SECTION 1 - FIRE SUPPRESSION PRINCIPLES

Strategy is an overall plan of action for fighting a fire which gives regard to the most cost efficient use of personnel and equipment in consideration of resource values threatened, fire behavior, legal constraints, and objectives established for resource management.

Tactics are the operational aspects of fire suppression. Determining exactly where and how to build a control line and what other suppression measures are necessary to extinguish a fire. Tactics must be consistent with the strategy established for suppressing a fire.

The purpose of this section on fire suppression principles is to acquaint all firefighters with the factors to size up a fire and apply the strategy and tactics that will enable an appropriate suppression response to be completed in a safe, efficient manner, and facilitate rehabilitation of the suppression impacts.

Most wildland fires are suppressed by initial attack (first to arrive) forces. Some wildland fires become large for various reasons. Fire suppression principles apply to initial attack as well as to large fires or parts of large fires.

FIRE SIZEUP AND INITIAL ATTACK

Often times firefighters and incident commanders take shortcuts concerning fire sizeup, establishing communications and safety. A thorough fire sizeup, establishing communications among all resources on a fire, and applying safety to all aspects of fire suppression are critical elements that must be adhered to. If adequate communications can not be established and firefighter safety is compromised then it is time to back off and re-evaluate your tactics.

If you are assigned to fight fire in an area where you are unfamiliar with the local fuels, weather, topography, and fire behavior you should request a briefing from the local agency, to provide you with this information.

In many cases sizeup and initial attack go hand in hand because the firefighter with a passion for safety begins to gather information about the fire situation from the initial dispatch and/or prior to departing to the fire incident.

<u>En route To a Fire</u>

En route to a fire begin to think about your knowledge of the fire area and how current conditions compare to past experiences. Some items to consider are:

- Firefighter safety.

- Fuels and terrain. What are the fuels? Are they heavy timber types or light, flashy, grass types? Are the fuels sheltered from direct solar radiation due to aspect or cover? Is the terrain steep or gentle? How do you expect this fire to burn compared to recent fires in similar areas?

- Weather-is the windspeed greater or less than the forecast? Is it from the same direction? Are there dust devils or gusty winds that would indicate erratic behavior? Is the humidity about what was forecast? Are there any indicator clouds or thunderstorms?

- Smoke column-check size, height, color, direction and shape.

    The greater the height and size of the column the greater the fire intensity. A fractured (bent over by the wind) column indicates a wind-driven fire. Wind-driven fires can pose serious threats to safety as the fire grows. Spotting can become long range creating new fires ahead of the main fire. However, direction and rate of spread is more predictable.

A large developing mushroom shaped column can indicate a plume-dominated fire where the fire's rate of spread and direction is very unpredictable. Strong wind indrafts and downbursts can occur with short range spotting in all directions.

Light colored smoke generally indicates lighter burning fuels whereas a dark colored smoke indicates heavier burning fuels such as brush or timber.

- Access routes and their limitations-also look for alternate routes.
- Fire barriers (natural and human made).
- Potential water sources.
- Land ownership (including cooperative agreements and assistance on fire suppression).
- History of fires in area and cause.
- Capabilities of responding resources and available back-up forces.
- Look for people coming from the fire area or suspicious people at the fire scene. Write down license plate numbers and descriptions of vehicles and/or people.
- Public safety concerns.

Arrival On Fire Scene

Safety of assigned resources, facilities, and the public should always be a prime item to consider when evaluating possible attack options. An appropriate decision **always** provides for safety first. The Fire Orders, Watch Out Situations, and the LCES system are to be implemented and reviewed often.

After arrival on the fire scene, your next decisions are critical to initial attack success. This is where you "make it or break it." If you go off in all directions little will be accomplished and firefighter safety could be jeopardized. You need to gather additional **critical** information to **complete** the fire sizeup and formulate an appropriate plan of attack.

These are the key factors you should observe in relation to fuels, weather, topography, and fire behavior during your sizeup process:

Fuels:

- Type/model.
- Size classes present and size classes burning.
- Are fuels light and continuous?
- Live/dead ratio (frost, bug kill, drought conditions).
- Fine dead fuel moisture (dangerous below 6%).
- Live fuel moisture (chaparral, sagebrush, Gambel oak, etc.)
- Vertical arrangement and horizontal continuity (ladder fuels, tight crown spacing less than 20 feet).
- Loading (heavy vs. light).
- Snag concentrations.
- Areas with reburn potential.
- Access restrictions for personnel.

Some fuels such as chamise, chaparral, pines, palmetto-gallberry, junipers, mountain laurel, rhododendron, and eucalyptus burn hotter and produce longer flame lengths than others because they contain flammable oils.

Generally, taller and thicker fuel will produce longer flame lengths and control
Lines must be wider.

Heavy fuels do not ignite easily and fires do not spread as fast as in light fuels such as grass, leaves, needles, and twigs. However, once ignited, logs, snags, and heavy branches burn for a long time and may require wide control lines to keep the flame, sparks, or radiated heat from igniting fuels across the line.

Fuel moisture and whether fuel is dead or alive have a definite effect on a burning fire's intensity. Generally, the drier the fuel the hotter it burns and longer flame lengths are produced. Longer flame lengths require wider firelines to stop the fire.

Topography:

- Aspect.
- Position on slope (ridge top, mid-slope, drainage bottom).
- Building line downhill or uphill.
- Width of canyons (wide/narrow).
- Box canyons and/or chutes.
- Percent slope.
- Potential for rolling material.
- Available natural and/or constructed barriers.
- Elevation.

When a fireline is built above a fire burning on a slope, generally the steeper the slope, the wider the line must be because the fire usually burns faster and more intensely than on a gentler slope. The more gentle the slope the narrower the line can be.

When a fireline is built below a fire burning on a slope, the width of the line does not depend so much on the slope, but trenching becomes important. Generally the steeper the slope, the deeper the trench must be, to prevent rolling burning material from crossing the fireline.

Weather:

- Maximum/minimum relative humidities.
- Wind velocity, direction and patterns (gusty vs. steady).
- Temperature variations.
- Thermal belts.
- Thunderstorm activity.
- Diurnal wind patterns and windspeed.

- Inversions.

- Foehn winds.

- Battling winds or sudden calm.

  When a gravity or foehn wind interacts with a local wind, significant wind reversals are likely. Definite indicators are winds baffling back and forth causing a wavering smoke column and a sudden calm.

  A decreasing foehn wind that allows a local wind to regain influence can be as dangerous as the foehn wind that overpowers a local wind. A wind reversal from a decreasing foehn wind has been a factor in several fatality fires.

- Weather forecasts (request spot weather forecast if predicted weather condition is unknown).

- Last precipitation and amounts.

- Indicators of turbulence (dust devils, thunderstorms, lee sides of ridges, saddles).

- Indicators of instability (clear visibility, smoke rising straight up, inversions lifting).

- Indicator clouds.

- Haines Index 5 or 6.

In general the higher the temperature and the lower the humidity, the lower the fuel moisture. The lower the fuel moisture, the more intensely a fire will bum and the wider the fireline must be.

The wind or air currents increase the burning intensity by supplying more oxygen, by moving currents of hot, drying air into the fuels ahead, or by actually carrying burning embers (spotting) ahead of the fire itself. Therefore, the 'stronger the wind or convection current, the wider the line must be.

Fire Behavior:

- Rate of spread on various portions of the fire.
- Flame lengths on various portions of the fire.
- Type of fire spread (smoldering, creeping, running, torching, spotting).
- Classification of fire (ground, surface, aerial [trees torching]).
- Indicators of extreme fire behavior (a rapid buildup of intensity, a high sustained rate of spread, a well developed convection column, frequent or long distance spotting *[600* feet or more], firewhirls, horizontal flame sheets)
- Size of fire.
- Location of fire in relation to topographic features (chutes, canyon bottoms, ridge tops, mid-slope).

Flame length is an important fire behavior factor you should be concerned with during sizeup. Generally fires with flame lengths greater than 4 feet are too intense for direct attack on the head by persons using hand tools (see Figure 2).

Figure 2 – Fire Suppression Limitations Based On Flame Length*

Flame Length	
4'	Fires can generally be attacked at the head or flanks by persons using hand tools. Handline should hold the fire.
4'-8'	Fires are too intense for direct attack on the head by persons using hand tools. Handline cannot be relied on to hold fire.
8'-11'	Fires may present serious control problems; torching out, crowning and spotting. Control efforts at the head will probably be ineffective.
>11'	Crowning, spotting and major fire runs are probable. Control efforts at the head of the fire are ineffective.

*This may be modified for local fuels and conditions.

Other critical elements to consider:

- Restrictions on suppression tactics (wilderness areas, threatened and endangered species, etc.).
- Span of control.
- Biological and environmental hazards.
- Constructed hazards (powerlines, hazardous waste dump sites).
- Urban interface.
- Availability of critical support (hose lays, helicopter/fixed wing).
- Physical and mental condition of assigned resources.
- Ability to re-supply.
- Availability of human made and natural barriers (game trails, cow paths, roads, trails, lakes, rivers, old burns).
- Availability of water sources.
- Observation points.
- Archeological sites.
- Cultural resource sites.
- Accessibility and mobility.
- Poor visibility.
- Coordination with dispatch and/or adjoining forces.
- Other agency involvement.

Now that you have sized up the fire the following decisions need to be made:

- How to establish and implement lookouts, communications, escape routes, and safety zones (LCES).
- How to attack the fire (direct, parallel, indirect attack).
- Where to anchor and attack the fire (rear, flanks, head).
- Organization and command structure.
- Location of control line.
- Type of control line (width, burnout).
- Additional help needed.

Considering the following factors will help make the decisions above.

- Firefighter safety.
- Size of fire and fire behavior.
- Fire environment (fuels, weather--current and predicted, topography).
- Forces presently available to construct control line and hold it.
- Location of the fire head.
- Period of day fire is burning into (morning, afternoon, night).
- Improvements and other values in path of fire.
- Point of origin and cause.
- Public safety.

HOW TO ATTACK A FIRE

If you are the first person to arrive at a fire or a single resource boss in charge of the first crew at a fire, you have several problems. You are confronted with deciding; 1) what is the most important work to do first, and 2) where the most effective work can be done. Keep in mind at all times that firefighter safety is the highest priority in fire suppression.

After sizing up the fire you need to select an anchor point and make your attack. Following are some good practices in making an initial attack or suppressing a large fire.

- If you are the incident commander, establish an organization and command structure. Make sure your subordinates know the plan and are kept informed on changing conditions, tactics and/or strategies.

- Use water or dirt to cool and extinguish hot spots.

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- Anticipate future control action when the fire cannot be contained promptly.

- Construct fireline uphill from an anchor point.

- As a first effort, keep fire out of the most dangerous fuels, and prevent it from becoming established in explosive types of fuels, such as grass, thickets of tree seedlings, heavy brush, or slash areas.

- Confine fire as quickly as possible.

- Locate and build firelines. Move all rollable material so it cannot roll across firelines.

- Leave no significant areas of unburned material close to fireline.

- To gain control, swiftly locate and build fireline in the easiest and safest places for line construction that can be held. Bum out as needed when line is constructed and burning out can be controlled.

- Utilize existing barriers to full extent.

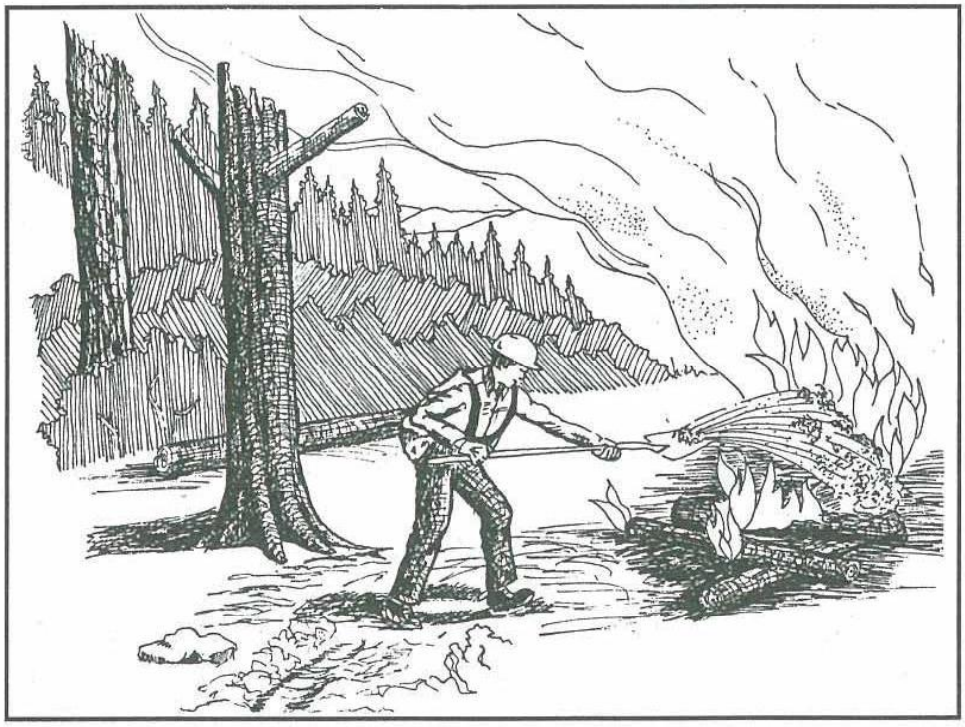
- If fire spread cannot be contained, notify dispatch and do some safe, effective work on at least a part of the fire.

