The Tallgrass Restoration Handbook

For Prairies, Savannas, and Woodlands

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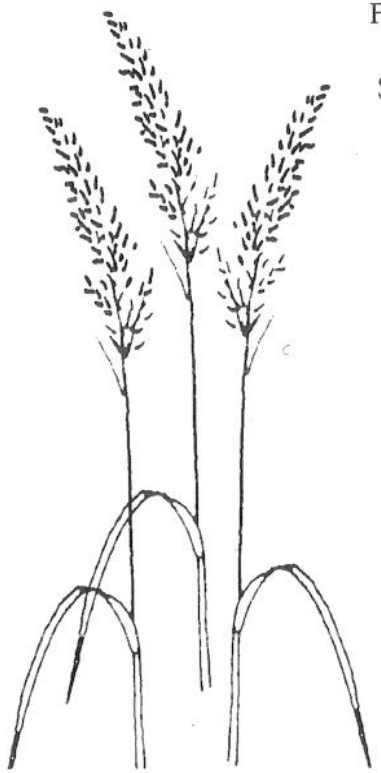
Society for Ecological Restoration



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Conducting Burns

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This chapter describes one style of conducting small prairie fires using hand-held equipment. It is aimed at the novice who has seen a few controlled burns and wants to know a little more. Obviously, just reading this chapter will not qualify you to conduct a controlled burn. Sign up for the prescribed burn courses offered by conservation groups and governmental agencies, and get practical experience by volunteering on burn crews. Burn leaders learn their craft through years of field experience.

A prairie fire burns in a long, narrow line of flames moving quickly through the grass. It is possible to walk several feet behind the flames without discomfort from heat or smoke because flames quickly consume dry grass and move forward for more fuel. Usually a line of fire carried with the wind (head fire) is 5–15 feet deep with flames that leap 8 feet or more, while fire burning into the wind (backfire) is only a foot deep with flames a foot high. But the description of a prairie fire varies considerably, depending on the kind and amount of fuel, height and moisture content of grasses, topography, slope, wind speed, humidity, etc.

The typical prairie fire doesn't exist because there are too many variables. The same prairie will not burn the same way twice, and the way it burns will change from morning to afternoon. Under proper conditions, a grass fire looks tame, but it reacts swiftly to change in wind direction, wind speed, and humidity. A change in wind direction will transform a creeping backfire into a blazing head fire, a doubling of wind speed will quadruple the rate of spread of the fire, and a reduction in relative humidity as a day warms makes a fire burn hotter and faster.

Never take fire for granted, because the worst danger is overconfidence. Under proper conditions of moisture and wind, fire can be controlled, but it is always dangerous. During a few seconds of inattention a fire can change from a safely controlled burn to a racing wall of flames.

There is no substitute for experience when working with fire. If you have never worked on a prairie fire, get experienced people to work with you. Contact local conservation organizations for permission to watch a controlled burn, or volunteer to help. Above all, start small. Your first burn should be no more than a fraction of an acre and planned with as much attention to detail as possible.

Fire History and Effects

Fire has influenced plant communities for millions of years. Furthermore, Native Americans increased fire frequency during the past five or six thousand years, especially in the eastern half of the United States, where lightning fires occur less often than in the West. Early inhabitants burned for many reasons, including improved game habitat, greater nut and berry production, and easier traveling.

Prairies exist in central North America because of the dry climate and periodic drought; along the more rainy eastern edge of the prairie (e.g., Illinois and Wisconsin) fires tip the balance toward prairie and away from forest. Savannas and open oak forests survive because of fire, without which brush and shade-tolerant trees would quickly invade. On the other hand, maple forests are damaged by the coolest ground fire. During a spring woodland walk, notice the dry, crinkled oak leaves ready to burn, while the maple leaves are wet, matted together, quickly decomposing, and ready to resist fire. Today fire is used as a management tool in part due to its historical role, but also because of low cost relative to other habitat management techniques such as mowing, herbicides, and chain-saw work.

