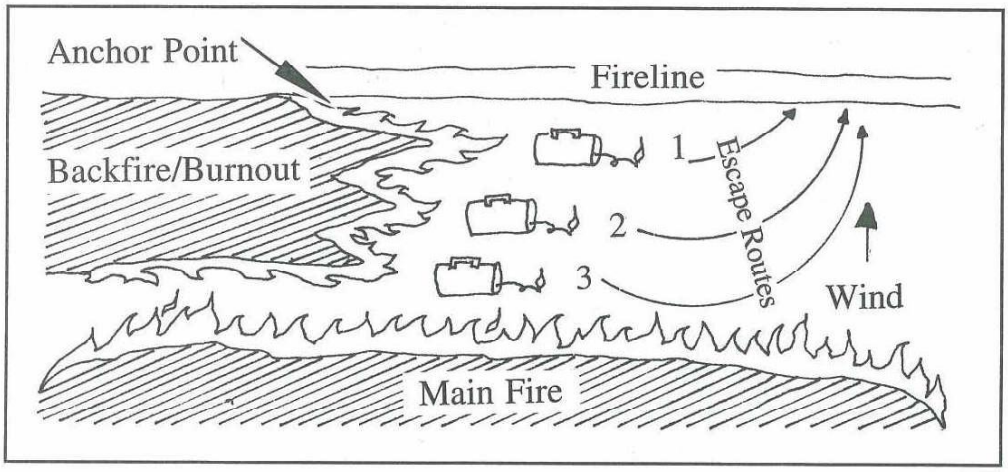
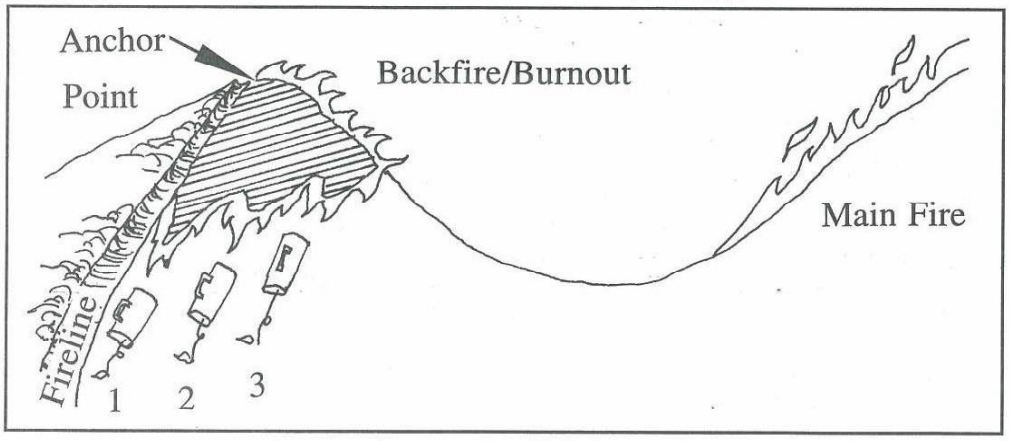
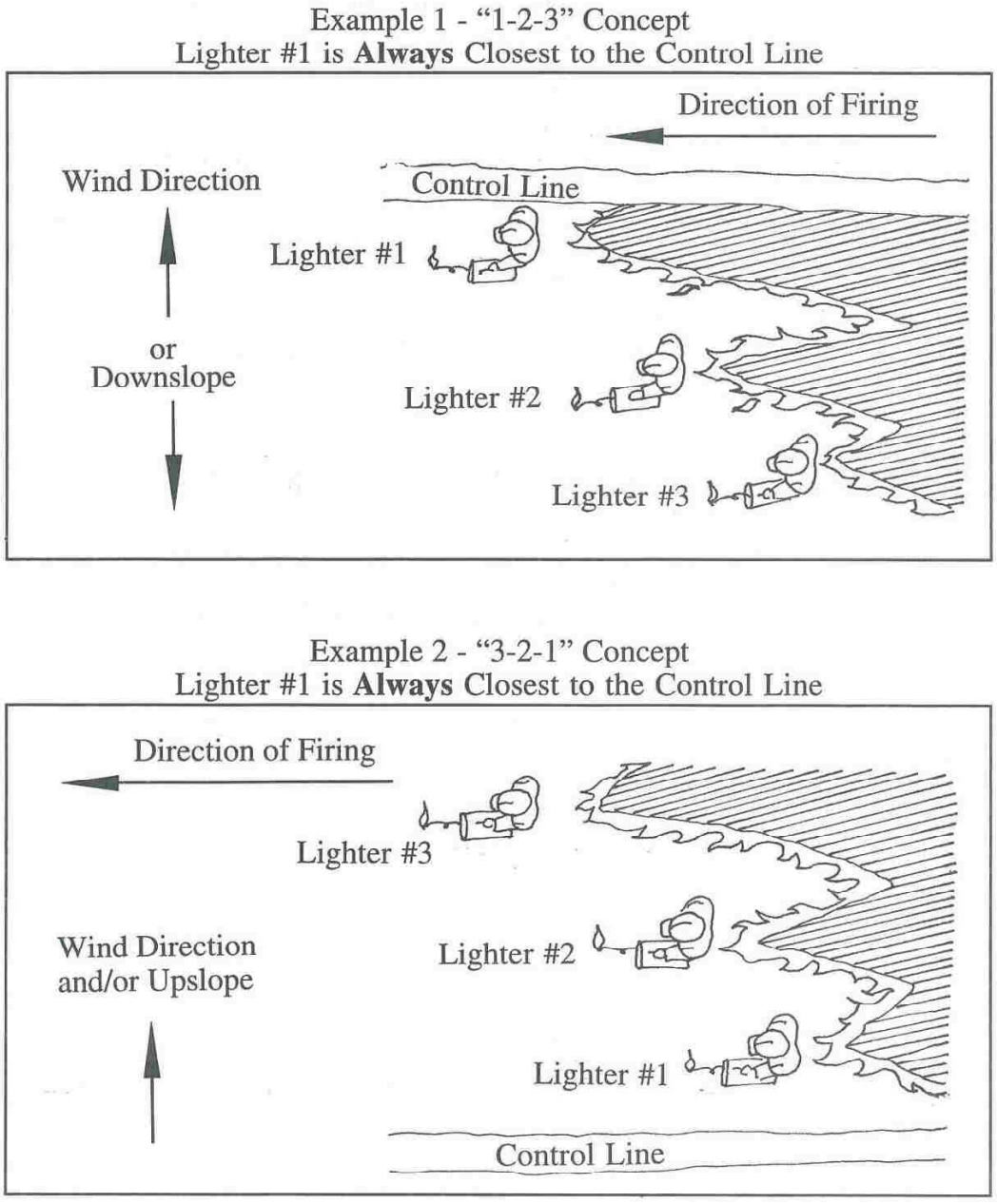