- Where improvements (houses, other buildings, fences) are involved, consider all the facts before determining which point to attack first. No improvement or piece of property is worth firefighter injury or fatality.

Now a decision must be made concerning how to attack a fire. The methods of attack are direct, parallel, and indirect.

Direct attack is made directly on the fire's edge or perimeter (see Figure 3). The flames may be knocked down by dirt or water and the fire edge is generally treated by a follow-up fireline. Or, a fireline is constructed close to the fire's edge and the fuel between the fireline and the fire is burned out or the fire is al6wed to bum to the fireline.

Figure 3 – Direct Attack

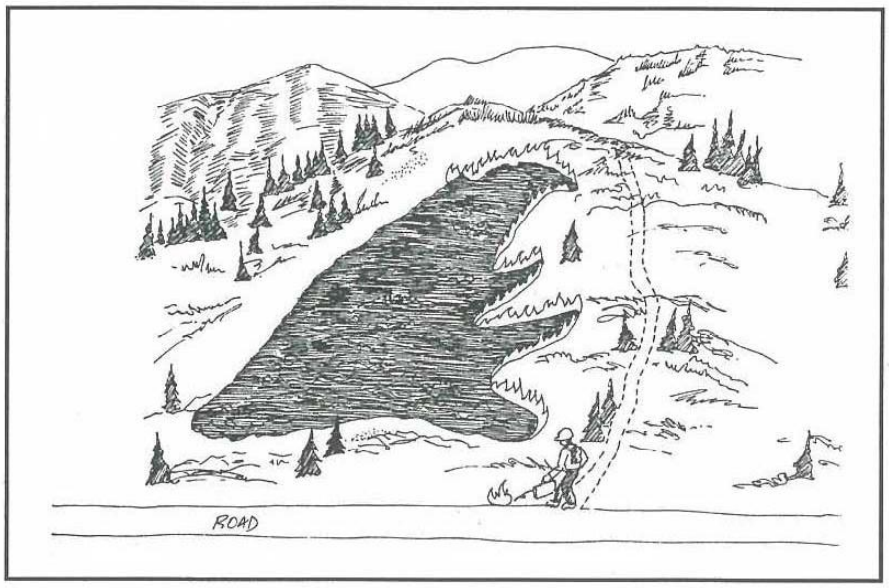


Direct attack generally works best on fires burning in light fuels or fuels with high moisture content burning under light wind conditions. Direct attack works well on low intensity fires (flame lengths less than 4 feet) which enable firefighters to work close to the fire.

A major advantage of direct attack is firefighter safety. Firefighters can usually escape back into the burned area for a safety zone. This is known as "keeping one foot in the black."

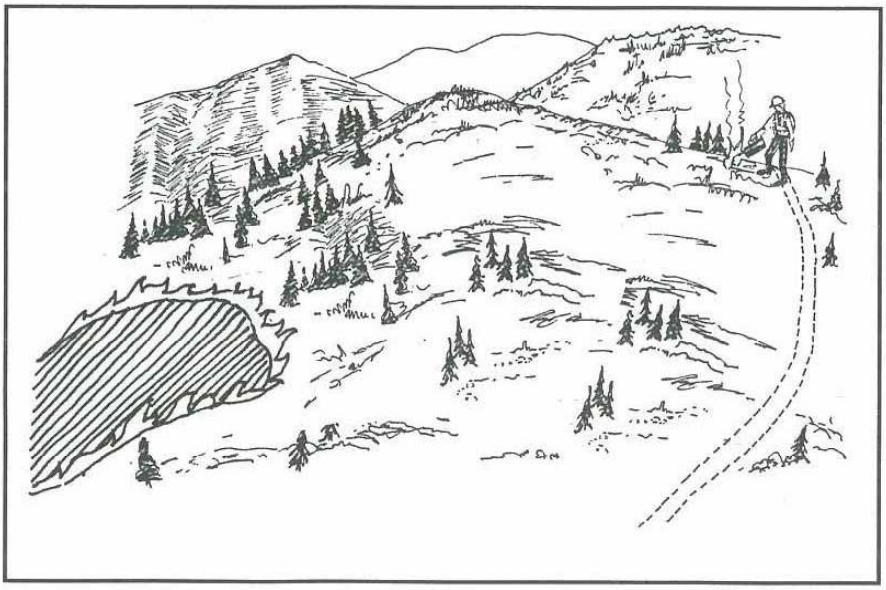
Parallel attack is made by constructing a fireline parallel to, but further from, the fire edge than in direct attack (see Figure 4). This tactic may shorten fireline construction by cutting across unburned fingers. In most cases the fuel between the fireline and the fire edge is burned out in conjunction with fireline construction.

Figure 4 – Parallel Attack



Indirect attack is accomplished by building a fireline some distance from the fire edge and backfiring the unburned fuel between the fireline and the fire edge (see Figure 5). Indirect attack takes advantage of using natural and human-made barriers as fireline and allows a choice of timing for backfiring . Indirect attack is generally used on hot fires with high rates of spread where direct attack is not possible.

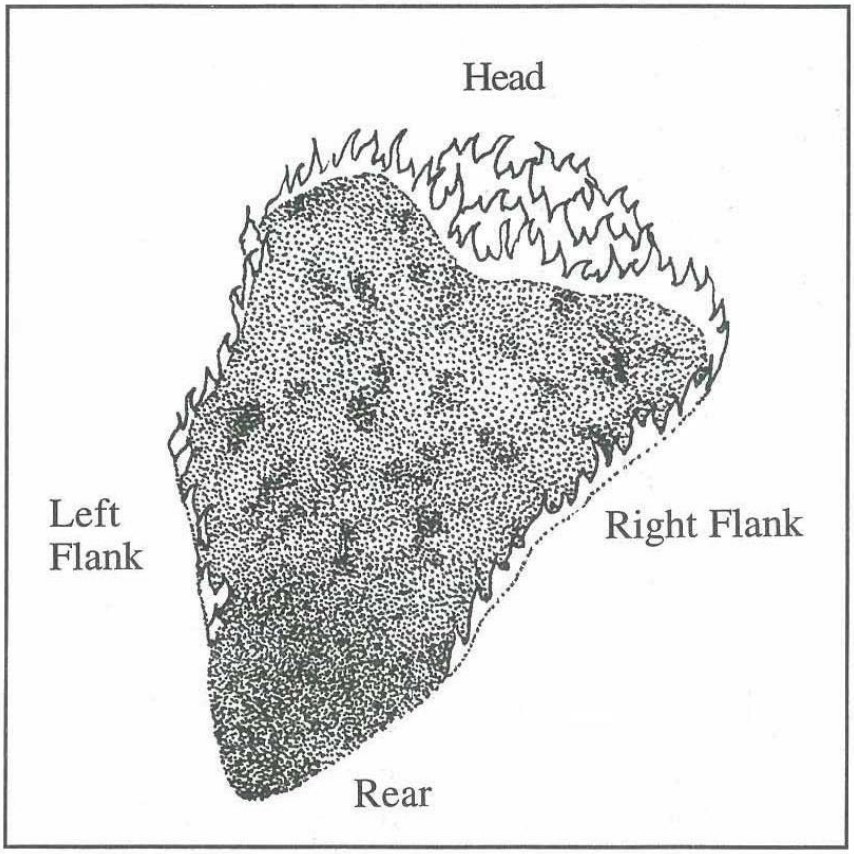
Figure 5 – Indirect Attack



WHERE TO ATTACK A FIRE

The parts of the fire to be controlled are the head, the flanks, and the rear (see Figure 6).

Figure 6 – Parts Of A Fire

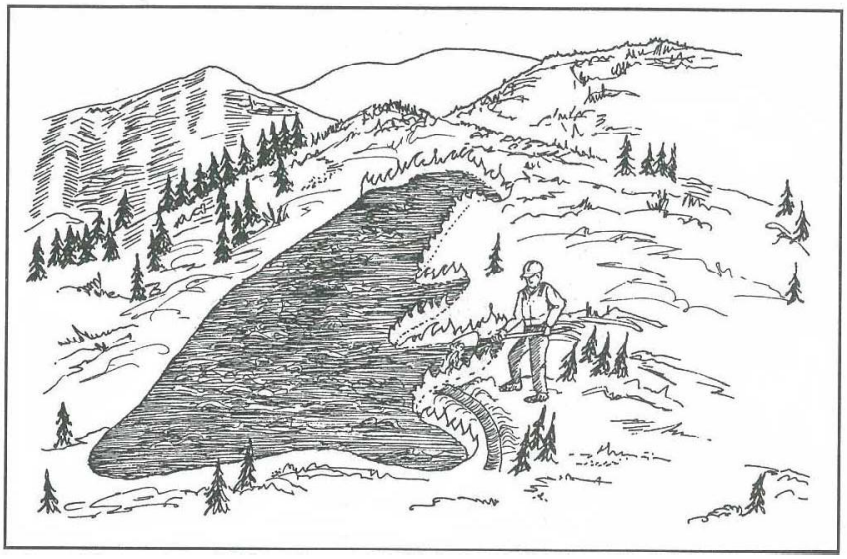


Fires are generally attacked where they are most likely to escape and this may require attacking the fire at the head, flanks, rear, or any combination of the three. However, your primary concern is attacking the fire where it can be done safely. A good practice is to always pick an anchor point to start fighting the fire and to prevent the fire from outflanking you.

Fireline intensity (flame length) and rate of spread generally determine which part of the fire to attack in both initial attack and suppressing large fires. Figure 2-Fire Suppression Limitations Based On Flame Length, page 12, provides guidance to make decisions on which part of the fire to attack and whether to make a direct, parallel, or indirect attack.

A technique to attack a fire where it is most likely to escape or stop hotter burning portions of a fire is called hotspotting (see Figure 7).

Figure 7 – Hotspotting, Using Temporary Lines
To Check Fire Spread And Gain Time



Hotspotting can be used to cool hot portions of a fire and allow firefighters more time to construct fireline or cool certain portions of a fire to prevent it from making a run. Hotspotting can be accomplished by building temporary check lines or applying dirt or water to knock down and cool hot portions of a fire. Hotspotting can be dangerous to firefighters because they are working without an anchor point, can be out-flanked by fire, and they are exposing themselves to intense burning portions of a fire.

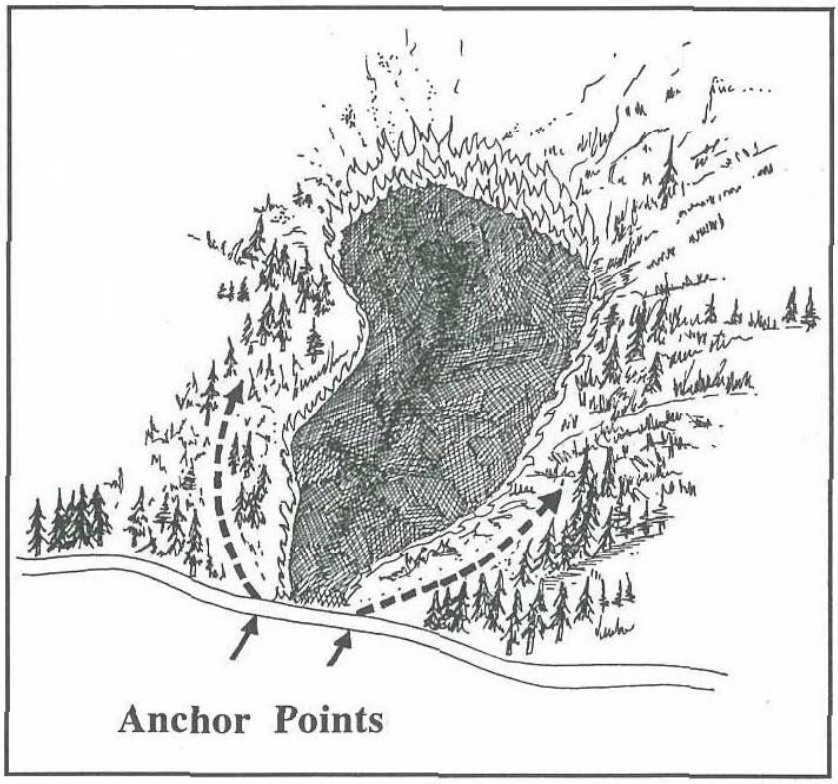
FIRELINE LOCATION

Following are some general principles of fireline location:

Locate the fireline as close to the fire edge as possible. This generally means a direct attack which provides firefighters more safety as they can usually get into the burned area for a safety zone.