The most obvious effects of a burn are easily seen. Fire rejuvenates a prairie; more plants flower, produce seed, grow taller, and are generally more robust than the previous year. Fire lengthens the growing season for most native prairie plants and shortens it for many Eurasian weeds. Fire increases available nutrients through indirect stimulation of microbial activity in the soil and by releasing a small amount of nutrients from the ash. Fire also controls the invasion of shrubs and trees.

Fire lengthens the growing season for warm-season native plants by burning off accumulated leaf litter in the spring and exposing a darkened soil surface to the warming rays of the sun. Without fire, the light-colored leaf litter reflects the sun's rays, insulates the ground like a blanket, and slows the soil-warming process. Most prairie plants grow best in warm soil, and the sooner the soil warms up, the sooner plants start growing. This may extend the growing season by as much as four weeks. Prairie plants are not damaged by a spring fire because most have buds that lie just beneath the soil, where they are protected.

In contrast, fire shortens the growing season for many Eurasian weeds (cool-season plants that originated in the meadows of Europe). Bluegrass, quack grass, and brome grass are examples of cool-season plants that are serious weeds in some prairies. These grasses are usually dormant during the heat of summer, and studies have shown that warm soil causes the roots of some cool-season grasses to stop growing.

As a result, the same fire that encourages warm-season plants discourages cool-season invaders by advancing the onset of warm soil temperatures. In addition, fire may induce water stress on drier prairies, and since prairie plants are better adapted to drought, they compete favorably with the cool-season meadow plants of Europe. Finally, a late-season prairie fire can burn off 3 to 8 inches of growth on the cool-season plants before prairie plants have even started growing.

These factors combine to shorten the growing season for cool-season weeds and give a competitive edge to prairie plants. Unfortunately, late-season burns also shorten the growing season for native cool-season grasses such as porcupine grass, June grass, and Canada wild rye. Although fire may reduce the dominance of these cool-season native plants, it will probably not eliminate them.

Fire controls woody invasion in two ways. First, fire stimulates prairie plants to form a vigorous sod, which prevents establishment of woody seedlings. Second, fire kills the above-ground parts of invading shrubs and trees. Deciduous trees and shrubs resprout from the roots, but red cedar and some pines are killed by fire. Repeated fires are needed to keep resprouting brush under control. Fire weakens brush but rarely eliminates it completely.

Almost any area that has prairie plants will benefit from a burn. Burn a planted prairie as soon as enough plant material has accumulated to carry a fire, which may take two or three years. Prairie seeds added to an old field or prairie planting often grow and flower if encouraged with fire and are most successful on drier sites. Increasingly, oak openings and oak woods are burned to increase light penetration, which seems to stimulate reproduction of wildflowers and oaks. The cool ground fire top kills young saplings of buckthorn, box elder, honeysuckle, etc., whose shade reduces reproduction of desirable species.

There are many plant species, kinds of prairies, and environmental factors that influence a prairie's response to fire, and therefore there is no precise answer to the question of how often a site should be burned—only suggestions. The greater the litter cover, the more positive the response to fire, and since mesic prairies accumulate litter faster than dry prairies, mesic prairies respond better to frequent burning. On average, mesic prairies need between one and three years to accumulate preburn levels of

leaf litter (i.e., where leaf litter production equals decomposition). Dry prairies may need four to six years to reach preburn levels. These intervals are adequate for burning healthy prairies with no serious weed problems.

Annual burns are recommended to improve prairies infested with cool-season grasses and will control these weeds more quickly on a dry site than a mesic one because of water stress. Three or more years of successive fires are recommended to begin controlling alien cool-season grasses and woody vegetation. If cool-season grasses are not a problem, then burn every three or four years at irregular intervals. Annual burns can increase the dominance of prairie grasses to the detriment of forbs, and burning at regular intervals can favor certain weeds. In a reasonably good-quality oak opening dominated by brush and saplings, a single fire can increase light penetration enough to improve wildflower growth and reproduction. The second and third consecutive years of fire may double and double again the percent of light reaching the ground.

Most prairie burns are conducted in late March, April, or early May. Dry prairies are usually burned on the earlier dates, because they start blooming several weeks earlier than moist prairies, and a late fire can damage early wildflowers such as violets and shooting stars, although another early wildflower, pasque flower, readily reblooms after a fire. Weedy prairies are burned on the later dates.