Figure 11 – Strip Firing (Adverse Slope)



A concept referred to as the "One, Two, Three - Three, Two, One" (1-2-3/3-2-1) is commonly used by crew firing organizations during strip firing operations (see Figure 12).

Figure 12 – "One, Two, Three - Three, Two, One" (1-2-313-2-1)



When a firing operation requires two or more lighting personnel, each lighter is assigned a number, i.e., lighter 1, lighter 2, lighter 3, etc. The lighter 1 position is always the closest to the control line. Depending on the wind and/or slope conditions, lighter 1 may not always be the lead lighter.

Example 1 of Figure 12 represents wind/slope conditions (normally considered adverse) that require lighter 1 to function as the lead lighter with lighters 2 and 3 following behind. This example is referred to as the "1-2-3" firing organization.

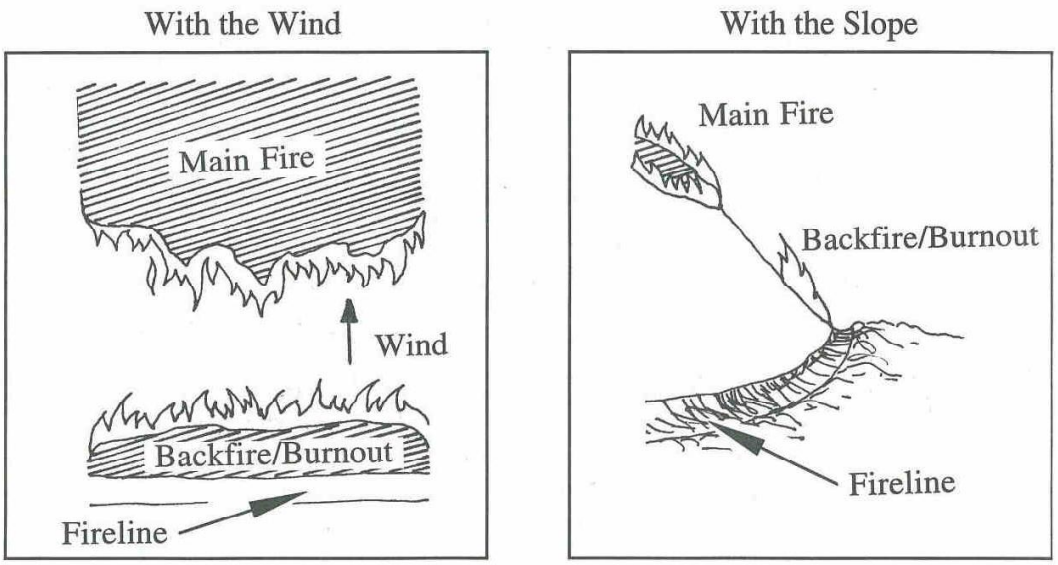
Example 2 of Figure 12 represents wind/slope conditions (normally considered favorable) that allow lighter 3 to function as the lead lighter with lighters 2 and 1 following behind. This is referred to as the "3-2-1" firing organization. The common element within the concept is lighter 1 is always the closest to the control line in both firing organizations.

In addition, firing team personnel can be given commands incorporating depth and width of strips when using two or more lighters during various firing operations. In a strip firing operation the entire command would be relayed to the firing team by the firing boss as in this example: "Your firing specifications are to 1-2-3 strip with 50-20 spacing." Translated: There are three lighters assigned, lighter 2's strip is 50 feet behind and 20 feet deeper into the unburned fuel from lighter 1. Lighter 3 is 50 feet behind and 20 feet deeper into the unburned fuel from lighter 2. If burning conditions allow, lighter 1 walks a position up to 20 feet inside the unburned fuel from the control line. If conditions do not allow for lighter 1 to take the entire first 20 feet, that lighter can vary the depth of the strip to regulate the required level of fire intensity in relation to control line specifications and the abilities of the holding resources. This concept adapts readily to most firing operations and is easily understood by crew personnel.

Head Firing or Strip Head Firing

Head firing or strip head firing involves setting fire and allowing the wind or slope to carry the head fire (see Figure 13). Head firing results in a high intensity fire, but consumption of fuels can be spotty because of rapid rate of spread.