Always anchor the fireline to a barrier or other control line to prevent being outflanked by the fire (see Figure 8). Barriers can be natural or human made i.e., roads, trails, rivers, lakes, old burns, rocks. Also burn out the fuels between the fireline and the fire edge beginning at the anchor point and continue burning out as the fireline is constructed.

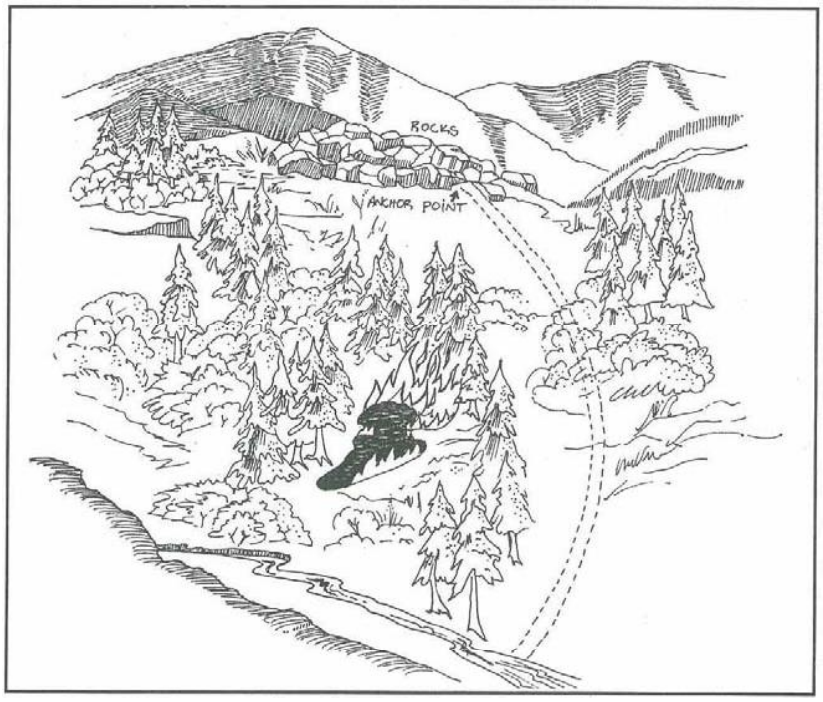
Figure 8 – Begin Fireline At Anchor Point



If the fire is spreading rapidly or is too hot for direct attack, place the fireline far enough back from the fire's edge to allow sufficient time for fireline construction and burning out to be completed safely.

Avoid downhill fireline construction with the fire directly below. Building fireline downhill when fire (either wildland fire, burnout, or a backfire) is directly below you can be hazardous and is one of the Watch Out Situations (see Figure 9). Fire spreads more rapidly upslope. Firefighters above the fire building fireline downhill can easily be outflanked or overrun by the fire.

Figure 9 – Building Fireline Downhill



When building fireline downhill of the following safety precautions must be adhered to:

1. The decision is made by a competent fireline supervisor after thorough scouting.

2. Downhill fireline construction should not be attempted when fire is present directly below the proposed starting point.

3. The fireline should not be in or adjacent to a chimney or chute that could burn out while firefighters are in the vicinity.

4. Communication is established between firefighters working downhill and firefighters working toward them from below. When neither crew can adequately observe the fire, communications will be established between the crews, supervising overhead, and a lookout posted where the fire's behavior can be continuously observed.

5. Firefighters will be able to rapidly reach a safety zone from any point along the line if the fire unexpectedly crosses below them.

6. Downhill fireline will be securely anchored at the top. Avoid underslung line if at all practical.

7. Burning out should be done as the fireline progresses, beginning from the anchor point at the top. The burned out area provides a continuous safety zone for firefighters and reduces the likelihood of fire crossing the line.

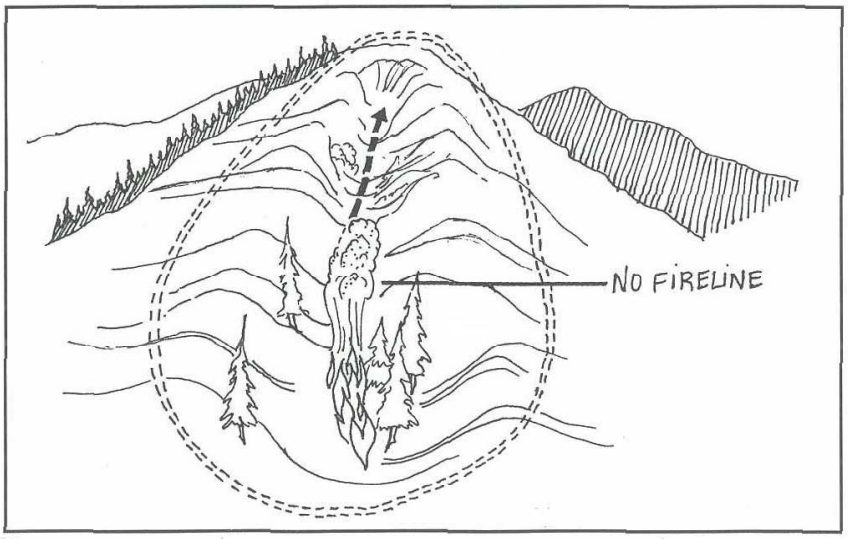
8. Be aware of and recognize the Watch Out Situations.

9. Full compliance with the Fire Orders is assured.

10. Implement LCES.

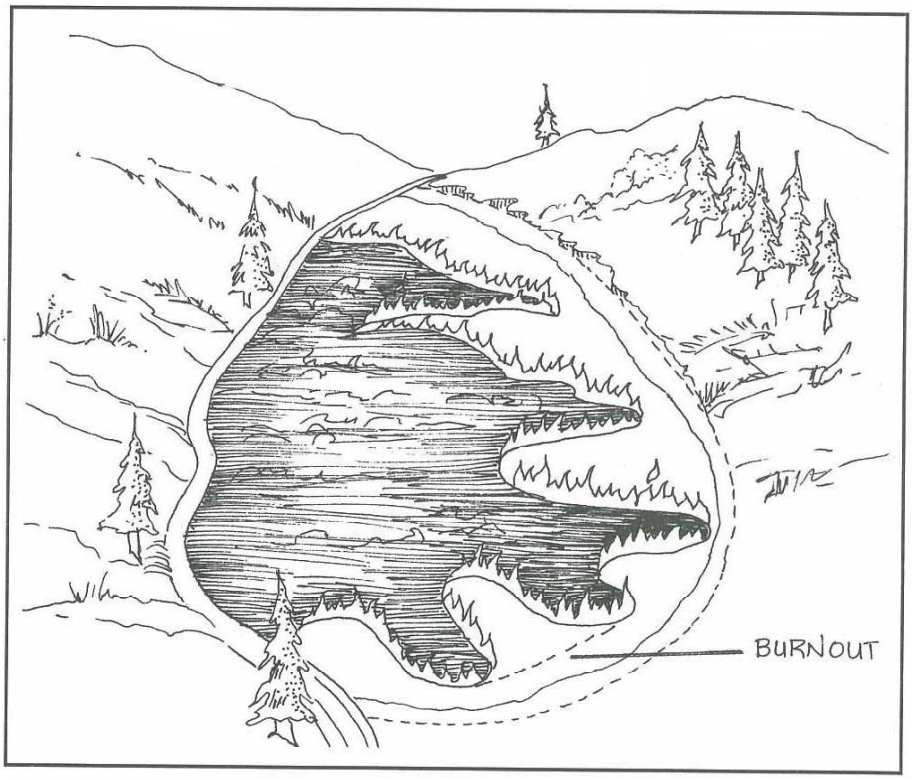
Fireline should not be constructed in or adjacent to chutes or box canyons that can channel the fire and produce extreme fire behavior (see Figure 10).

Figure 10 – Fireline Constructed Near Chute or Box Canyon



Make the fireline as short as possible (see Figure 11). Tie ends of fingers together with a fireline and promptly bum out. Cold trailing is a method of using the extinguished edge of a fire as the fireline. The cold fire edge must be carefully inspected to detect any fire and every live spot must be lined and extinguished. Cold trailing can shorten the fireline to be constructed, but must be accomplished with caution.

Figure 11 – Short Fireline



Capitalize on existing barriers to fire spread in selecting fireline location.

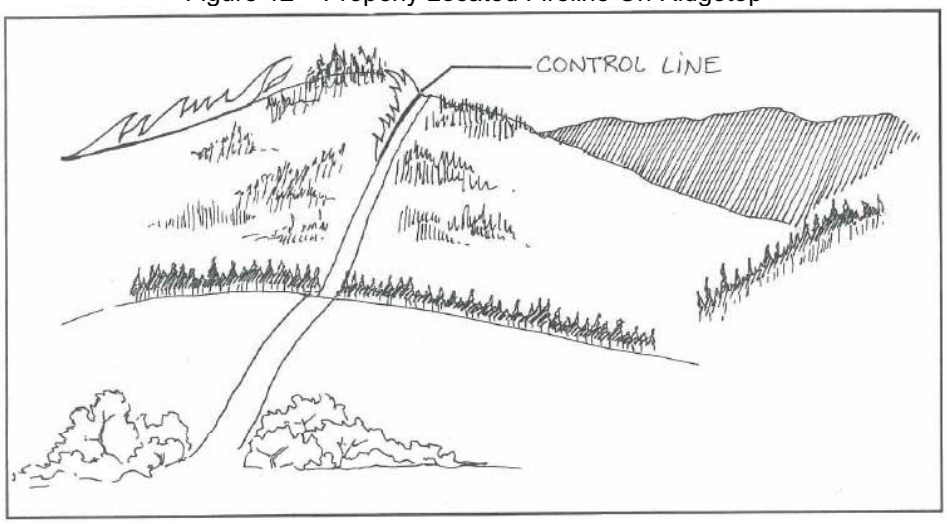
When possible put the fireline through open areas to reduce clearing work.

Avoid sharp angles in the fireline.

Block off high hazard fuels where possible by leaving them outside the fireline.

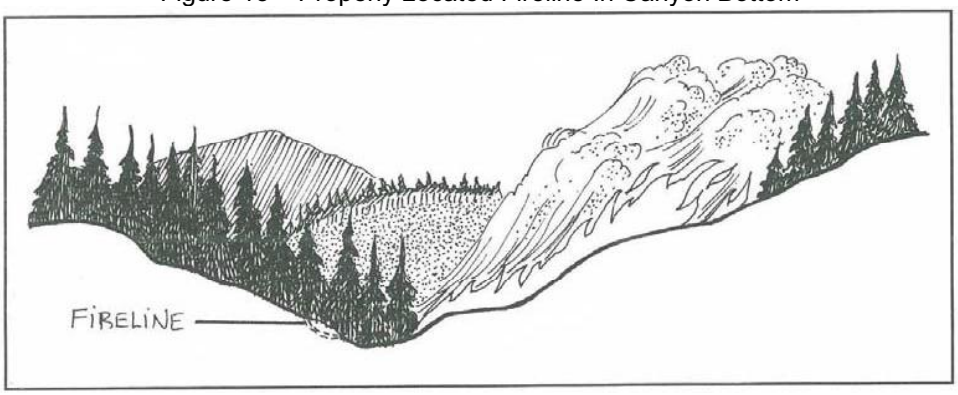
When constructing fireline on a ridgetop, locate the fireline on the back side of the ridge (see Figure 12).

