Firing Techniques

General

Various firing techniques can be used to accomplish a burn objective. The technique chosen must be correlated closely with burning objectives, fuels, topography, and weather factors to prevent damage to forest resources. The proper technique to use can change as these factors change. Atmospheric conditions should be favorable for smoke to rise into the upper air and away from smoke-sensitive areas such as highways, airports, and urban areas.

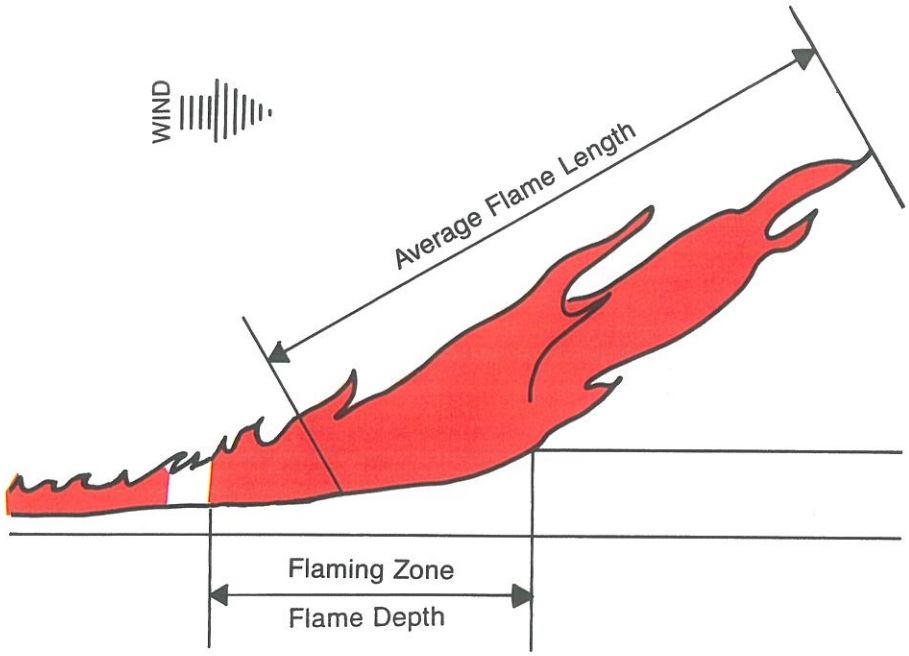
Based on behavior and spread, fires either move with the wind (heading fire), against the wind (backing fire), or at right angles to the wind (flanking fire). The movement of any fire can be described by these terms. For example, a spot fire would exhibit all three types. Heading fire is the most intense because of its faster spread rate, wider flaming zone, and longer flames. Backing fire is the least intense, having a slow spread rate regardless of windspeed. This type of fire has a narrow flaming zone, and short flames. Flanking fire intensity is intermediate. The slope of the land has an effect on rate of spread similar to that of wind.

If you encounter slight variations in fuel volumes or weather conditions, consider combining two or more firing techniques to achieve the desired result. A solid line of fire always spreads faster and thus builds up intensity quicker than does a series of spot ignitions spaced along the same line. Intensity increases abruptly when two fires burn together. The magnitude of this increase is greater when fires converge along a line rather than along a moving point. The line of crown scorch often seen paralleling a downwind control line delineates the zone where a heading fire and a backing fire met.