Fall fires are sometimes difficult to set up because cool temperatures, absence of killing frosts, and short days keep vegetation too moist to burn. Fall fires destroy winter food and shelter for wildlife, may induce erosion on steep hill prairies, and might escape into the crops adjacent to many prairie remnants. Spring fires are often easier to control because the vegetation has been packed down by snow; the fire moves slower, and flame height is reduced.

Whenever possible, though, degraded oak openings are burned in November and December when the leaves of non-oak species (e.g., common buckthorn, box elder, black cherry) provide effective fuel, instead of the soggy, decomposing leaf mat of spring. In contrast, oak leaves remain crisp and flammable well into spring.

Many ecologists are concerned about the negative impact of fire on insect populations, and recommend leaving half to two-thirds of large remnant prairies unburned each year so the insects can reinvade the burned portion.

Equipment and Its Use

A fire rake is an iron garden rake used to spread fire. (See appendix E for sources of this and other fire equipment.) Check that the metal rake head

is bolted on, lest it fall off when heated by the fire. Specially designed fire or asphalt rakes have a 12-inch metal extension between the wooden handle and the rake head, which keeps the worker a foot farther away from the fire and keeps the wooden handle out of the flames. To start the fire, rake up a small bundle of dry grass, light it, and drag it along the ground, exerting a slight downward pressure. It will bounce along, dropping small bits of burning grass and picking up more dry grass for fuel. When dragging the fire rake, there is a tendency to go slower than necessary. Experiment with dragging the fire rake at different speeds. Notice that several seconds after passing over an area, fires start from pieces of burning grass that fall off the fire rake—as though dropping a hundred matches. If the rake is moved too slowly, the handle could burn and the rake head fall off. When necessary, an experienced person can set a line of fire while dragging the fire rake at a jog. Use extra rakes to clear fuel from firebreaks, from around wooden posts and specimen trees, and from any spots benefited by reducing fire intensity.

A wholly different type of fire rake has four sharp triangular teeth (sickle bar teeth) and is ideal for clearing narrow firebreaks in wooded areas. It cuts through small vines, roots, and saplings and does not get clogged with leaves as does the garden rake.

The drip torch is the professional's tool of choice for starting fires. It contains about one gallon of a three-to-one mix of fuel oil and gasoline, which drips out at a controlled rate past a flaming wick that ignites the fuel as it drips to the ground. The volatile gasoline ignites the fuel oil. As the wick heats, its ability to volatilize and ignite the fuel oil increases, becoming less prone to blow out on windy days. Do not increase the percentage of gasoline past 35 percent, and reduce the percentage on warm days. Never use 100 percent gasoline, which would be explosive. Control the drop rate by loosening or tightening the vent screw.

A major advantage of drip torches over fire rakes is the ability to quickly kindle continuous lines of fire, so your crew can immediately put out one edge of a firebreak's fire line. Rakes make interrupted lines of fire, which take several minutes to coalesce into contiguous fire lines. In addition, this increased efficiency gives the torch handler free time to set the torch down and become an extra pair of eyes or hands for fire control. A drip torch is particularly effective for setting fires through the oak openings, where a garden rake gets caught in the vines and saplings. Blow out the torch each time you set it down, and do not drip on your pants or shoes.

A fire swatter is a 12-by-18-inch piece of reinforced rubber attached to a 5-foot handle. It is used to smother small grass fires, and in tall grass it can extinguish the backfire. Swatters alone are useless against a head fire. Swatters are most effective when teamed up with a backpack pump;

the pump operator knocks down the hot fire, and swatters follow behind mopping up.

To use the swatter, raise it 1 or 2 feet and strike at the base of the flames. Do not strike with excessive force, or flaming debris will scatter, starting new fires. When striking the ground, pause momentarily to smother the fire. If the fire is stubborn, like a clump of burning bunch grass, then place the swatter over the fire and step on it to suffocate the flames. Pause occasionally to let the swatter cool since rubber can burn, or ask someone to spray it with water.