Figure 12 – Properly Located Fireline On Ridgetop



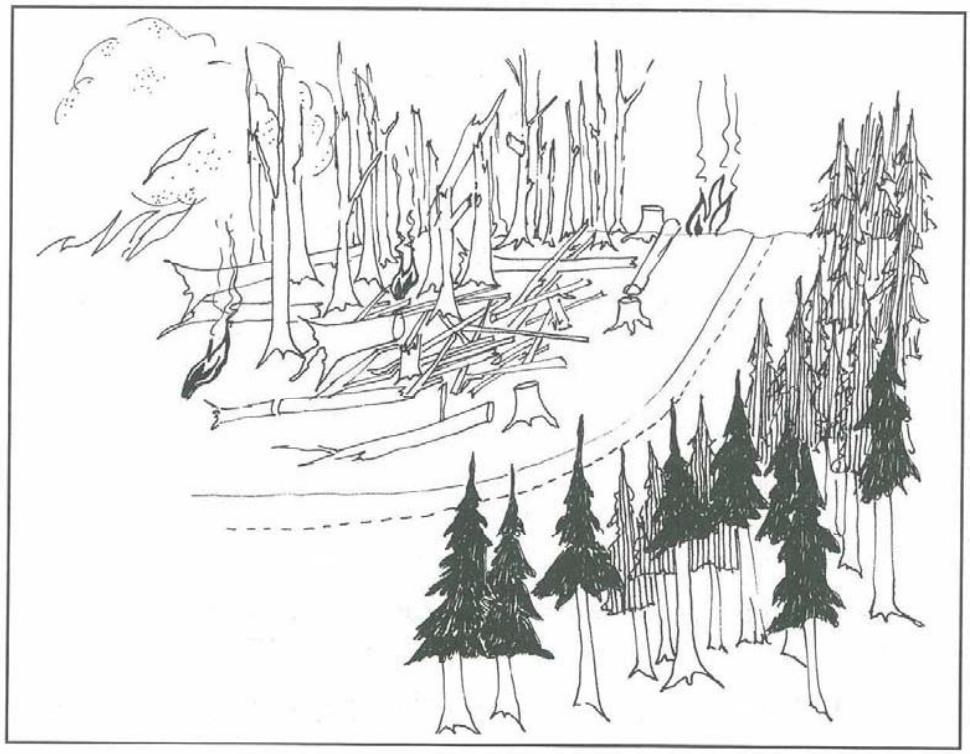
When constructing fireline in the bottom of a canyon locate line on the opposite side to prevent underslung line and the need for cup trenching (see Figure 13).

Figure 13 – Properly Located Fireline In Canyon Bottom



Locate the fireline far enough away from burning snags to enclose them if they fall over or are cut down (see Figure 14).

Figure 14 – Properly Located Fireline With Snags Close to Fire Edge



Encircle the area where spot fires are so numerous that individual control of them is impracticable.

Where a definite topographic feature, such as a ridge, cannot be used for fireline location, oblique (slanting) lines should be used for frontal attack to pinch off the fire head, rather than a line squarely across the front.

Take advantage of the normal daily shift between local up-canyon drafts during the day and down-canyon winds during the night. Unless general winds counter the effect of local drafts, fires generally burn up-canyon during the day and down-canyon at night.

FIRELINE FLAGGING

Line location is a common practice in some types of terrain and fuels, particularly when a fire is burning in timber.

When locating firelines, consider the following flagging techniques:

1. When tying and positioning individual flags, allow enough time for crew or mechanical equipment to construct line before fire edge approaches flag line.

2. Avoid flagging long sections of line. Flagging long sections of line separates you from your crew and equipment creating possible communication problems and unsafe situations.

3. Use a high visibility/reflective color whenever possible that can be easily seen in day light or night time conditions. Notify the crews constructing fireline what color of flagging was used.

4. Deploy an adequate amount of flagging for conditions. Flagging must be deployed heavier for night operations and/or during heavy fuel buildups because of poor visibility. Resources that can't find flag lines are nonproductive and may be put at risk during critical fire behavior situations and/or when working in adverse topography.

5. Avoid flagging dog legs or sharp angles. Whenever possible flag away from snags, widow makers, and other potentially hazardous areas.

6. If possible avoid flagging underslung line conditions which will require trenching and future holding problems. Depending on the size or the complexity of the fire, more than one individual with radio(s) may be required to accomplish this task. Whether locating line downhill or uphill, the outside perimeter will take on an overall wedge shape configuration and all unburned material should be burned out. On larger fires, an indirect method of attack may be warranted requiring flag lines to take advantage of ridges running parallel to the main fire. The unburned area then should be backfired.

7. If an existing flag line must be rerouted, remove enough flagging to ensure crews or other adjoining resources will not mistake the old flagged line for the new flagged line. This situation can create nonproductive periods and expose crews to potentially unsafe conditions. Use a different color flagging and make sure crews following behind are aware of the change.

8. At night, when cold trailing, constructing parallel line across unburned fingers, and/or flagging indirect line, use two or more individuals with headlamps. The lead line locator searches out and determines where the line should be located. Once this individual has determined the approximate line location, a second person commences flagging staying on line with the lead person's headlamp. A third person may be necessary when there are larger fingers to assist in keeping the middle flagger on line with the lead line locator. This is accomplished by positioning the rear flagger at the opposite side of the finger from the lead line locator in a location where they can keep the middle flagger centered between their two locations. Once all three individuals are in position, there are two common alternative flagging procedures recommended. The first alternative requires the middle flagger to commence flagging, working away from the rear flagger keeping visual contact with the headlamps of the rear flagger and lead line locator. The second alternative requires the middle flagger to move to a position normally half way between the rear flagger and the lead line locator. After the center flagger is in position, the rear flagger commences flagging to the center flagger's position. After the first half of the line is flagged in, one of the two individuals remains at that location and the other commences flagging to the lead line locator's position.

9. Spot fires should be flagged and tagged with a written note. Flag lines leading to spot fires should originate from the existing main line. Always tie and secure a note or write directly on the flagging the following information:

    a. Date found
    b. Time found
    c. Size of spot fire
    d. Location from main fireline
    e. Determine if spot is lined or unlined
    f. Color(s) of flagging used to flag the spot fire
    g. Name of crew or individual reporting spot

    It is suggested that each time the spot is checked, the time, date and individual's name be recorded on the initial note.

10. It is necessary to understand the relationship of the flag line to the proposed control line. This must be communicated to the resources responsible for constructing the line. It becomes especially important when numerous saw teams are constructing line in heavy fuel conditions. In this situation the flag line is normally positioned at the point that will end up being the outside green edge of the completed line. The initial saw team should commence cutting its assigned strip just to the inside of the flag. This provides additional saw teams an edge to cut from and/or a location to place their cut material.

11. Always designate whether your flag line is to remain intact during line construction. Many times when using a saw team during night periods the operator will cut down a flag line in scattered brush or timber leaving only staubs. This situation may cause the personnel scraping the line to become disoriented, resulting in production loss.

12. Hazards such as bees, hornets, wasps and/or snags should be identified using yellow and black striped flagging. This is a universal flagging color recognized by most wildland firefighting agencies.

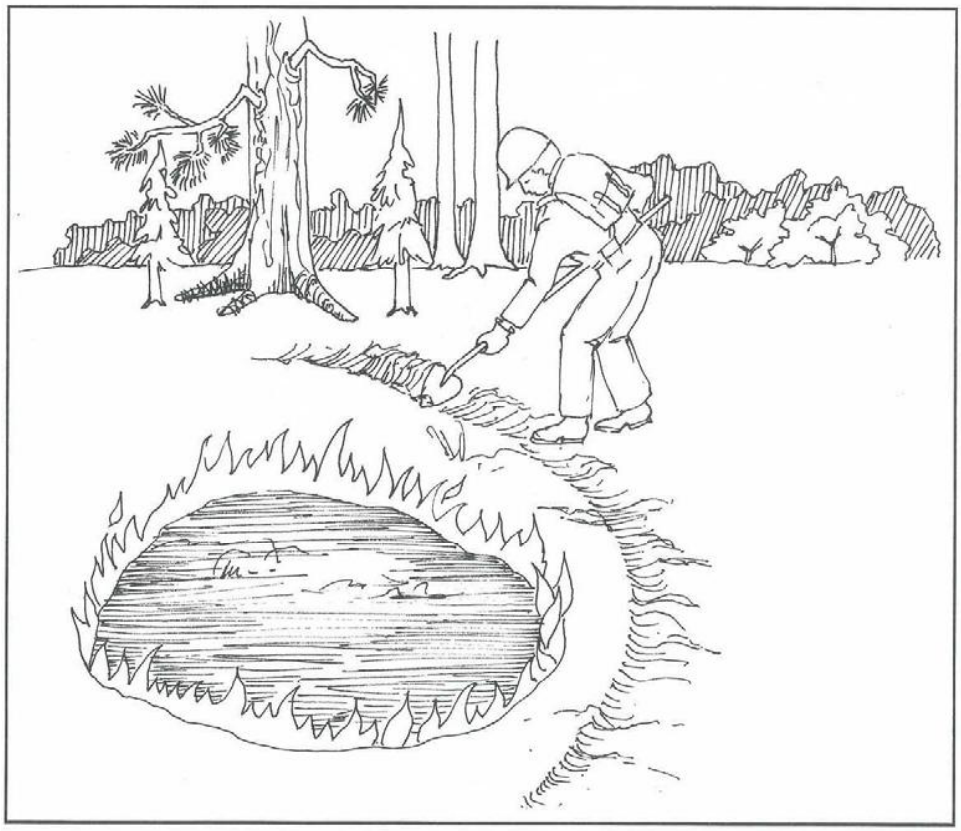
13. Escape routes and safety zones should be identified using lime green flagging.

FIRELINE CONSTRUCTION

Following are some of the more important principles of fireline construction:

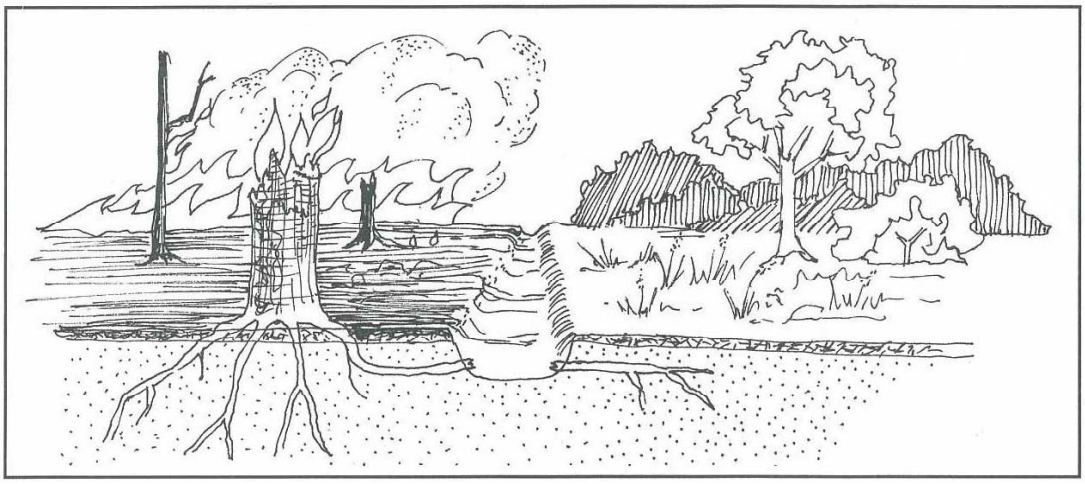
Make fireline no wider than necessary (see Figure 15). The time and energy saved by keeping firelines no wider than necessary to stop a fire can be better utilized in construction of more fireline to encircle or control the fire.

Figure 15 – Make Fireline No Wider Than Necessary



Clean all fireline to mineral soil for all or part of width (see Figure 16). Cleaning a fireline to mineral soil prevents the fire from spreading through fuel across the fireline, particularly dead roots. However, constructing fireline to mineral soil may not be practical in some types of fuel such as bogs, peat, tundra, etc.