Figure 13 – Head Firing



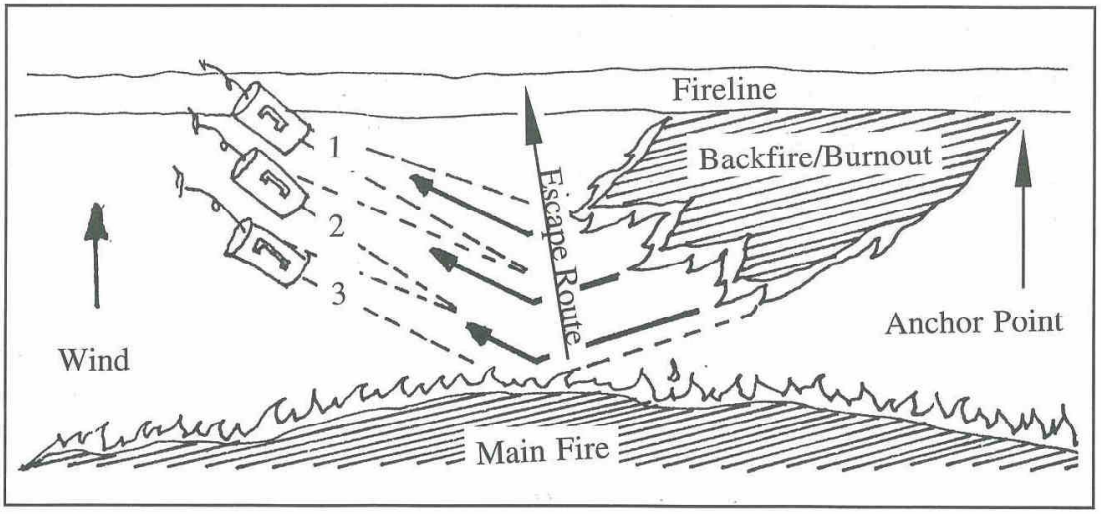
Blowhole Firing

The purpose of blowhole firing is to fire shorter sections at a time making the control line easier for crews to hold.

This ignition technique can be very dangerous for the lighting personnel. It should be used only by experienced firefighters with stringent and constant observation of lighters at all times.

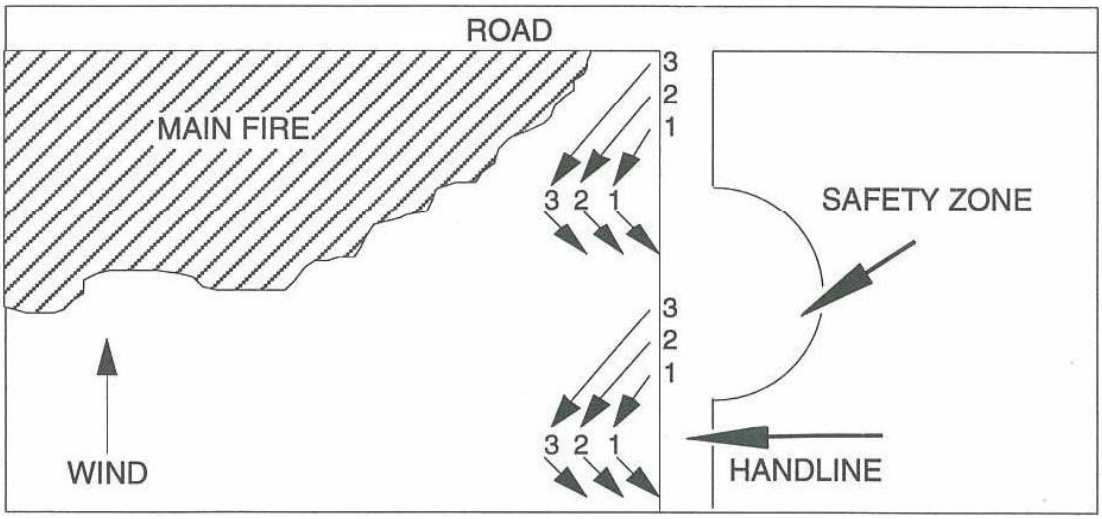
Blowhole firing, when used in advance of a fire, is normally conducted as an indirect attack and backfire operation (see Figure 14). Firing commences from the control line on a 45 degree angle towards the main fire to a point dictated by the current fire behavior and other conditions and then the strips are turned back to the control line. The depth of firing is determined by personnel safety, wind, slope and desired effect. This technique, when hand fired, should be practiced only where the firing area can be traversed fairly easily on foot.

Figure 14 – Blowhole Firing Backfiring Against the Wind (1-2-3 Organization)



It is more commonly used on the flanks as a form of strip firing when crews are making direct or parallel attack. When used on the flanks, strips are fired on a 45 degree angle downhill or into the wind. One or more strips are lit (either by aerial device or hand fired) on a 45 degree angle from the control line towards the main fire to a point (determined by the current conditions) and then back to the control line (see Figure 15).

Figure 15 – Blowhole Firing (Backfiring/Burning Out on Flanks**)**

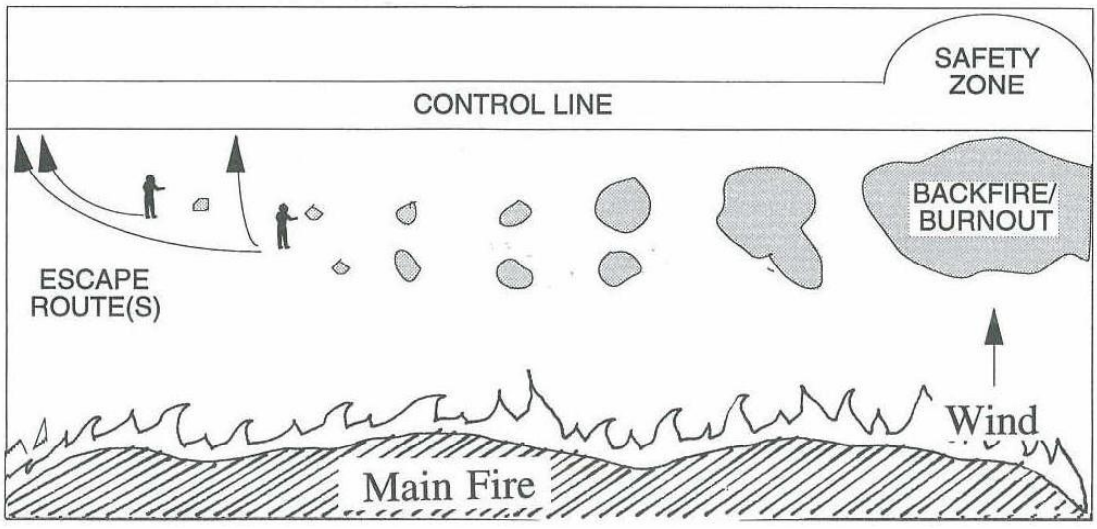


Spot Firing

This technique allows fast ignition and elimination of pockets of heavy fuel when fine fuel moistures are high.