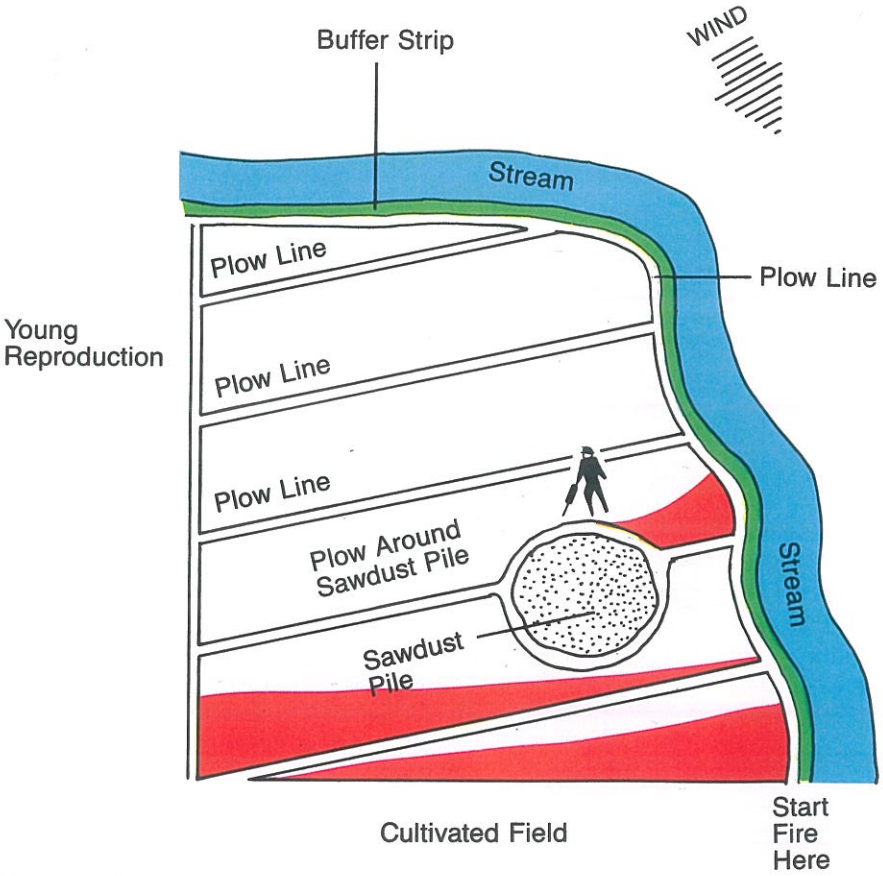
Residence time is the time it takes the flaming zone to move past a given point. The residence time of heading and backing prescribed fires is often about the same because the deeper flame depth of a heading fire compensates for its faster movement. Generally, backing fires consume more forest floor fuels than do heading fires. The total heat applied to a site may be roughly equal for both heading and backing fires, as long as additional fuels are not involved. This result can be expected even though the fireline intensity of the heading fire would be greater. In a backing fire, the released heat energy is concentrated closer to the ground.

Using a driptorch

Heading fire may be used with light fuel loadings



Flame dimensions for a wind-driven fire



Backing fire technique

Backing Fire

A backing fire is started along a baseline (anchor point), such as a road, plow line, stream or other barrier, and allowed to back into the wind. Variations in windspeed have little effect on the rate of spread of a fire burning into the wind. Such fires proceed at a speed of 1 to 3 chains per hour. Backing fire is the easiest and safest type of prescribed fire to use, provided windspeed and direction are steady. It produces minimum scorch and lends itself to use in heavy fuels and young pine stands.

Major disadvantages are the slow progress of the fire and the increased potential for feeder-root damage with increased exposure to heat if the lower litter is not moist enough. When a large area is to be burned, it often must be divided into smaller blocks with interior plow lines (usually every 5 to 15 chains). All blocks must be ignited at about the same time to complete the burn in a timely manner. In-stand winds of 1 to 3 mph at eye level are desirable with backing fires. These conditions dissipate the smoke and prevent heat from rising directly into tree crowns.

When the relative humidity is low, a steady wind is blowing, and fuels are continuous, an excellent burn can be anticipated once the fire backs away from the downwind control line. Under such conditions, however, extra care must be taken to make sure the initial fire doesn't spot across the line.

Factors Associated with Backing Fires:

- Must be ignited along the downwind control line.
- Use in heavy roughs.
- Use in young stands (minimum basal diameter of 3 inches) when air temperature is below 45°F.
- Normally result in little scorch.
- Costs are relatively high because of additional interior plow lines and extended burning period resulting from slower movement of the fire.
- Not flexible to changes in wind direction once interior lines are plowed.
- Requires steady in-stand winds (optimum: 1 to 3 mph).
- Will not burn well if actual fine-fuel moisture is above 20 percent.
- Requires good fuel continuity to carry well.
- A single torch person can progressively ignite lines.