A backpack pump is a tank with a five-gallon capacity and a slide-action pump that can shoot a stream of water 20 feet. It is the most valuable piece of hand-held fire-control equipment. The empty tank weighs about 12 pounds, and water weighs about 8.5 pounds per gallon; a full tank weighs over 50 pounds. But tanks are not filled to the top because the water in the top 3 inches splashes out and down your back when you bend over!

Backpack pumps usually have both a single-hole and a two-hole nozzle. The two-hole nozzle produces a spray for working close to the fire and for wetting down areas before they catch fire. This spray nozzle is particularly useful in putting out backfires that are less than a foot deep. The closer the spray is to the fire, the better, so when extinguishing a backfire, work with the nozzle 2 or 3 feet above the base of the flames if the heat allows.

Head fires are 5 to 15 feet deep and hot enough to keep you 10 to 15 feet away. For hot fires use the single-hole nozzle aimed at the base of the flames. Fan the pump side to side so the stream of water covers a wider area. Sometimes in putting out a line of flames, especially backfires, you can stand at one end of a line of flames and lay a stream directly on 20 feet of flames.

Use water efficiently. Very little water is needed to cool a large volume of fuel below the kindling point, especially if a spray is used. With a hot fire, you must use the straight stream, but you can still create a spray. With practice you can use your index finger to create a wide variety of sprays with the single-hole nozzle. Keep the knuckle straight, and hold the fingertip about a half inch in front of the nozzle, so water strikes the fingertip and breaks into large droplets. By moving the fingertip in and out of the water stream, you can adjust the distance and intensity of the spray, or even direct the spray upward to extinguish the underside of logs. Commonly, beginners place a finger directly over the nozzle, as is done with a garden hose, and get more water on themselves than the fire.

Usually, two or more tanks are needed to control a fire. Keep track of how much water you've got left and work with a buddy—one person watches the fire, while the other refills a tank. Take along a bucket and strainer for getting water from lakes, rivers, and ditches.

If your tank goes dry, drop the strap off the left shoulder; this tips the tank, so remaining water pools over the intake hole of the pump hose. You'll get a few extra squirts this way. A few drops of detergent added to each tank breaks water surface tension and makes it spread on the vegetation. Practice so you can hit the target and experiment with the best way to hold the pump to deliver a powerful stream. Remember, the hose must always point down, so the ball valve at the base of the pump works properly.

Take the pump apart and learn how it works so you can fix it during a fire. Most can be taken apart with the fingers. Keep the pump slide well oiled, which reduces water leaking past the gland nut and soaking your hands and clothing. If water continues to leak after oiling, replace the rubber gasket in the gland nut. Occasionally, a tarnish builds up on the sliding brass cylinder, causing the pump to stick. Polish it with a very fine steel wool and it will work like new. Do not allow water to freeze in the tank. Empty the tank, and pump all water out of the hose—pumps are destroyed when water left in the mechanism freezes and expands. Galvanized tanks will rust, and flakes of rust will clog the nozzle; so thoroughly dry out the tank before storing it for the season, or store it upside down.

Sometimes you can borrow equipment from the fire department or from the state conservation department fire-control office. Also, check with local conservation organizations for leads on where to borrow, rent, and buy equipment

Finally, a few comments on clothing. If you can afford it, fireproof Nomex pants and shirts are hard to beat, but those of us on tight budgets can get by with a little common sense. Avoid synthetics such as nylon coats, which burn and melt, and avoid clothing with frayed edges. Wool coats and pants are quite fire resistant, insulate you from the heat, and keep you warm when the fire is finished. Gloves and a long-sleeve shirt protect your arms from radiant heat, which can cause first-degree burns, and a hat keeps embers from your hair. Pull down the brim to help protect your face from sudden flare-ups.

Weather Conditions and Planning

Selecting a day to burn can be discouraging. Spring weather is variable, and there may be only a few days in April when weather is not too windy, wet, dry, calm, or humid for burning. Therefore, plan to burn as early as possible, unless you require a late burn for weed control.

Relative humidity is the most important factor influencing the

behavior of a grass fire. Relative humidity is a percentage comparing the actual quantity of water vapor in the air to the maximum quantity of water vapor air can hold at a given temperature. For example, a 60 percent relative humidity at 50° F means that the air contains only 60 percent of the total water vapor it can hold at that temperature. As temperature increases during the day, the quantity of moisture the air can hold also increases, and therefore the quantity of moisture creating 60 percent relative humidity at 50° F will yield only 30 percent relative humidity at 70° F.