Figure 16 – Fireline Cleaned To Mineral Soil

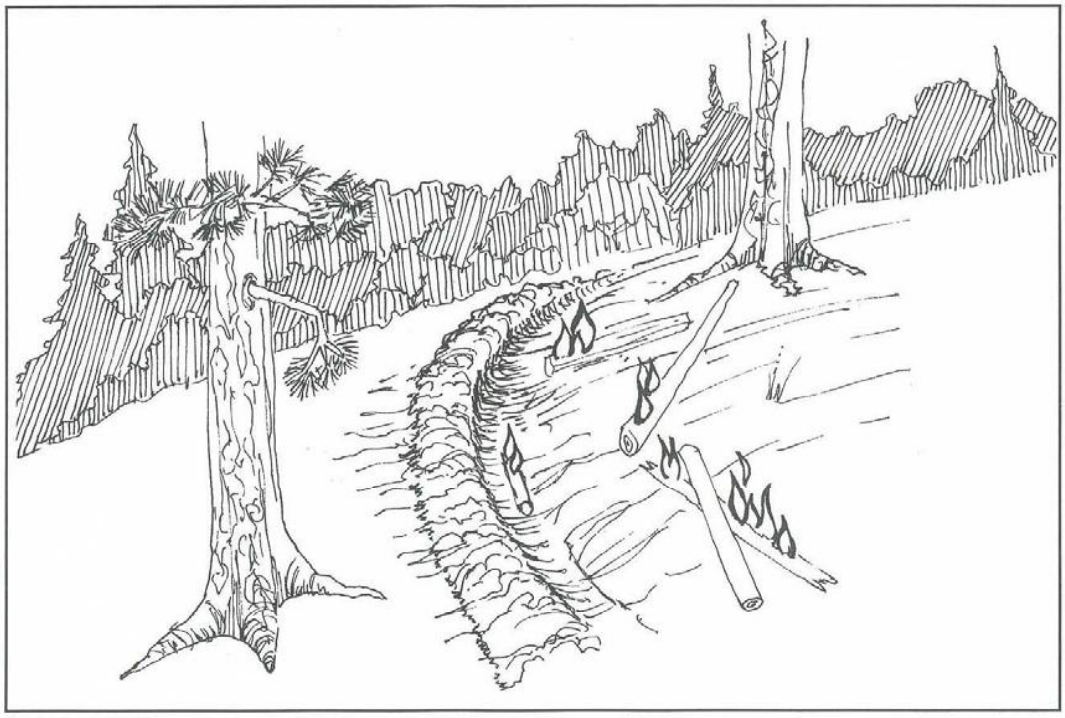


Scatter charred or burning material from fireline construction inside the burned area.

Unburned material from fireline construction is generally scattered outside the fireline. Unburned material can be scattered on either side of the fireline, provided this does not increase burning and heat at the line and make the line too hard to hold or complicate mopup; if fuel is needed for burning out, place inside the fireline.

Underslung or undercut fireline is fireline constructed across a slope below the fire. Protect underslung or undercut firelines from rolling material by building a cup trench (see Figure 17). A cup trench is sometimes called a roll trench or “V” trench.

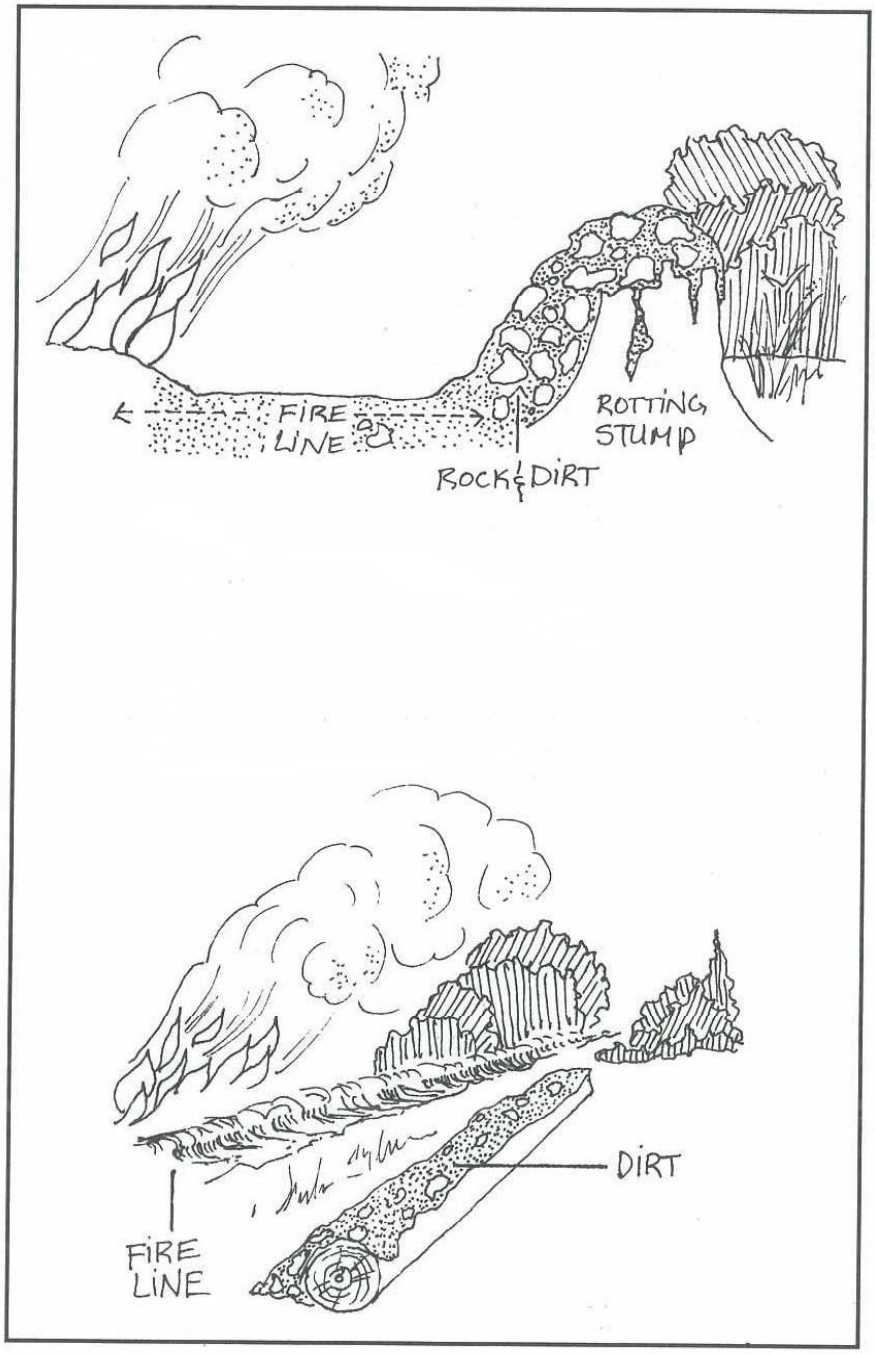
Figure 17 – Cup Trench Below A Fire On A Slope



Effectiveness of a given width of line can be increased by using dirt or water to cool down adjacent fire.

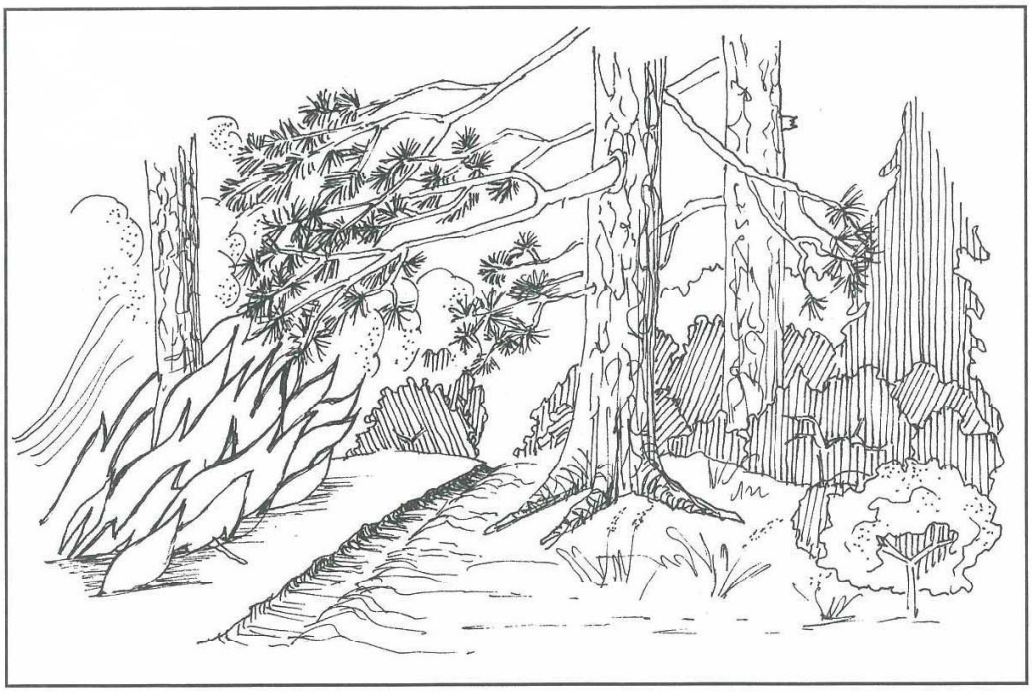
Fuels outside the fireline can be pretreated with retardant or foam, covered with dirt, or wet down. (see Figure 18).

Figure 18 – Protection of Stumps and Logs Outside Fireline



Remove low hanging limbs from trees on both sides of the fireline to prevent the fire from spreading across the line (see Figure 19).

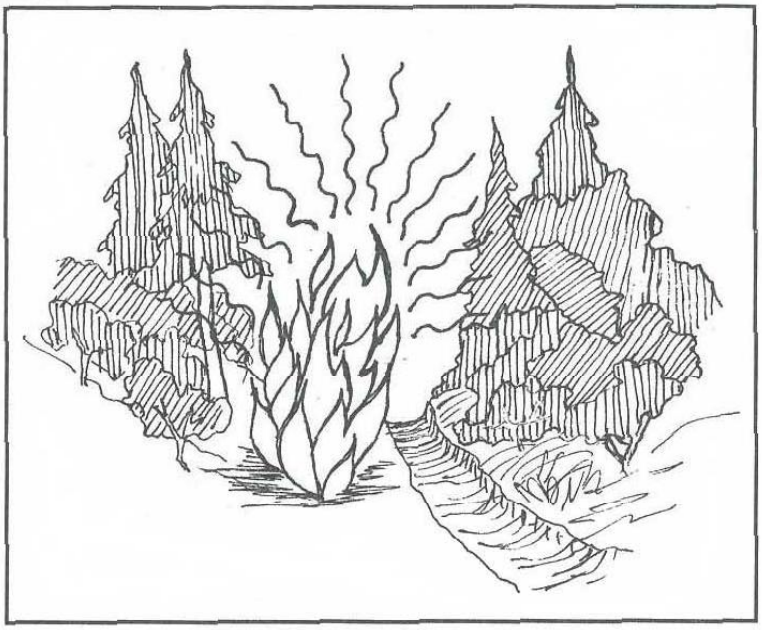
Figure 19 – Low Hanging Limbs Can Spread Fire Across Fireline



Heat can ignite fuel across or above the fireline even if flames do not reach the fuel. Radiant or convective heat may ignite fuel on the opposite side of a fireline which is too narrow or has too little overhead clearance.

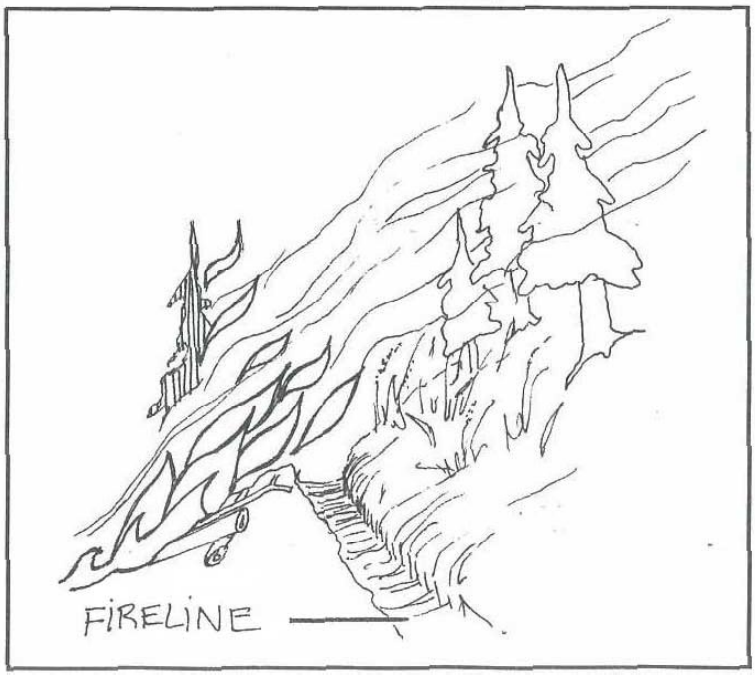
Radiation is transmission of heat through the air by rays. The heat may be radiated in all directions, horizontally as well as vertically (similar to heat radiated from a stove). Fuels too close to intense heat can be ignited even if they are not in contact by flame (see Figure 20).