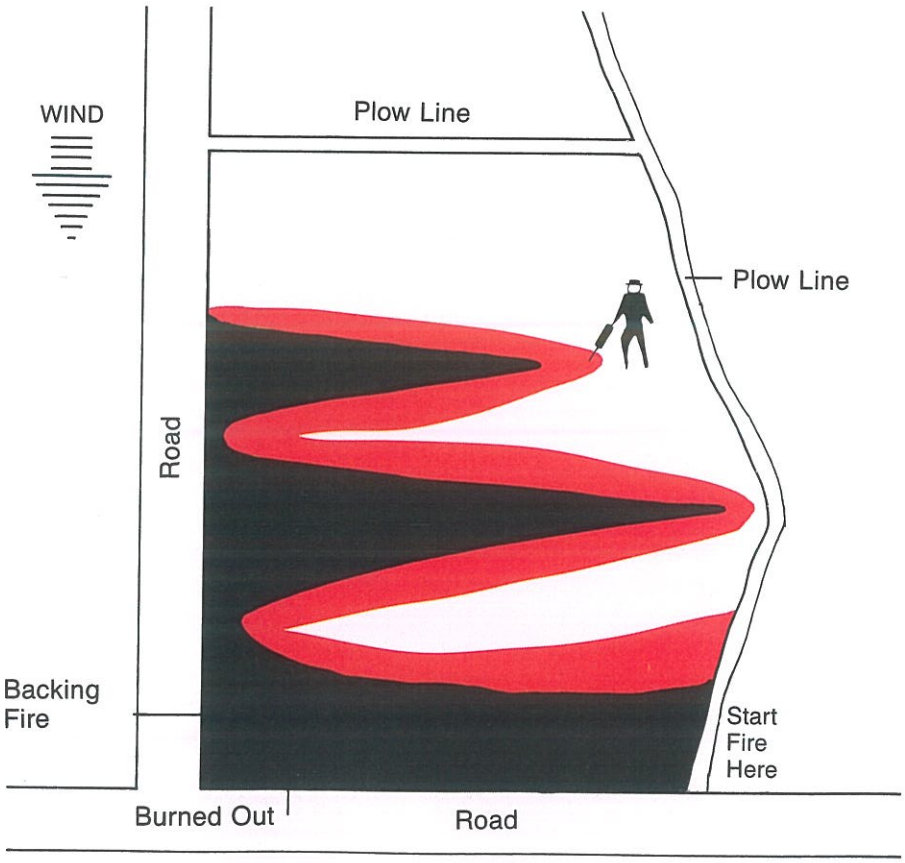
Strip-Heading Fire

In strip-headfiring, a series of lines of fire are set progressively upwind of a firebreak in such a manner that no individual line of fire can develop to a high energy level before it reaches either a firebreak or another line of fire. A backing fire is generally used to secure the base line and the remainder of the area then treated with strip-heading fires. Strips are often set 1 to 3 chains apart. The distance between ignition lines is determined by the desired flame length. This distance can be varied within a fire to adjust for slight changes in topography, stand density, weather, or the type, amount or distribution of fuel. Compensation for minor wind direction changes can be made by altering the angle of strip fire with the base line. Treat major changes in fuel type separately. An effective method of reducing fire intensity is to use a series of spots or short 1- to 2-foot-long strips instead of a solid line of fire. An added advantage of these short strips or spots is that driptorches will not have to be filled as often. Strip-heading fires permit quick ignition and burnout, and provide for smoke dispersal under optimum conditions. However, higher intensities will occur wherever lines of fire burn together, increasing the likelihood of crown scorch.

Occassionally, on areas with ***light*** and ***even*** fuel distribution, a heading fire may be allowed to move over the entire area without stripping to better accomplish the objective(s). This method reduces the number of areas of increased fire intensity that occur each time two fires burn together. **Caution:** Be sure the fire will not escape control. **First** set a backing fire along the downwind control line and allow it to burn out a strip wide enough to control the heading fire.

Factors Associated with Strip-heading Fires

- Secure the downwind base line before igniting a heading fire.
- Do not use in heavy roughs. Consider alternative techniques if fire-free interval exceeds 3 years.
- Winter use is best because cool weather (below 60°F) helps avoid crown scorch.
- Use in medium-to-large sawtimber. May be used for annual plantation maintenance burns after initial fuel reduction has been accomplished.
- Can be used in "flat" fuels such as hardwood leaves.
- Is a good method for brownspot control.
- Because fire movement is fast, large blocks can be burned.
- Can be used with high relative humidity (50 to 60 percent) and high actual fine-fuel moisture (20 to 25 percent).
- Needs just enough wind to give direction (1 to 2 mph in-stand).
- Cost is lower than other line-firing techniques because fire progress is rapid and few plow lines are required.
- The technique can accommodate wind shifts up to about 45 degrees.
- Flame lengths increase whenever heading fire converges with a backing fire, thereby increasing the possibility of crown scorch.
- A single torch person can progressively ignite strips.
- Do not force a burn on a marginal day at the low end of the prescription window. The fire may burn slowly until after the crew leaves, then pick up intensity and escape.