This technique employs a series of small spot fires. These spot fires burn in all directions and come together, minimizing the possibility of any one spot gaining sufficient momentum to start a hot run. Timing and spacing of spot ignitions is the key to successful application of this technique (see Figure 16). Aerial mounted firing devices produce this type fire. Spot firing is commonly used in conjunction with strip firing. **Do not confuse this technique with spot fire.**

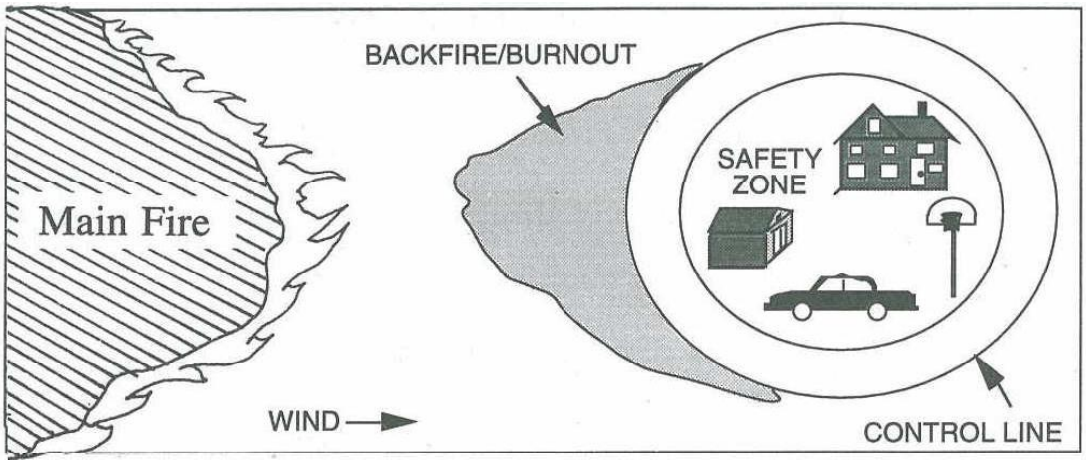
Figure 16 – Spot Firing



Ring Firing

This technique is generally used as an indirect attack and backfire operation. It involves circling the perimeter of an area with a control line and then firing the entire perimeter (see Figure 17). Ring firing is often used to bum out around structures, preserve historic or archeological sites, or protect endangered species. However, firing personnel may not have a strong anchor point to commence firing. Escape routes and safety zones must be established.