Figure 20 – Fire Spread Across Fireline By Radiation



Convection is transmission of heat by currents of air. Convection currents preheat the fuel ahead of a fire (across and/or above the fireline) and make the fuel easier to ignite (see Figure 21). If too close, fuel can actually be ignited by convection currents.

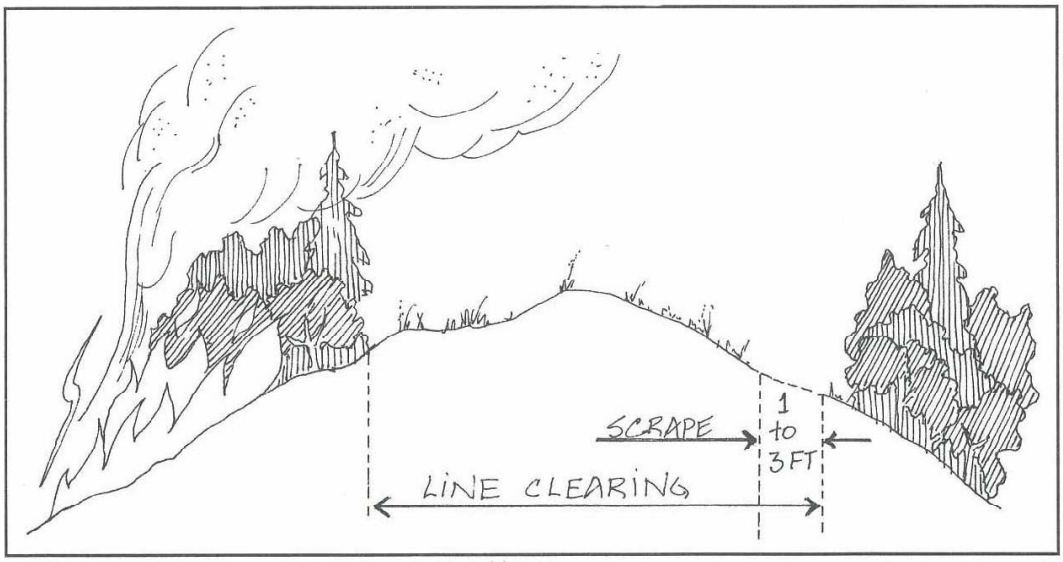
Figure 21 – Fire Spread Across Fireline By Convection



Anything that affects how a fire burns must be considered in deciding the width of fireline needed to hold or control a fire. The hotter or faster the fire burns, the wider the control line must be. Six important factors in determining fireline width are: 1) fuel, 2) slope, 3) weather, 4) part [head, flanks, rear] of fire, 5) size of fire, and 6) possibility of cooling.

The width of a fireline is generally accomplished by clearing and scraping (see Figure 22). Brush, trees, and logs must be removed by clearing a strip wide enough to prevent the flames, radiation or convective heat or any combination of the three from igniting fuel across the fireline. All flammable material must be removed by scraping to mineral soil a strip wide enough to prevent fire from spreading through roots and other ground fuel across the fireline. The scraped strip must be placed on the outside (side away from the fire) of the cleared strip.

Figure 22 – Fireline Showing Cleared and Scraped Area



A general guideline for determining the width of a fireline is that it should be one and one half times as wide as the dominate fuel is high. The scraped portion of a fireline is generally one to three feet wide. However, in timber a fireline is generally 20 to 30 feet wide with a three to four foot scrape. A fireline in timber should be constructed to stop the burning surface and lower aerial fuels. Most firelines will be unsuccessful in stopping a crown fire in timber.

COYOTE TACTIC

The "coyote tactic" consists of a progressive line construction technique involving self-sufficient crews who build fireline until the end of an operational period, remain overnight (RON) at/near that point, and then begin again on the next operational period. Crews should be properly equipped and be prepared to spend several shifts on the line with minimal support from the incident base.

Operations and Logistical Considerations

1. Meals during "coyote tactic" operational periods may consist of rations and/or sack lunches.

2. The "coyote tactic" generally will not last over three or four operational periods for any one crew.

3. Division supervisors will be responsible for establishing on and off operational period times.

4. Operations personnel will ensure that crews understand "coyote tactic" policy before the crews go to the line.

5. Crews working "coyote tactic" operational periods will be re-supplied on the fireline as close as possible to the RON point.

Coyote Tactic Guidelines

1. Can "coyote tactic" meet the Fire Orders, Watch Out Situations and LCES?

2. Can emergency medical technicians (EMTs) be provided on the line?

3. Can a timely medivac plan be implemented?

4. Can daily communications (verbal and written) be maintained?

5. Can daily logistical support of food and water be provided?

6. Does each individual crew boss feel comfortable with the assignment?

Crew bosses, strike team/task force leaders and division supervisors should consider the following prior to and during a coyote assignment:

1. Operations personnel should consider bringing with them in their gear a toothbrush/paste, extra pair of socks/underwear, light coat, double lunch, space blanket, etc.

2. Anticipating early in the operational period where the crew(s) will remain overnight (RON) and that the RON location provides for safety and logistical needs of the crew, i.e., main fire poses no threat, helicopters can long line or land at site, personnel are provided semi-flat ground to sleep on, there is adequate firewood for warming fires, etc.

3. Anticipating re-supply needs early in the operational period and placing those orders early through appropriate channels. Crew leaders should make arrangements to have qualified individuals at RON locations to accept those orders by long line or internal helicopter operations.

4. Bears may be a valid concern in some areas and personnel should take appropriate measures to prevent problems with food, trash, etc. It is a common practice to leave one or more individuals with radio communications at the RON location to coordinate the "back haul" of trash or the pre-positioning of re-usable supplies to advanced RON locations.

5. How will crew time and commissary items be managed during the operation? Normally this function can be provided by using in/out bound helicopter flights at the RON location, or the time is turned in upon returning to the incident base.

6. How will medical emergencies be managed during the operation? An emergency medical technician may need to be provided at the RON location.

HANDCREW PRODUCTION RATES

Table 1 shows average overall handcrew production rates for initial attack. Table 2 shows Type 1 and 2 handcrew production rates for sustained attack. Remember, these tables are guidelines only as there are many factors that influence a handcrew's fireline production.

Table 1 – Handcrew Production, Initial Attack

(Chains per hour per person)

Fire behavior fuel model		Conditions used in	Construction rate
1	Short grass	Grass Tundra	1.0
2	Open timber Grass understory	All	3.0
3	Tall grass	All	0.7
4	Chaparral	Chaparral High pocosin	0.4 0.7
5	Brush (2 feet)	All	0.7
6	Dormant brush/ hardwood slash	Alaska black spruce All others	0.7 1.0
7	Southern rough	All	0.7
8	Closed timber litter	Conifers Hardwoods	2.0 10.0
9	Hardwood litter	Conifers Hardwoods	2.0 8.0
10	Timber (litter and understory)	All	1.0
11	Light logging slash	All	1.0
12	Medium logging slash	All	1.0
13	Heavy logging slash	All	0.4

Table 2 – Handcrew Production, Sustained Attack

Chains per hour per crew (Chains per hour per person)

Fire behavior fuel model		Conditions used in	Crew category Type 1	Type 2
1	Short grass Tundra	Grass	30 (1.50)	18 (0.90)
2	Open timber/ grassy understory	All	24 (1.20)	16 (0.80)
3	Tall grass	All	5 (0.25)	3 (0.15)
4	Chaparral High pocosin	Chaparral	5 (0.25)	3 (0.15)
5	Brush (2 feet)	All	6 (0.30)	4 (0.20)
6	Dormant brush/ hardwood slash	Black spruce	7 (0.35)	5 (0.25)
7	Southern rough	All	4 (0.20)	2 (0.10)
8	Closed timber litter Hardwoods	Conifers	7 (0.35)	5 (0.25)
9	Hardwood litter Hardwoods	Conifers	28 (1.40)	16 (0.80)
10	Timber (litter and understory)	All	6 (0.30)	4 (0.20)
11	Light logging slash	All	15 (0.75)	9 (0.45)
12	Medium logging slash	All	7 (0.35)	4 (0.20)
13	Heavy logging slash	All	5 (0.25)	3 (0.15)

FIRELINE EXPLOSIVES

Fireline explosives are linear explosives that enable crews to construct firelines under certain conditions much faster and with less environmental impact than conventional methods. The quality of line constructed varies from a nearly finished line in light brush or grass fuels to a lower quality line than required in heavy brush and slash fuel types. However, even in heavy brush and slash the cleaning action of explosives can enhance access and effectiveness of fire crews who finish the line. Fireline explosives are also effective in falling hazard trees during line construction, but even more so during the mopup and rehabilitation of a fire.

All fireline explosives are tested by the Bureau of Mines to ensure that they will not accidentally detonate in conditions found in the field. They are impact tested to insure that they will not detonate when paracargoed even if the parachute fails to deploy. They will not detonate when shot with a 30 caliber projectile and they will not mass detonate if accidentally caught on fire. Only those fireline explosives that pass the tests and that are accepted on the qualified products list can be used for this activity. In conjunction with fireline explosives, the exploding bridgewire detonator (EBW) system is exclusively used to ensure the safest system for building firelines.

Advantages of Fireline Explosives

As labor and overhead costs rise, fireline blasting offers real time savings. Smaller crews may be used to suppress fires because less cutting and/or digging hand line is required, particularly in heavy fuels or ground cover. Increased speed of building the line can save wildland resources. Sometimes smaller crews equipped with explosives can be delivered to a fire faster than larger, conventionally equipped crews. Other advantages include:

- Brush and other debris (fuel and slash) are scattered rather than piled next to the finished line.

- Mineral soil in the line is loosened and easy to dig for use in hotspotting and mopup.

- A fine layer of soil dusts fuels close to the line and acts as a retardant. Blasting is generally more environmentally sound than using hand tools or dozers.

- Fireline explosives can be paracargoed into extremely remote locations.

Disadvantages of Fireline Explosives

- Use of explosives for fuels management or wildfire projects can be limited by lack of adequate explosive storage facilities.

- Personnel using fireline explosives must be carefully selected and thoroughly trained.

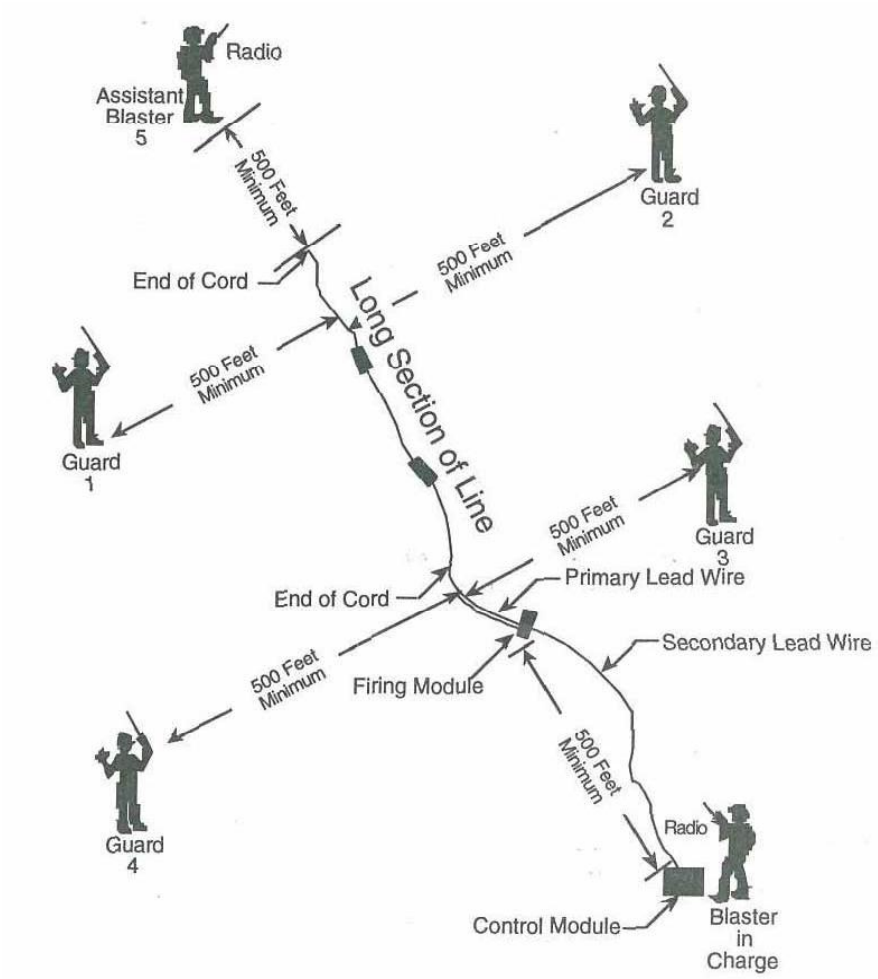
- Transportation and handling demand special precautions.