Strip-heading fire technique

Flanking Fire

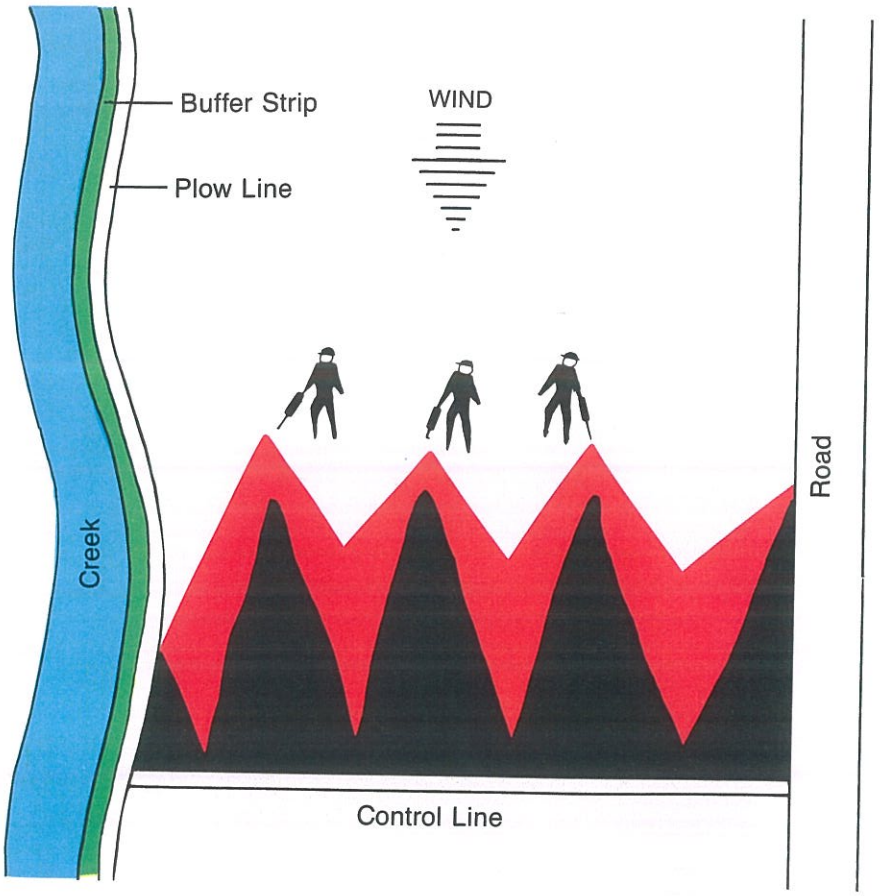
The flanking-fire technique consists of treating an area with lines of fire set directly into the wind. The lines spread at right angles to the wind. This technique requires considerable knowledge of fire behavior, particularly if used by itself. It is used quite often to secure the flanks of a strip-heading fire or backing fire as it progresses. It is sometimes used to supplement a backing fire in areas of light fuel or under more humid weather conditions. It is useful on a small area or to facilitate burning a large area in a relatively short time when a line-heading fire would be too intense.

This method of firing can stand little variation in wind direction and requires expert crew coordination and timing. For safety, all lines of flank fire should be ignited simultaneously and all torch people should keep abreast of one another. If only one or two torch people are available, this technique is usually altered to set the ignition lines 45 degrees into the wind.

In the Piedmont, any ignition line that drops perpendicularly off a ridge creates a flanking fire under no-wind conditions. If several lines are ignited off the end of a ridge or knoll, the pattern looks like a chevron or maple leaf.

Factors Associated with Flanking Fires:

- Always secure downwind base line first.
- Fuel loading should be light to medium—less than 8 tons per acre.
- Wind direction ***must*** be steady.
- Best used in medium-to-large sawtimber.
- Allows fast area ignition.
- Needs few control lines.
- In areas with a high understory, multiple torch people are needed and coordination is very important. Use radio communications whenever torch people cannot see one another.
- Useful in securing flanks of other fire types.