As air cools, its ability to hold water vapor is reduced. At night the temperature often falls past the point where relative humidity is 100 percent, and excess water vapor is deposited as dew, which has the same effect as light rain. Relative humidity determines how hot a grass fire will burn. Dry air (low relative humidity) absorbs dampness from dead grass, whereas damp air (high relative humidity) returns moisture to the grass, and dead grass can adjust within minutes to a change in relative humidity. High relative humidity and moist fuel slow a fire because heat is wasted drying the grass before it will burn. In fact, at dusk the falling temperature and rising relative humidity can extinguish a grass fire.

A relative humidity between 25 percent and 60 percent is appropriate for a controlled fire; below 20 percent is hazardous, and above 70 percent grass burns poorly if at all. Above 50 percent there is little chance of spot fires starting from embers carried in the wind, but a fairly brisk wind (10 mph) is needed to drive the fire. The effect of wind is to deflect the angle of the flames and to drive drying heat into the vegetation ahead.

A useful rule of thumb to predict changes in relative humidity during a midwestern spring day is: relative humidity will drop to one-half of its previous value as temperature increases 20° F and will double as temperature decreases 20° F. For example, if the early morning temperature is 40° F, with an 84 percent relative humidity and an expected high for the day of 80° F, as the temperature increases to 60° F, the relative humidity will drop to 42 percent, and at 80° F the relative humidity will be about 21 percent. In another example, if the midafternoon temperature is 70° F with a 33 percent relative humidity, as the temperature drops to 50° F, the relative humidity will double to 66 percent.

The lowest relative humidity of the day is usually between 3:00 P.M. and 5:00 P.M. Therefore, early evening is a good time to burn firebreaks because the falling temperatures cause increased relative humidity and the grass absorbs moisture, burns cooler, and makes fire easier to control. But burning firebreaks in the morning can be tricky, because rising temperatures, decreasing humidity, and increasing winds make fire increasingly difficult to control as the day progresses. Remember, weather conditions affecting a fire can change dramatically in a few hours. You must stay aware of those changes and adapt fire-control techniques accordingly.

Air temperature primarily influences fire behavior by the associated changes in relative humidity, and direct sunshine speeds the drying process. It is hazardous to conduct a prescribed fire above 80° F, and from 70° F to 80° F the rate of spread of fire increases exponentially. Below 32° F light fuels do not burn, although a heavy mat of grass can burn well. Prolonged high temperatures coupled with a lack of rain will dry out heavier fuels like brush and dead wood. This increases the chance that these larger fuels will flare up. Bright sun multiplies the effect of temperature; a south-facing slope will warm up and dry out much faster than a level area. On a partly sunny day, a fire moderates when a cloud blocks the sun and quickens after it passes.

In the evening there can be a temperature inversion, which will hold smoke near the ground. Inversions occur on calm evenings as the sun disappears below the horizon. Air near the ground cools rapidly, but the upper air continues to be warmed by the setting sun. The interface between cold air below and warm air above traps smoke near the ground.

A steady breeze of 3 to 15 mph is ideal for burning because it carries fire in a definite direction, while gusts or steady winds over 15 mph make fire difficult to control. Do not burn on a calm day, when breezes can come from unexpected directions and take fire out of control. It is interesting to note that although wind speed has a marked effect on a head fire, it has little effect on the speed of a backfire. Wind speeds above 15 mph are appropriate for oak opening fires where trees diminish the wind needed to drive fire through sparse fuel. Nonetheless, burning at wind speeds above 15 mph is exclusively for managers experienced in the fire hazards of a particular site. In general, wind is calmer in the morning, picks up during the day, and falls off at dusk. You may choose to burn firebreaks during the morning and evening hours, avoiding the winds of midday.

Fires create their own thermal winds when the quick rise of hot air causes the inrush of cooler air to take its place. A steady breeze moderates the thermal updraft's tendency to take fire in erratic directions and also inhibits the formation of small fire whirlwinds. Whirlwinds form most often while burning grassland on rolling terrain and behave like dust devils you may have seen on dusty ball diamonds. Whirlwinds can pick up a piece of burning debris and carry it several dozen feet.