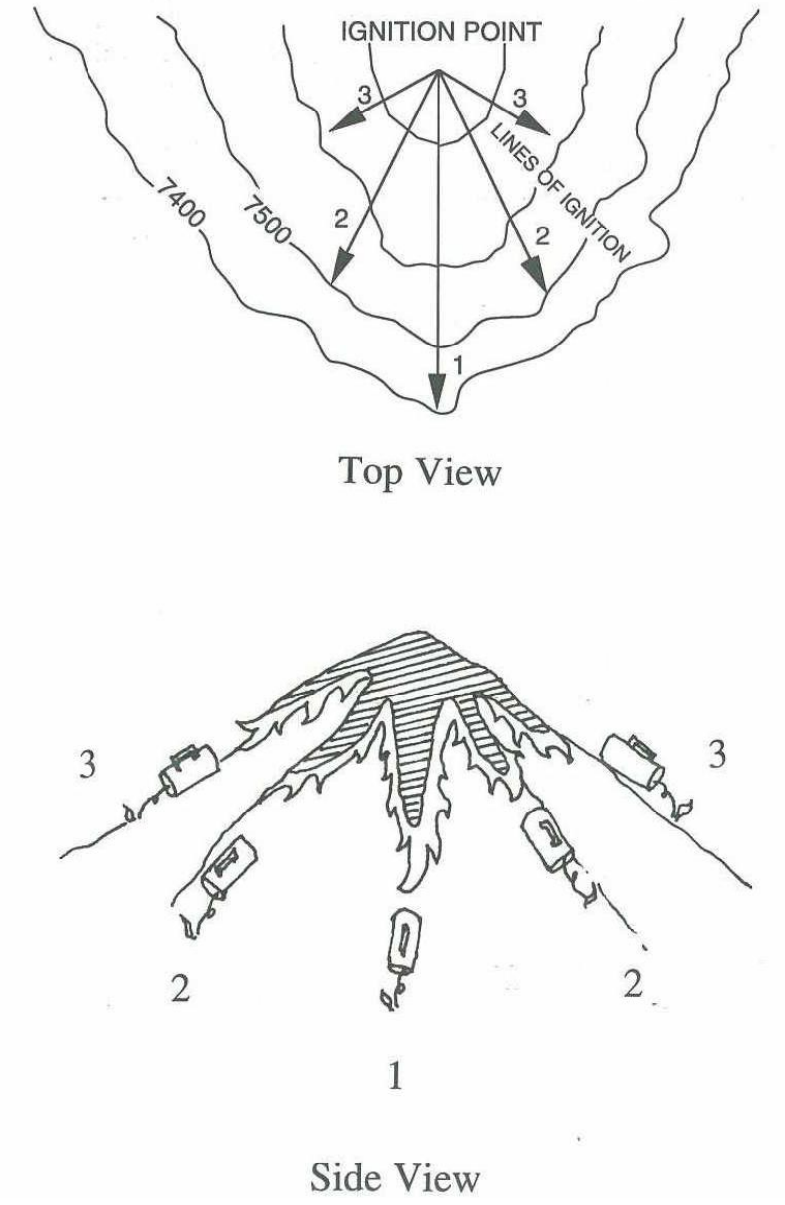
Figure 17 – Ring Firing



Chevron Firing

This technique is generally used during prescribed fire application. It establishes a line of fire in a V-shaped pattern to burn off ridge points or ends. The burn progression must be down hill. Chevron Firing should be used in combination with other firing techniques. When hand firing, this technique requires three or more lighters. The lead lighter is the center/point position and generally initiates the first strip from the top of the ridge working downhill. Lighters spaced at left and right positions are determined on personnel safety in relation to topography, fuels, and fire behavior conditions (see Figure 18). Using aerial ignition devices provides the greatest amount of personnel safety and expedites the overall operation.

Figure 18 – Chevron Firing



Burn Strip

Generally this technique is used more as a line construction method rather than an actual ignition technique. Two parallel control lines are constructed, i.e., dozer lines, dozer/highway combination, wet lines in light fuels, etc., and then the inner lying fuel is burned out. This concept is commonly used along existing roadways as a means of hazard reduction and presuppression effort (see Figures 19 & 20).

Figure 19 – Bum Strip (Backfiring in Front of Head Fire)
Burn at Anchor Points First

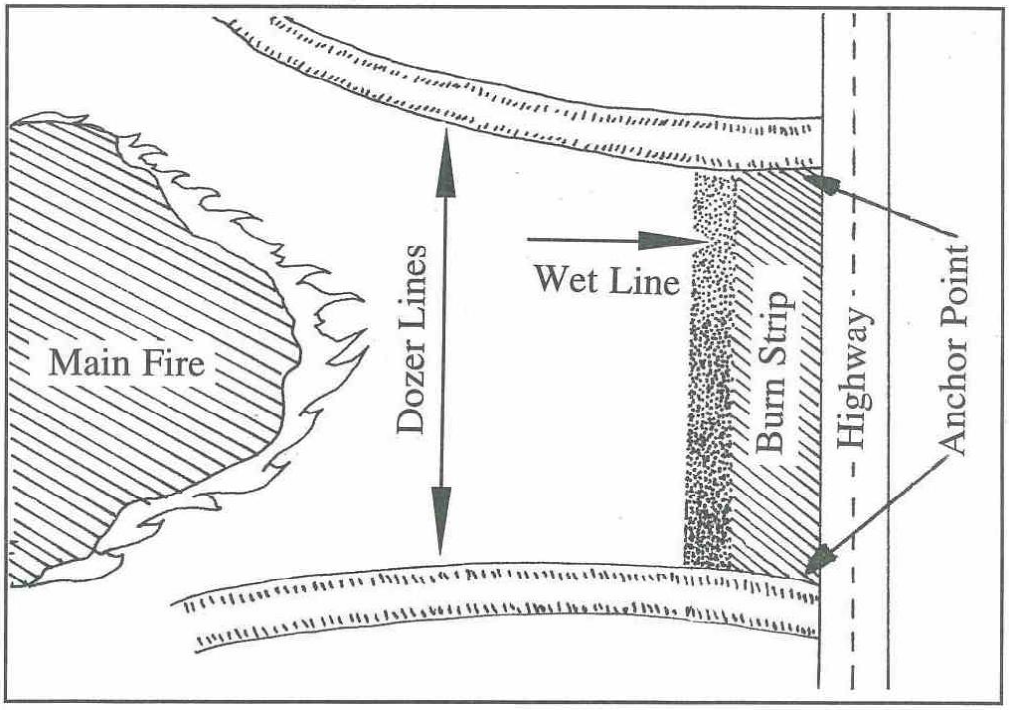
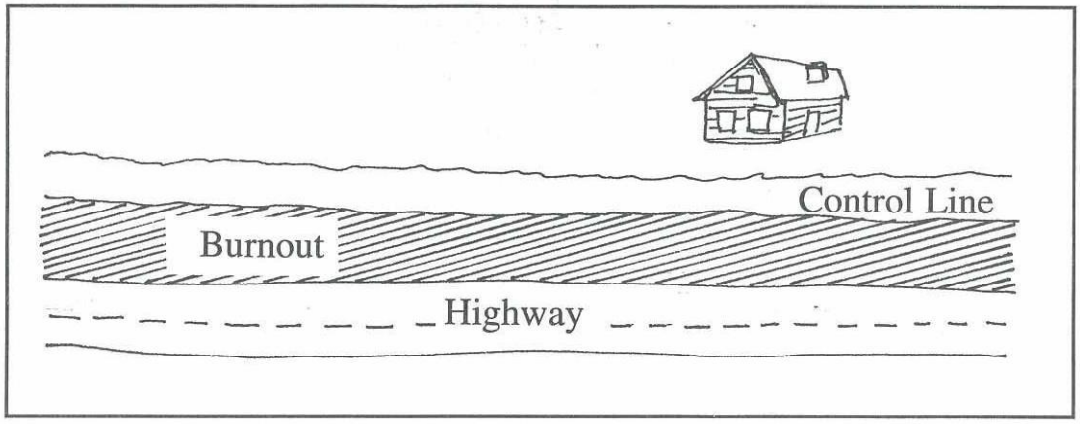


Figure 20 – Burn Strip
(Burning Out Between Two Parallel Control Lines as a Line
Construction Method or Hazard Reduction Along Roadways)



PLANNING AND CONDUCTING FIRING OPERATIONS

Before firing operations can begin, control lines must be located to safely meet control objectives. Firelines should be tied or anchored to safe points of control. Examples of anchor points are: high points, barriers (both natural and human made), recently burned areas, other fuel voids, or firelines in adjacent divisions.