Flanking fire technique

Point Source Fires

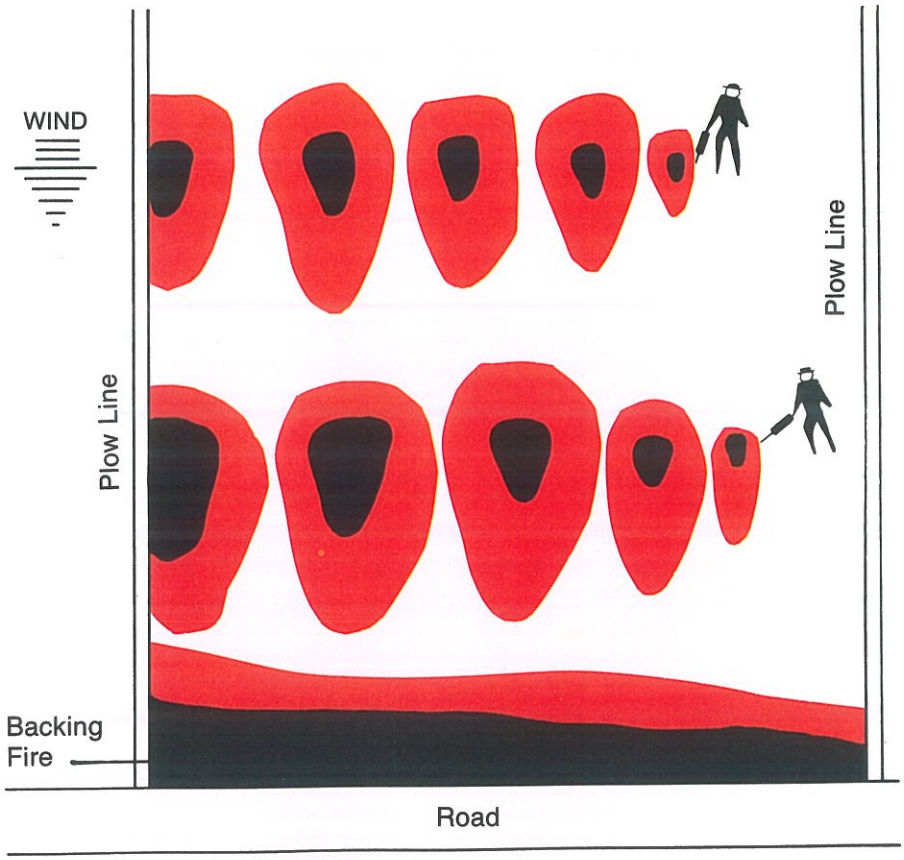
A prudent burning boss will often switch from strip-heading fires to point source fires as the day progresses and continuous lines of fire become too intense. When properly executed, a grid of spot ignitions will produce a fire with an intensity much greater than that of a line-backing fire but somewhat less than that of a line-heading fire. Timing and spacing of the individual ignition spots are the keys to the successful application of this method. First a line backing fire is ignited across the downwind side of the block and allowed to back 10 to 20 feet into the block to increase the effective width of the control line. A line of spots is then ignited at some specified distance upwind of the backing fire and the process continued until the whole block has been ignited.

To minimize crown scorch, ignition-grid spacing is selected to allow the spots along a line to head into the rear of the spots along the downwind line before the flanks of the individual spots merge to form a continuous flame front. The merger of successive ignition lines thus takes place along a moving point rather than along a whole line at the same time. Merger along a moving point can be ensured by beginning with a closely spaced square grid (2 chains by 2 chains is recommended). Close spacing between lines helps the individual spots develop, but ensures that the head of one spot will burn into the rear of the downwind spot before the heading fire's potential flame length and intensity are reached. Of course, the closer the spacing, the more merging points you have. You must be aware that a large number of small fires burning simutaneously can produce the same kind of explosive convective energy as a single large fire because too much heat energy is released too rapidly. This situation is discussed more fully under the section on Aerial Ignition.

Rectangular grids with wider spacing between lines than within a line should not be used initially because such a pattern may allow the spots along a line to merge into a line of heading fire before running into the rear of the downwind spots. Once the first few lines have been ignited and fire behavior has been assessed, intensity can be regulated to some extent by changing the time between ignition points within a line, the distance between points, and the distance between lines. Thus the balancing act between spacing and timing has to be continually adjusted as fire behavior reacts to both temporal and spatial changes in fuel and weather.

Intensity is decreased by widening the interval between ignition points along a line. If fireline intensity is still too high after doubling this interval while maintaining a 2-chain

Point source ignitions



Grid or point source ignition technique

distance between lines, firing should be halted. Allow the area to burn with a backing fire or plow it out. Although intensity at the head of an individual spot is increased by widening the distance between lines, the average intensity of the burn as a whole is usually somewhat lower. Check to see that convergence-zone flame lengths are within tolerable limits, and that other fire behavior parameters appear satisfactory. If everything is within prescription, you can increase both between- and within-line distances. This step will reduce ignition time, and decrease the number of ignitors used. The number of convergence areas with their higher intensities will also be decreased.

Experience to date shows grids up to 4 chains by 4 chains (one ignition point every 1.6 acres) can produce excellent results. The time needed to complete the burn can be reduced by offsetting successive ignition lines by one half of the within-line spacing. The heading fires from one line will then come up between the backing fires on the next line.