- Cost (very expensive)

Procedures

A typical blasting team is made up of the Blaster-In-Charge, Assistant Blaster, and Guards/Flaggers (see Figure 23). Guards are numbered by the Blaster-in-Charge.

Figure 23 – Example of Explosive Layout and Placement of Guards



The Blaster-in-Charge will plan communications with designated blasting team regarding:

- Safety

- Layout and firing procedures

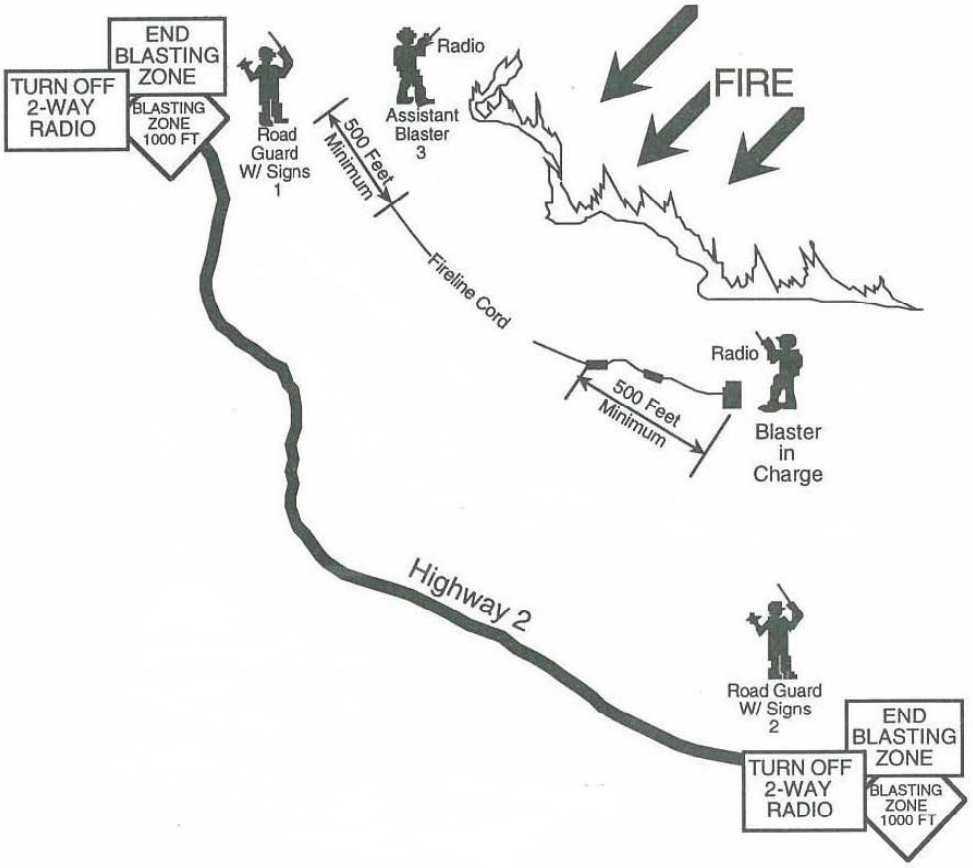
- Location of guards and/or flaggers

- Length of explosive that can be safely guarded and controlled

The blasting team should have a clear channel while in actual operations. Each team member should have a radio.

The Blaster-in-Charge must brief the team and ensure good communications within the blasting team and with personnel in the division using fireline explosives (see Figure 24). Guards are numbered by the Blaster-in-Charge.

Figure 24 – Example of Placement of Guards When Blasting
Close to Roads or Any Public Facility



MOPUP

After primary fireline construction is completed many things remain to be done to make the fireline "safe" and put the fire out. This work is called mopup. The objective of mopup is to put out all fire embers or sparks to prevent them from crossing the fireline.

A certain amount of mopup work is done along with line building. Mopup becomes an independent part of firefighting as soon as the spread of the fire is stopped and all line has been completed. Ordinarily, mopup is composed of two actions; putting the fire out, and disposing of fuel either by burning to eliminate it, or removing the fuel so it cannot burn.

The principles of mopup are as follows:

Start work on each portion of fireline just as soon as possible after the fireline has been constructed and burning out is completed. Treat the most threatening situations first.

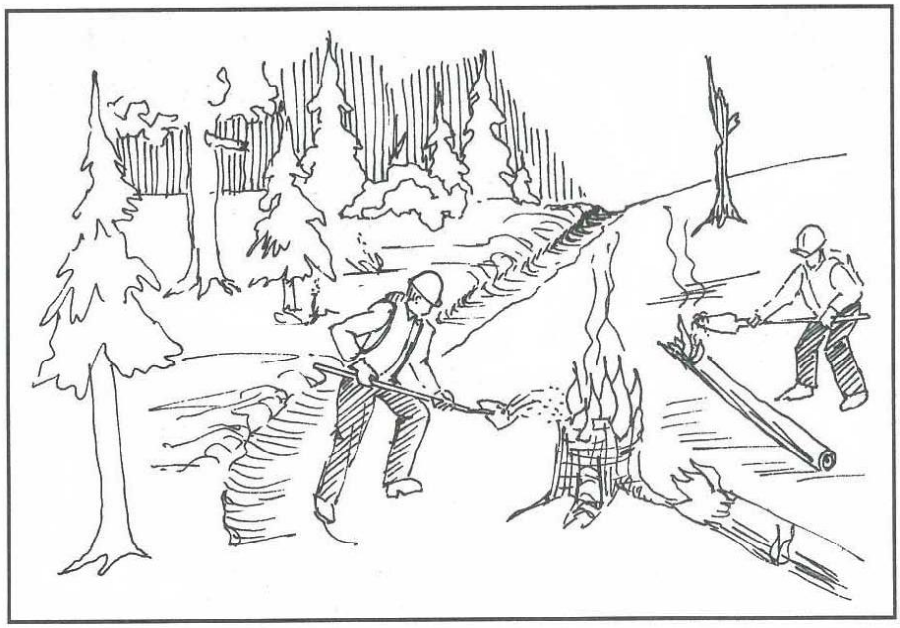
Allow fuel to burn up if it will do so promptly and safely.

On small fires, all fire should be extinguished in mopup, whenever quantities of burning material are not so large as to make this impracticable.

Mopup considerations on large fires include potential/predicted weather and fire behavior, fuels involved, social impacts, etc. Generally the fire perimeter is mopped up a specified distance; i.e., 100 feet, 500 feet, etc.

On large fires, completely mop up enough of the area adjacent to the line to be certain no fire can blow, spot, or roll over the fireline under the worst possible conditions anticipated (see Figure 25).

Page 45 Figure 25 – Mopup Area Adjacent To Line



Search for smoldering spot fires.

All smoldering material not put out with water or dirt should be spread well inside the fireline.

Consider potential for problems from snags, punky logs, and fuel concentrations outside of the fireline

Look for and dig out burning roots near the fireline.

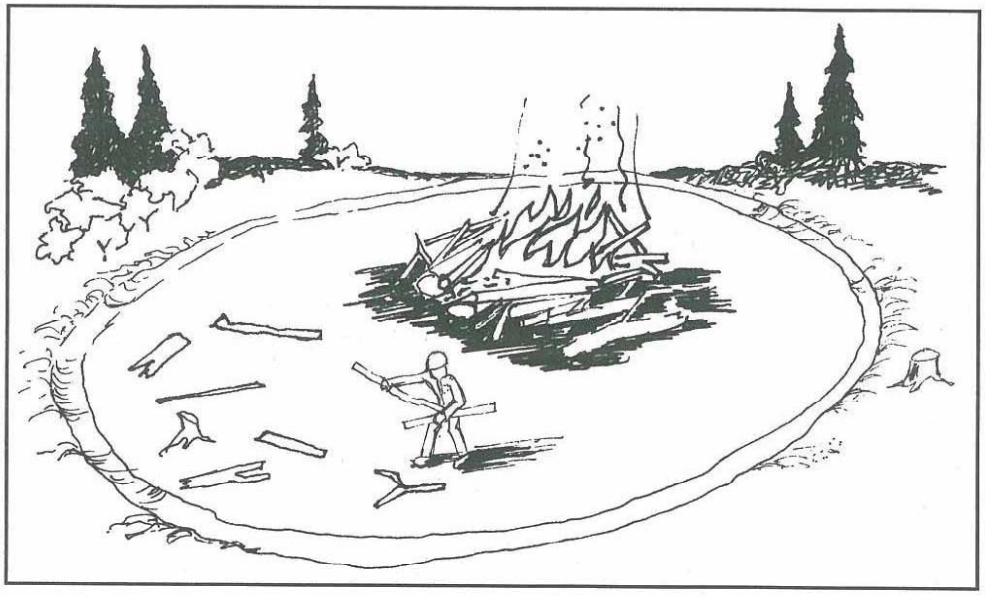
Use water wherever possible and practical in mopup.

Use water sparingly, but use enough to do the job. Match the amount of water to the job. Let no person use water alone, but always with another person with a hand tool to scrape or stir the fuel while applying water.

Add wetting agents to water to mop up deep burning fuels such as peat, duff or needles. Scrape or stir the fuel while applying water. In dry mopup, stir and mix hot embers with dirt.

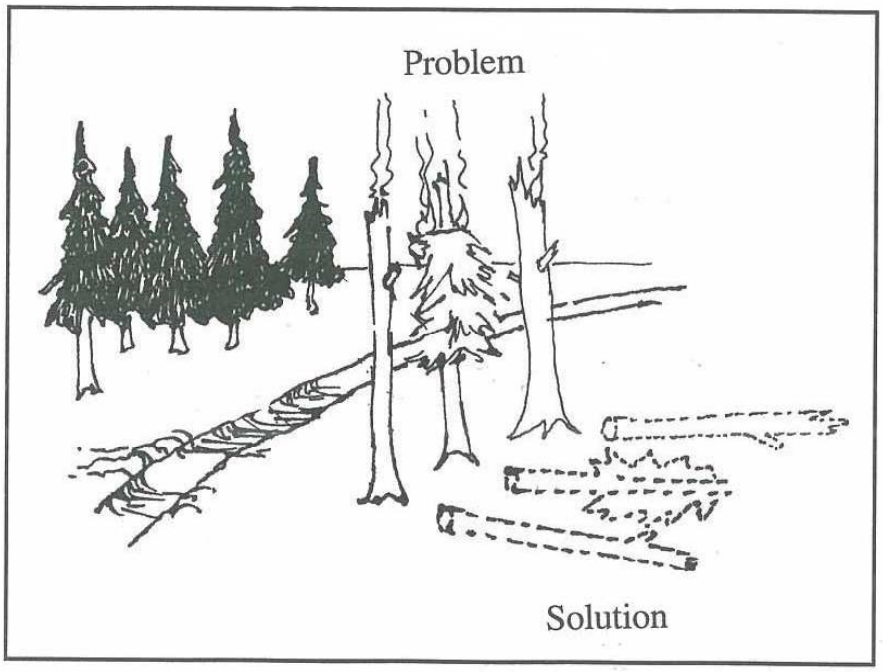
Separate masses of large fuel to reduce heat and danger of spotting.