Proper timing is essential in conducting a successful firing operation. There are several points to consider. Conditions must be good enough to permit a reasonably clean bum. Firing too early in the day or too late in the evening might result in unburned islands of fuels, potential for reburn, and mopup problems. If fire behavior conditions are too extreme, or there is not enough time, firing must be suspended until more favorable conditions exist. Finally, and perhaps most importantly, the main fire can approach and threaten the control line at different points and times; thus, firing must be done in a planned sequence, with those areas presenting the most serious threat to control being attended to first.

When organizing a firing operation, remember these basic principles:

- Don't jeopardize personnel or equipment.
- Keep firing crews as small as possible and only use trained personnel. It's important that only one individual be in charge of the entire operation.
- Know the chain-of-command and use it. Remember, personnel should be allocated for firing, holding and lookout duties.

Communications are a difficult but extremely important area to manage. Here are five essential considerations when dealing with communication:

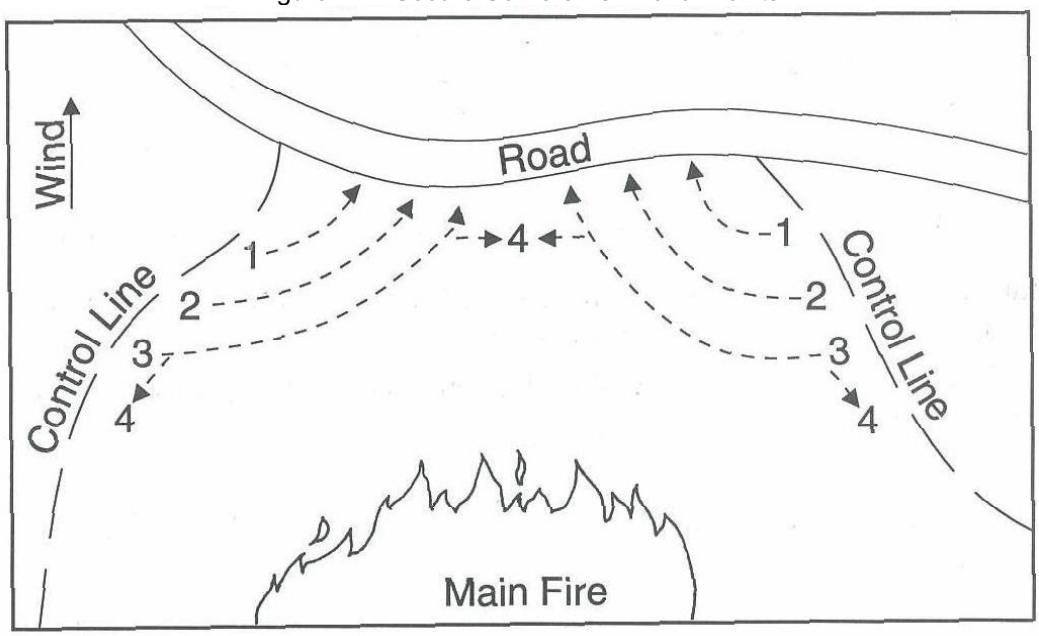
- Advise your supervisor of preparations, schedules, logistics and supply needs before firing.
- Establish radio communications with key personnel.
- Brief all involved personnel on the firing plan.
- Check for the latest weather forecast.
- Report progress and results of the operation to your supervisor. Keep people informed as the operation progresses.

Remember, the single most important factor during any tactical firing operation is personnel safety. Provide the necessary communications to safely perform the assignment and keep firing personnel and adjoining forces advised of conditions.

SPECIAL FIRING CONSIDERATIONS

When necessary secure the corners and control line as anchor points prior to igniting the firing operation. Figure 21 is an example of securing corners as anchor points.

Figure 21 – Secure Corners As Anchor Points

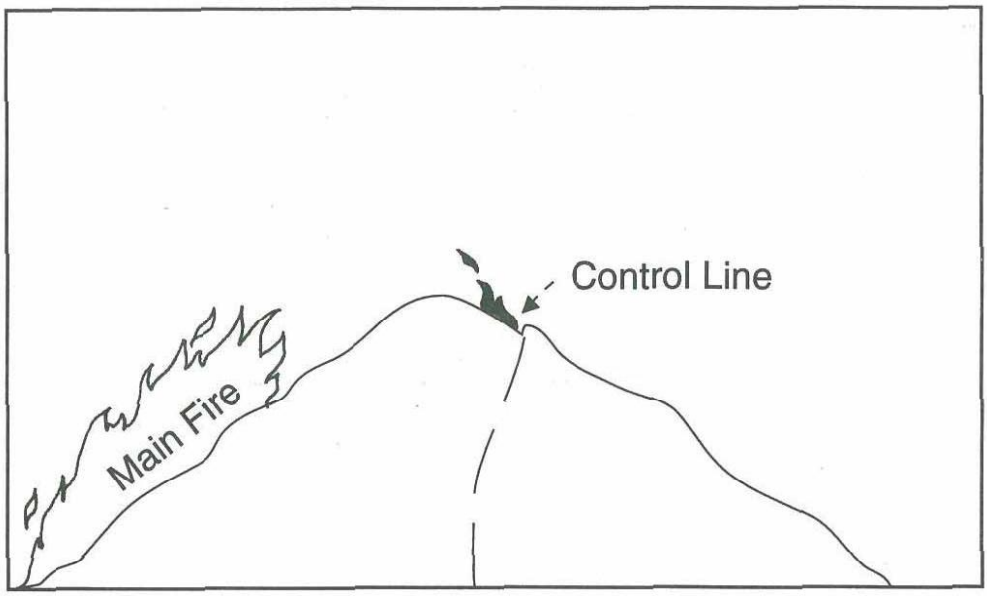


Begin firing from higher elevation and work downhill. This will prevent intense uphill runs. An exception is when strong, steady downhill winds are present.