Factors Associated with Point Source Fires

- Assume much of the area will be burned by heading and flanking fires and very little by backing fires.
- If conditions are ideal for traditional line-backing fires, point source fires may be too intense.
- Preferred burning conditions include low (1-2 mph) in-stand windspeeds. Wind direction can be variable. Actual fine-fuel moisture should be above 15 percent.
- When underburning, start with a square ignition grid (equal distance between spots within a line and between flight lines). Two chains by 2 chains is often used.
- Always secure the downwind base line first.
- Be careful when underburning stands with a flammable understory or a heavy rough.
- Severe crown scorch is likely if fuel is too dry.
- Under the same weather conditions, fires in Piedmont fuel types tend to spread slower and be less intense than those in Coastal Plain fuel types.
- The usual changes in weather during a typical winter day may require modification of ignition patterns throughout the day. Burn until fires verge on getting "too hot." Then either quit burning or resort to backing fires only.
- Continually modify the ignition grid to take advantage of topography and changes in understory fuels.
- Costs are low because firing is rapid and no interior control lines need to be constructed.

Aerial Ignition

When ground ignition techniques are used, the downwind spots will usually coalesce and burn out before the whole block has been ignited. In contrast, aerial firing permits ignition of a block to be completed before the downwind spots have burned out. This does not present a problem at the damp end of the prescribed burning window when actual fine-fuel moisture is near 20 percent. Rapid ignition of a block reduces both flying time and the time needed to complete the burn. However, when using aerial ignition techniques under "traditional" ideal burning conditions for line-backing fires with actual fine-fuel moisture near 10 percent, rapid ignition of the entire area can result in an increase in fire intensity to unacceptable levels. You would then have little recourse except to let the area burn out and hope that damage is limited to just a loss in overstory growth.

Some experienced burners start firing early in the day, before the fuel is dry enough to carry fire well. They reduce the distance between spots within a line to less than 2 chains by 2 chains. The increased number of ignitions creates more heat and helps dry the surface fuels, especially when a helitorch is used. The distance between spots must be expanded as the morning progresses and burning conditions improve. Otherwise, the spots will merge laterally forming lines of heading fire that get too intense before reaching the next downwind line of ignition points. The distance between lines can also be increased as necessary to maintain a square ignition grid.

Current aerial ignition techniques can be separated into two major types: the DAID (Delayed Aerial Ignition Device) or ping-pong ball system, and the helitorch or flying driptorch system. The ping-pong ball system utilizes small plastic spheres containing potassium permanganate. The balls are injected with ethylene glycol and immediately jettisoned before the chemicals react thermally to produce a flame that consumes the ball. The dispensing machine can be mounted in small airplanes or helicopters. The ping-pong ball system works best in continuous fuels or in areas where a mosaic burn pattern is desired.

The helitorch is simply a giant driptorch and drum of gelled gasoline mounted or slung under a helicopter. The helitorch is well suited for discontinuous fuels such as those in clearcuts because this system emits a steady stream of burning fuel globs. It is very difficult to effectively regulate the spacing between these fuel globs. At least one gadget that apparently solves this problem is being marketed. Any helitorch not modified to effectively control the timing between the globs of burning fuel should be considered a line-firing device.

Both types of aerial ignition dramatically reduce the time needed for an area to burn out. Although roughly the same amount of smoke is produced, it is emitted over a shorter period and more of it is entrained in the convection column. Thus, the impact of any adverse air quality effects is much reduced.

Factors Associated with Aerial Ignition

- Rapid firing and burnout allows use of a much smaller prescription window.
- Damp, fine fuels are of critical importance. Actual fine-fuel moistures of 15 to 25 percent are preferable.
- Requires an experienced burning boss to make ignition grid adjustments and to determine when to halt ignition due to conditions.
- Although not likely under prescribed fire conditions, too much heat energy released over too short a period will result in a sudden, dangerous increase in fire intensity.
- Large acreages can be safely burned in a single burning period.
- Many widely dispersed tracts can be burned during a single day.
- A contingency plan is essential in the event the aircraft is reassigned or equipment breaks down during operation.

DAID (Delayed Aerial Ignition Device) dispenser mounted in helicopter

Helitorch in action

Factors Assoicated with Ping-pong Ball (DAID) System

- Best suited for continuous fuels or when a mosaic pattern is desired.
- Ignition spacing within and between flight lines can be easily adjusted.
- A 2 by 2 chain to 4 by 4 chain grid (one ignition point every 0.4 acre to one every 1.6 acres) works well in both palmetto/gallberry and Piedmont fuel types.
- When underburning Coastal Plain fuel types, actual fine-fuel moisture should be 20 to 25 percent (even higher in very heavy fuels) and the air temperature should be low, preferably below 50°F.
- In Piedmont fuel types, actual fine-fuel moisture contents between 10 and 15 percent and air temperature below 55°F work well.
- Make sure no DAID's are mistakenly dropped outside the burn as the helicopter turns at the end of each line.