Figure 26 – Separate Masses of Large Fuel



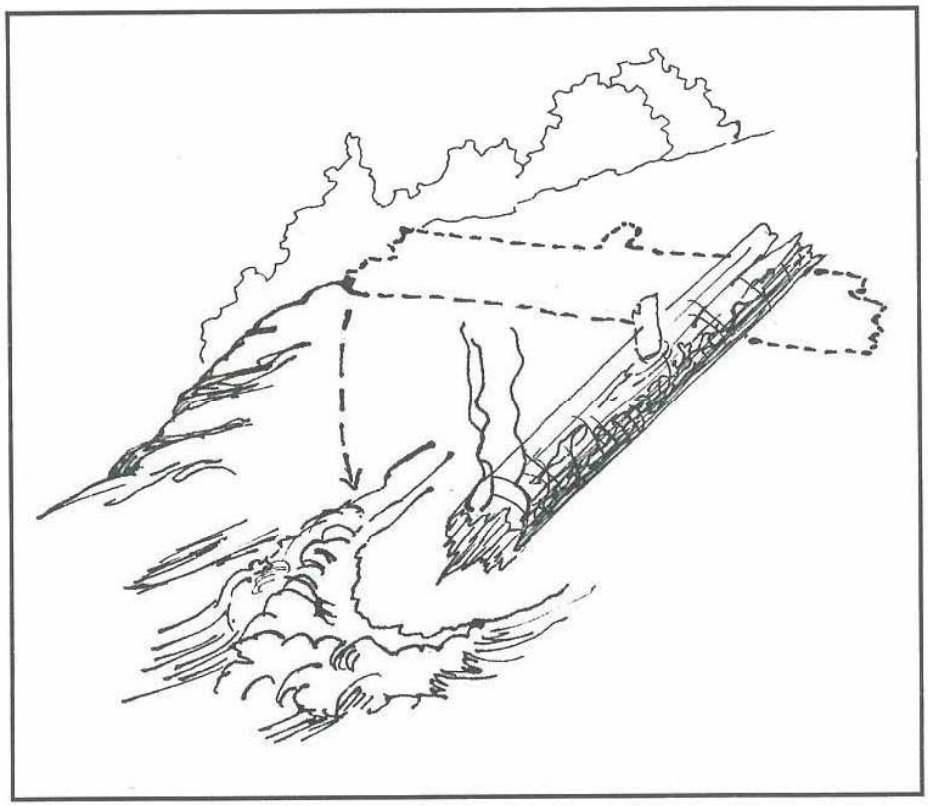
Eliminate all snags inside the fireline that could result in spotting or fire spread across the fireline (see Figure 27). Exercise extreme caution when working near snags as they can fall over anytime.

Figure 27 – Eliminate Problem Snags



Put all rolling material into such a position it cannot possibly roll across the fireline (see Figure 28).

Figure 28 – Turn Logs Perpendicular To Slope



Dig trenches immediately below all heavy material which might roll across the fireline.

Look for indications of hot spots. Some indicators are gnats swarming, white ash, ground which shows pin holes, and wood boring insects. Feel with hands for possible smoldering spots. Use caution to prevent burning of hands and/or fingers.

Portable infrared devices may be available to assist in locating "hot spots." If so, use with a trained operator.

MINIMUM IMPACT SUPPRESSION TACTICS (MIST)

The following guidelines for MINIMUM IMPACT SUPPRESSION are for agency administrators, incident management teams, and firefighters to consider. Some or all of the items may apply, depending upon the situation.

Managers and firefighters need to ask, "Are suppression and mopup tactics commensurate with the fire's potential to spread and cause resource damage in this land allocation? What tactics are adequate for the behavior of this fire? Are our tactics causing long-term adverse impacts on the land? Will MIST compromise firefighter safety?'

One evident tactic is the choice of fireline to use. There are good examples where cattle trails in fine fuels on 30% slopes were used as fireline and as the anchoring point for burnout. There are bad tactical examples in similar or lighter fuels where blade-wide dozer lines were used. In some cases, several blade-wide parallel dozer lines through grass/scab areas were made. Dozer lines are now in places where vehicle trails did not exist, thus opening additional area to possible destructive vehicle use.

Good tactical examples exist on easily accessible ground where fire spread was halted by engines driven along the fire perimeter using water for holding and extinguishing fire spread. In similar situations, bad examples exist where dozer lines were constructed parallel to existing gravel roads that could have served as adequate firelines.

Another very evident tactic that causes long-term lasting impact and resource loss is tree cutting. A bad tactical example exists in a situation, where up to 400 yards inside the fire's perimeter, living ponderosa pine that had minimum fire in the base have been cut. Instead of using hand pumps and/or dirt, the chain saw served as a means to extinguish the fire from the base of these trees, which often have evidence of past fires extinguished naturally or by some other means. The question needs to be asked. "Even if a tree is on fire and may never be used for timber volume, why is it being cut?" Dead, standing trees are acknowledged as a resource for some specific management objectives.

Consider

COMMAND AND GENERAL STAFF

- Evaluate each and every suppression tactic during planning and strategy sessions to see that they meet agency administrator objectives and minimum impact suppression guidelines.

- Include agency resource advisor and/or local representative in above sessions.

- Discuss MIST with other overhead during operational period briefings, to gain full understanding of tactics.

- Ensure MIST are implemented during line construction **as** well as other resource disturbing activities.

PLANNING SECTION

- Use resource advisor to evaluate that suppression tactics are commensurate with land/resource objectives, and incident objectives. Use an assessment team for a different perspective of the situation.

- Use additional consultation from "publics" or someone outside the agency, especially if the fire has been, or is expected to be, burning for an extended period of time.

- Adjust line production rates to reflect the minimum impact suppression tactics.

- Use brush blade for line building-when dozer line is determined as necessary tactic.

- Leave some trees randomly in fireline.

- Ensure that instructions for minimum impact suppression tactics are listed in the Incident Action Plan.

- Detail objectives for extent of mopup necessary - for instance:
"_____ distance within perimeter boundary."

- If helicopters are involved, use long line remote hook in lieu of helispots to deliver/retrieve gear.

- Anticipate fire behavior and ensure all instructions can be implemented safely.

- Consider coyote camps versus fixed camp site in sensitive areas.

- If extremely sensitive area, consider use of portable facilities (heat/cook units, latrines).

OPERATIONS SECTION

- Emphasize minimum impact suppression tactics during each operational period briefing.

- Encourage strike team leaders and crew superintendents to provide input on firefighter safety as it relates to MIST.

- Explain expectations for instructions listed in Incident Action Plan. Consider showing minimum impact suppression slide-tape program or video to the crews upon arrival at airport/incident.

- Consider judicious use of helicopters-consider long lining instead of helispot construction.

- Use natural openings so far as practical.

- Consider use of helibucket and water/foam before calling for air tanker/retardant.

- Monitor suppression tactics/conditions.

LOGISTICS SECTION

- Ensure actions performed around areas other than incident base, i.e., dump sites, camps, staging areas, helibases, etc., result in minimum impact upon the environment.

DIVISION/GROUP SUPERVISOR AND STRIKE TEAM/TASK FORCE LEADER

- Ensure crew superintendents and single resource bosses understand what is expected.

- Discuss minimum impact tactics with crew,

- Ensure dozer and falling bosses understand what is expected. If helicopters are involved, use natural openings as much as possible; minimize cutting only to allow safe operation.

- Avoid construction of landing areas in high visitor use areas.

- Monitor suppression tactics/conditions.

CREW SUPERINTENDENTS

- Ensure/monitor results expected.

- Discuss minimum impact suppression tactics with crew.

- Provide feedback on implementation of tactics-were they successful in halting fire spread; what revisions are necessary.

- Look for opportunities to further minimize impact to land and resources during the suppression and mopup phase.

- Emphasize use of lookouts.

MIST Implementation Guidelines

Minimum impact suppression is an increased emphasis to do the job of suppressing a wildland fire while maintaining a high standard of caring for the land. Actual fire conditions and your good judgment will dictate the actions you take. Consider what is necessary to halt fire spread and ensure it is contained within the fireline or designated perimeter boundary.

SAFETY

- Safety is of utmost importance.

- Constantly review and apply the Watchout Situations and Fire Orders.

- Be particularly cautious with:

  -- burning snags you allow to burn down

  -- burning or partially burned live and dead trees

  -- unburned fuel between you and the fire

  -- hazard trees (identify them with either observer, flagging, and/or glow-sticks)

- Be constantly aware of the surroundings, of expected fire behavior, and possible fire perimeter one or two days hence.

FIRELINING PHASE

- Select procedures, tools, equipment that least impact the environment.

- Give serious consideration to use of water as a firelining tactic (fireline constructed with nozzle pressure, wetlining)

- In light fuels:

  -- cold-trail line

  -- allow fire to burn to natural barrier

  -- consider burn out and use of gunnysack or swatter

  -- constantly recheck cold trailed fireline

-- if constructed fireline is necessary, use minimum width and depth to check fire spread

- In medium/heavy fuels:

  -- consider use of natural barriers and cold-trailing

  -- consider cooling with dirt and water, and cold-trailing

  -- if constructed fireline is necessary, use minimum width and depth to check fire spread

  -- minimize bucking to establish fireline; preferably build line around logs

- Aerial fuels:-brush, trees, and snags:

  -- adjacent to fireline: limb only enough to prevent additional fire spread

  -- inside fireline: remove or limb only those fuels which if ignited would have potential to spread fire outside the fireline

  -- brush or small trees that are necessary to cut during fireline construction will be cut flush with the ground

- Trees, burned trees, and snags:

  -- MINIMIZE cutting of trees, burned trees, and snags

  -- live trees will not be cut, unless determined they will cause fire spread across the fireline or seriously endanger workers. If tree cutting occurs, cut stumps flush with the ground

  -- scrape around tree bases near fireline if hot and likely to cause fire Spread

  -- identify hazard trees with either an observer, flagging and/or glowsticks

- When using indirect attack:

    -- do not fall snags on the intended unburned side of the constructed fireline, unless they are an obvious safety hazard to crews working in the vicinity

    -- on the intended bum-out side of the line, fall only those snags that would reach the fireline should they burn and fall over. Consider alternative means to falling, i.e., fireline explosives, bucket drops.

    -- review items listed above (aerial fuels; brush, trees, and snags)

MOPUP PHASE

- Consider using 'hot-spot' detection devices along perimeter (aerial or hand-held).

- Light fuels:

    -- cold-trail areas adjacent to unburned fuels.

    -- do minimal spading; restrict spading to hot areas near fireline only.

    -- use extensive cold-trailing to detect hot areas.

- Medium and heavy fuels:

    -- cold-trail charred logs near fireline; do minimal scraping or tool scarring.

    -- minimize bucking of logs to check for hot spots or extinguish fire: preferably roll the logs.

    -- return logs to original position after checking or ground is cool.

    -- refrain from making boneyards: burned/partially burned fuels that were moved should be arranged in natural positions as much as possible.

    -- consider allowing larger logs near the fireline to bum out instead of bucking into manageable lengths. Use lever, etc., to move large logs.

- Aerial fuels-brush, small trees and limbs

    -- remove or limb only those fuels which, if ignited, have potential to spread fire outside the fireline.

- Burning trees and snags

    -- If possible allow burning trees/snags to burn themselves out or down. (Ensure adequate safety measures are implemented and communicated.)

    -- identify hazard trees with either an observer, flagging, and/or glowsticks.

    -- if burning trees/snags pose serious threat of spreading fire brands, extinguish fire with water or dirt. FELLING by chain saw will be last means--consider falling by blasting, if available.

CAMP SITES AND PERSONAL CONDUCT

- Use existing campsites if available.

- If existing campsites are not available, select campsites that are unlikely to be observed by visitors/users.

- Select impact-resistant sites such as rocky or sandy soils, or opening within heavy timber. Avoid camping in meadows, along streams or lake shores.

- Change camp location if ground vegetation in and around the camp shows signs of excessive use.

- Do minimal disturbance to land in preparing bedding and campfire sites. Do not clear vegetation or do trenching to create bedding sites.

- Toilet sites should be located a minimum of 200 feet from water sources. Holes should be dug 6-8 inches deep.

- Select alternate travel routes between camp and fire if trail becomes excessive.

- Evaluate coyote camps versus fixed camp site in sensitive areas.

RESTORATION OF FIRE SUPPRESSION ACTIVITIES

- Firelines

  -- after fire spread is secured, fill in deep and wide firelines, and cup trenches.

  -- waterbar, as necessary, to prevent erosion, or use woody material to act as sediment dams.

  -- ensure stumps from cut trees/large size brush are cut flush with ground.

  -- camouflage cut stumps, if possible.

  -- any trees or large size brush cut during fireline construction should be scattered to appear natural.

- Camps

  -- restore campsite to natural conditions as much as possible.

  -- scatter fireplace rocks, charcoal from fire; cover fire ring with soil; blend area with natural cover.

  -- pack out all garbage and unbumables.

- General

  -- remove all signs of human activity (plastic flagging, small pieces of aluminum foil, litter).

  -- restore helicopter landing sites.

  -- cover, fill in latrine sites.