To hold a line with a smaller defensive force, light the line to give a narrow flame front to the line.

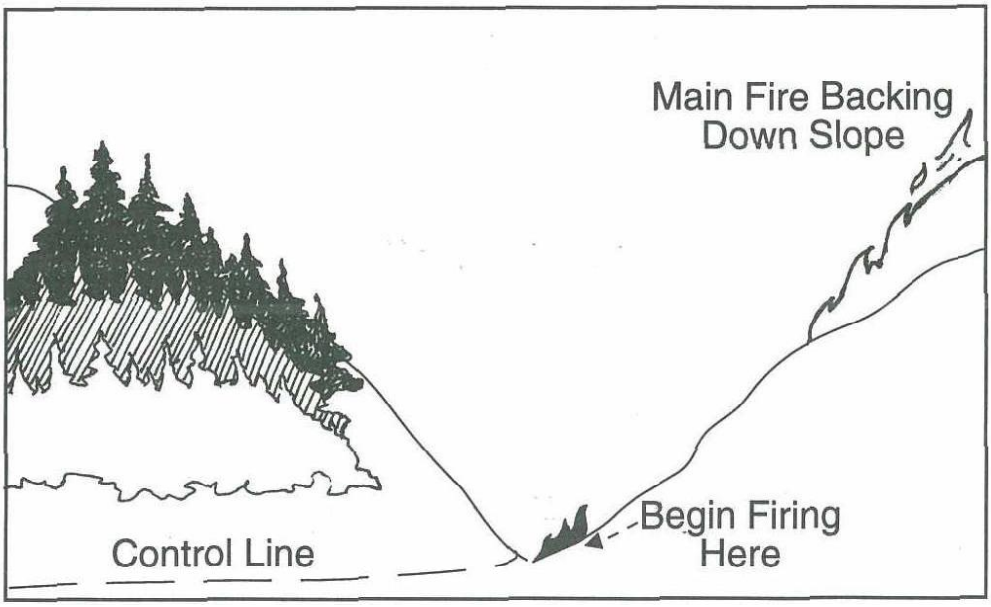
When firing from a ridgeline, start from the back side of the ridge, not on top (see Figure 22).

Figure 22 – Firing From A Ridgeline



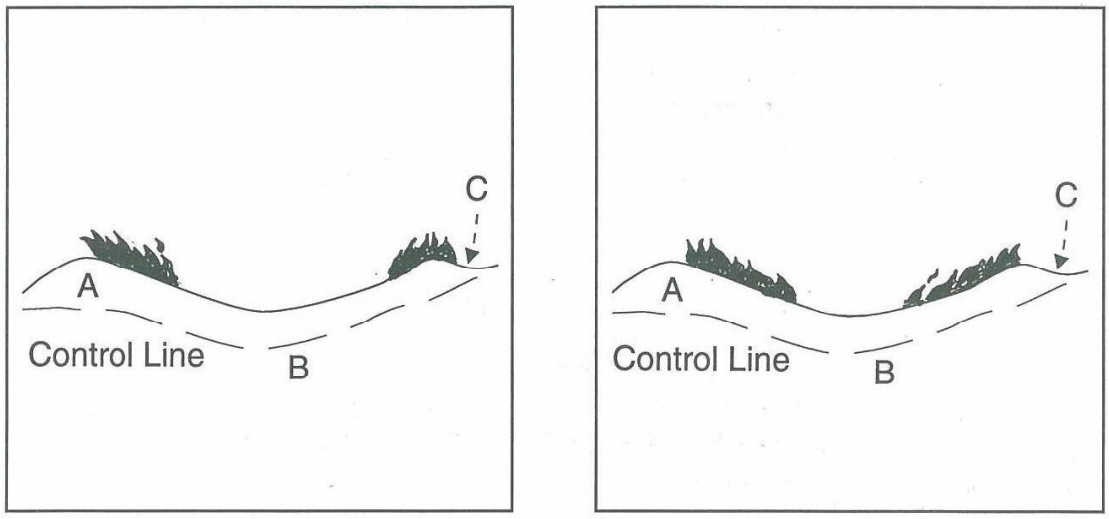
If the main fire is backing down one slope in a V-shaped canyon, begin firing a short distance from the bottom of the slope on which the fire is burning (see Figure 23). However, a head fire may be too intense and you might want to use strip firing.

Figure 23 – Firing In V-Shaped Canyons



When firing a saddle bum into the saddle simultaneously from both directions. In Figure 24 firing would begin at points A and C at the same time. From points A and C firing would continue simultaneous reaching point B about the same time.

Figure 24 – Firing Saddles



FIRING EQUIPMENT

Equipment that can be used in a firing operation includes primary devices and secondary devices. Primary devices are: fusees, drip torches, matches, and natural fire. Secondary devices are: pneumatic torches, propane torches, Very pistols, flare pen, fusee launchers, blivets, power flame throwers, Burnol Bursters, helitorches, ping-pong ball machine, and fusee gatling gun.

Fusee - This is the most widely used firing device. It projects very hot flame, can be broken into sections, ignited, extinguished, and re-ignited; bums approximately 20 minutes depending on size; and comes in boxes of 72 each. The fusee is most effective in *dry,* light, continuous fuels and is classified as a "Flammable Solid" by the Department of Transportation (DOT).

Drip Torch - A hand-held device, the drip torch incorporates fuel oil (or diesel) mixed with gasoline (normally 3 parts oil or diesel to 1 part gasoline), which is dripped from the canister past a flaming wick to be ignited. This device works well on almost all fuel types and is used for long firing jobs. One full tank used judiciously can last approximately 1 hour. Diesel fuel is classified as a "combustible liquid," and gasoline is classified as a "flammable liquid." Diesel/gasoline is classified as "flammable."