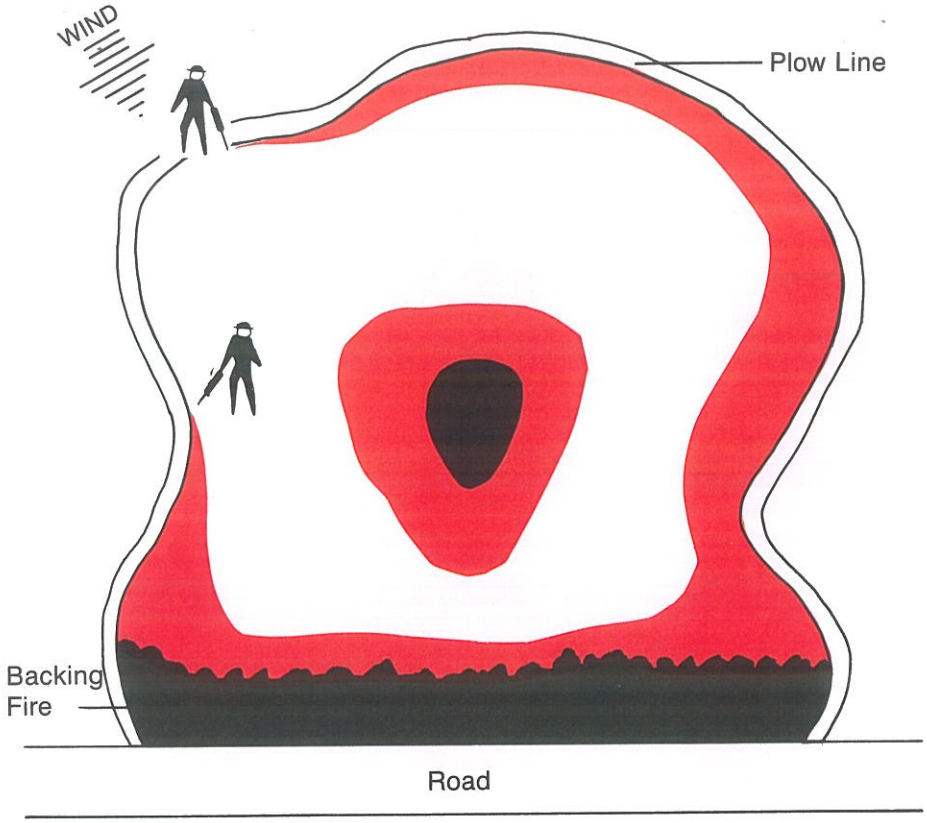
Factors Associated with Helitorch System

- Not as safe as the DAID system, but less expensive.
- If the torch and fuel tank is slung under rather than attached to the helicopter, a larger crew will be required.
- Creates disposal problems.
- Very difficult to regulate spacing within a flight line.
- Fuel-mixing viscosity is sometimes inconsistent due to temperature changes which, in turn, further aggravate in-line spacing of ignition spots.
- The most efficient firing technique for large, cleared areas with discontinuous fuels, including piled or windrowed debris.
- Use extreme caution when underburning Coastal Plain fuel types. Try to keep within-line ignition point interval to at least 2 chains.

Center and Circular (Ring) Firing

This technique is useful on cut-over areas where a hot fire is needed to reduce or eliminate logging debris prior to seeding or planting. It works best when winds, if any, are light and variable. This procedure should never be used for underburning because of the likelihood of severe tree damage as the flame fronts merge

As with other burning techniques, the downwind control line is the first line to be ignited. Once the base line is secured, the entire perimeter of the area is ignited and the flame fronts allowed to converge. One or more spot fires are often ignited near the center of the area and allowed to develop before the perimeter of the block is ignited. The convection generated by these interior fires creates indrafts that help pull the outer circle of fire toward the center. This firing method can generally be used in any season, and weather conditions are not as critical. However, caution is in order, particularly when the atmosphere is unstable. This type of fire tends to develop a strong convection column which can cause spotting a considerable distance downwind.



Ignite backing fire first, then center, and then perimeter.