Matches - Kitchen (wooden) preferable, but paper matches also are effective when ignition is easily attainable. Best in light dry fuels, used in conjunction with other firing devices as a source of ignition.

Natural Fire - During direct-line construction, natural fire is normally readily available and can be moved with hand tools or hand carried. Examples are: hot coals, yucca stalks or pine boughs, cedar bark, slash, or palm fronds.

Pneumatic Torch - This device incorporates a backpack tank with diesel fuel under pressure expelled through a nozzle past a burning wick. Torches can project burning fuel from 8 to 20 feet, depending on model, and can be used to apply diesel fuel to heavy fuels when ignition is slow, difficult, or sparse. Torches can be used to supplement fusees and drip torches when they are inadequate.

Propane Torch - A canister of liquefied propane gas (LPG) with hose, nozzle, and pilot light produces a very hot flame but with little lasting effect if fuels are moist. This is generally a hand-held device, but it can also be mounted in the back of a trailer or pickup. This type of torch projects flames up to 4 feet. LPG is classified as a "flammable gas."

Very Pistol - This is a hand pistol varying in diameter from 12 gauge to 25 mm. Most effective in *dry,* light, continuous ground fuels, the Very pistol, allows remote ignition. Burning time is approximately 8 seconds. Effective range varies from 50 to 200 feet, depending on the size of the ordnance and whether fired uphill or downhill. The Very pistol requires special training; (follow agency policy) and is not advised for aerial application from helicopters due to shots being fired into rotor arc, skid system and/or within the helicopter itself. Ammunition is classified as a "Class C Explosive."

Flare Pen - This is a hand-held cylindrical device resembling an over-sized pen that launches small flares using a spring or trigger device. It is best suited for dry, light, continuous ground fuels, allows remote ignition, has a burning time of approximately 5 seconds, and an effective range from 50 to 150 feet, depending on the size of the ordinance and whether fired uphill or downhill. This device requires special training (follow agency policy) and is not recommended for aerial application from helicopters due to shots being fired into rotor arc, skid system and/or within the helicopter itself. Ammunition is classified as a "Class C Explosive."

Fusee Launcher - This device consists of a launch tube with hose and an air compressor that uses 100 to 130 psi of pressure to launch standard fusees. Best suited in dry, light continuous ground fuels. Burns approximately 20 minutes depending on size. Launches fusees approximately 600 feet depending on terrain and air pressure setting. This device requires special training (follow agency policy) and is classified as a "flammable solid" by the DOT.

Blivet - This is a sealed plastic bag containing a jelled fuel mixture, typically diesel and gasoline. The blivet works best in heavy and slightly damp fuels such as slash or piles. It is useful in rolling and hilly terrain. Plastic bags of jelled fuel are primarily hand placed, but can be thrown. If hand placed, they should be lit with a fuse. They can be equipped with a section of igniter cord, lit and hand thrown. Jelled gasoline/diesel and igniter cord are subject to 49 CFR Part 397 (Hazardous Materials).

Power Flame Thrower - (Power flame-thrower sold as Terra Torch TM by Firecon, model 6430 portable torch, and Hot Shot TM by Simplex, model 6410) Similar to a military flame-thrower, the device has a mixing and storage tank, positive displacement pump, and a firing wand. Jelled gas is sent through the pump and ignited by a propane (LPG) lighter. It projects hot, high-volume flaming jelled fuel approximately 20 to 150 feet, depending on terrain and pump pressure. Fuels are coated, producing a lasting effect. This device requires special training (follow agency policy). Jelled gasoline/diesel is classified as a "flammable liquid."

Canisters - (Canister backfiring devices sold as Burnol TM.) Burnol TM backfiring devices consist of pint or quart sized metal containers of gelled fuel (napalm) and a No. 6 fuse cap with a 90-second black-powder core safety fuse. These are hand thrown devices. Upon detonation, the device propels burning napalm over an open circular area of approximately 20-30 feet in diameter. The gel-like petroleum clings to forest fuels and bums from 4 to 10 minutes. These devices require special training and certification (follow agency policy). Fuse caps are classified as "Class C Explosives," and canisters of napalm are classified as "flammable liquids."

Aerial Ignition Systems

Of the many methods available for starting ignition, setting fires from the air offers many benefits over those requiring ignition from the ground. Among the benefits are (1) less chance of ground personnel being trapped in a fire, (2) larger areas can be burned when conditions are best, (3) fewer personnel and less time needed to accomplish the tasks, and (4) in many situations, costs are lowered.

There are many factors that should be considered in making a selection of an aerial ignition system, including the size of the area to be burned, phase of the fire, values at risk, strategy, topography, fuel and site conditions, availability of different aerial ignition systems, trained and qualified personnel, carded aircraft and pilots, and economic concerns. No one system will completely satisfy all of these factors in every instance.

Helitorch - This device is mounted externally on a helicopter. The pilot controls placement of the burning fuel. This device uses jelled gasoline, produces large amounts of fire in a short period of time, and will burn standing brush and other fuel types with little or no ground fuels. It ignites fuels with higher fuel moistures expanding the prescription window. Use of this device is limited to daylight hours and requires a complex firing organization and special training (follow agency policy). Jelled gasoline/diesel is classified as a "flammable liquid."

Plastic Sphere Dispenser - (ping pong ball machine). This device is mounted in the rear door opening of a helicopter. The device dispenses polystyrene spheres (similar to the size and composition of ping pong balls) filled with potassium permanganate crystals. The machine injects the polystyrene spheres with ethylene glycol and releases the spheres which drop to the ground. An exothermic reaction occurs and the spheres ignite within 20 to 30 seconds. The device is most effective in dry, light, and open canopy fuel. However, some users indicate it works well for underburning in canopy fuels as the balls fall through the canopy to ignite the ground fuels. It produces a relatively low intensity fire from each ignition source.