Center firing technique

Pile and Windrow Burning

The objective of piling logging debris before burning it is to prolong fire residence time on a restricted area so that larger materials have time to be consumed. Some areas will contain an unacceptable amount of large, scattered debris that must be concentrated to ensure consumption. This material should be piled and not windrowed. Windrowing can reduce site quality by removing topsoil. Piedmont soils are also susceptible to compaction from the heavy equipment used, especially during wet weather. Full exposure of the soil to the sun and rain bakes the top layer. Furthermore, the direct force of raindrops will clog soil pores and often results in erosion on steep slopes. The area beneath the windrows is lost to production because the debris is rarely consumed completely and what remains makes planting difficult or impossible. Even when windrows contain breaks spaced every couple of chains, they still present a barrier to firefighting equipment and wildlife.

The biggest deterrent to windrow burning, however, is that it causes a high percentage of all smoke incidents. Large volumes of fuel, including larger pieces that contain a lot of moisture, are consumed. However, oxygen for good combustion is lacking, especially in large piles and wide windrows. Large amounts of soil are often mixed in, further compounding the problem. The result is a fire that continues to smolder for days or weeks, creating air quality problems because the smoke produced by smoldering combustion is not hot enough to rise into the atmosphere. The smoke stays near the ground where it cools even more, drifting and concentrating in low areas because of cool air drainage. To make matters worse, the smoke often mixes with humid air to produce fog which further reduces visibility. Coupled with these problems is the fact that the weather changes from day to day making it impossible to predict, and thus manage, the smoke for more than a day or two. For these reasons, air quality regulations prohibit pile and windrow burning in some areas.

Although it generally costs more to pile than to windrow, piles are preferable to windrows because access within the area is no problem, planting is easier, burning is safer and, most important, smoke problems are significantly reduced since piles burn out much quicker! Generally, piles contain less dirt and dry faster. Burning piles can easily be "bumped" to remove any dirt and pushed in to increase consumption. The whole area can then be utilized.

Keep piles small and minimize the amount of soil in them so surface water can pass through, and the debris can dry quickly. Always pile when the ground surface is dry; less soil compaction will take place, and considerably less soil will end up in the piles. Allow fresh logging debris to cure first and to dry after rain. Then "shake" the debris while piling to remove as much soil as possible. If material is piled while green or wet, the centers of the piles take an exceedingly long time to dry. Piles that contain little soil and are constructed to allow some air movement will

Tractor-mounted firing device for piled-debris ignition

Piles burn more efficiently than windrows

result in a burn that consumes significantly more of the debris and produces less smoke. More efficient burning and greater heat output will lift smoke higher, reducing smoke concentrations near the ground. Burn when the atmosphere is neutral to slightly unstable, but not unstable enough to create control problems.

Forest managers can take many steps to minimize these debris problems. Much of the larger material left after harvest is cull hardwood, and periodic use of underburns during the rotation will reduce the number of large hardwoods at harvest. Some of the cull material can often be sold or given away as firewood. Sites often can be prepared for seeding or planting by a broadcast burn without piling the debris. Trees should be cut close to the ground, leaving low stumps.

Advances in harvesting equipment and methods have also helped. Large mobile harvesters chip the whole tree, increasing utilization and reducing the need for site preparation. Tree-length logging and gate delimbing (backing a drag-load of trees between two posts) tend to concentrate much of the debris at the logging deck. Piles created in this manner are generally free of soil (providing logging was suspended in wet weather) and can be burned as is.

Techniques used in burning piled debris are somewhat fixed because of the character and placement of fuel. Traditionally, each pile is ignited along its perimeter, but burnout can be speeded up considerably by igniting the pile center. A helitorch is often used because burning globs of gelled gas penetrate deep into piled fuels and provide a "large" heat source. Tractor-mounted ignition devices that help burning fuel penetrate down toward the center of a pile have also been fabricated.

Factors Associated with Pile and Windrow Burning:

- A large majority of all smoke-related incidents are caused by this type of burning.
- Produces the most smoke of all firing techniques.
- Burns can continue to smolder for many weeks.
- Smoke produced at night tends to stay near the ground.
- Cannot be readily extinguished after ignition. If extinguished, even more effort is required to reignite them the next day.
- Can burn in light or variable winds.
- Usually safe and easy to control, provided piles are not next to the edge of the area and are not left unattended, particularly when burning during periods of high fire danger.
- Piles should be as free of soil as possible.
- Fuel should be dry.
- Burn area should be as small as economically practical.
- Need neutral to unstable conditions for good smoke dispersion – which generally do not occur after sunset.
- Need good mixing heights and transport winds.

Dirt in windrows can aggravate smoke management problems

Windrows can smolder for long periods of time