On the day of the burn, walk over the site and observe wind shifts and gusts. As you walk, throw small pieces of dry grass into the air to see how far they blow and in what direction. Do this several times in different locations. You cannot predict good burning weather more than a few hours ahead of time, so check weather reports the night before, and again

on the morning of the fire. There is no substitute for experience in deciding what combination of weather conditions is appropriate for safe burning, so consult with someone who has had experience. For the inexperienced crew, it may be best to start when conditions favor control—45 percent to 60 percent relative humidity, wind around 3 to 10 mph, and air temperature 40° F to 60° F. Burn in late afternoon to early evening, when you know relative humidity is on the rise. Experiment with a few small burns and learn about the fire's behavior and the combustibility of various fuels.

Firebreaks

A firebreak is anything that will stop a fire and contain it in a controlled area. It could be a plowed field, a road, a mowed path, or a burned strip of land. The mowed trail is the most frequently used firebreak; however, sometimes fire is used to widen existing firebreaks or make them where none exist.

A minimum of three to four people is necessary to burn firebreaks. Equipment should include at least two fire backpacks, a fire rake or drip torch, extra water, and a few swatters. Often the person in charge of a crew lights the fire and drags the fire no faster than the crew can handle. One person walks back along the burned firebreak extinguishing smoldering areas that could flare up, while the other crew members work with the individual lighting the fire.

In the spring, you can cut the tall grass before burning a firebreak to make fire easier to control. On the other hand, grass mowed once in the fall at the end of the growing season mats down and is difficult to burn in spring. Grass mowed once in early summer grows enough to carry a fire the following spring, and the reduced fuel load makes fire easier to control.

The following describes how to burn a firebreak at right angles to the wind. With wind from the north, use this method to burn firebreaks on the south and north borders. Make the first firebreak in an east-west direction at the south end of the prairie by starting a fire at the southwest corner and dragging it 5 to 10 feet eastward. Quickly extinguish flames carried with the wind on the south side of the line of fire, because an unexpected gust of wind can fan it into a racing head fire. Allow the fire to slowly back into the wind on the north side. Set fire slowly enough so the crew can keep up.

Allow the backfire to burn until the firebreak is 3 to 20 feet wide, then extinguish it and drag the fire another 10 to 40 feet east. Again, quickly extinguish the south side of the flames carried with the wind and allow the backfire to burn north against the wind. Repeat this process until you

have a firebreak the length of the area to be burned. Keep that backfire to a manageable length, usually 40 feet or less, because a wind shift can quickly transform that slow backfire into a blazing head fire. If you need to speed things up, light a second line of fire 5 to 10 feet upwind (north) and parallel to the first line of backfire, and the wind will drive this second line into the backfire of the first line, quickly widening the firebreak.

Some people prefer to rake a scratch line before they burn out the firebreak. They rake away as much litter as possible in a narrow line as wide as the rake along the downwind side of the proposed firebreak. Then they light a backfire along this scratch line. A good scratch line will significantly reduce the amount of water and work required to control a fire.

The following describes how to put in a firebreak by burning directly into the wind. With wind from the north, this is a technique to make firebreaks along the east and west borders. For this firebreak along the east border, start at the south end (downwind), and drag a 3- to 20-foot line of fire at right angles (east-west) to the wind. Put out the flames on the downwind (south) side and allow the fire to back into the north wind, making a firebreak 3 to 20 feet wide. Control the fire by putting out the edges of the line of fire, and allow it to burn into the wind, forming a firebreak along the east (or west) border of the prairie.

To burn firebreaks on steep slopes, burn the first break along the crest, so if fire escapes while burning the other firebreaks, it will burn uphill and stop at the top firebreak. To burn firebreaks down the side of a hill, use a modified version of the technique for burning firebreaks into the wind. Start a 5- to 20-foot line of fire at the top of the hill and parallel to the crest. Extinguish fire on the uphill side and allow it to creep downhill. Control the width of the firebreak by extinguishing the sides of the fire. Fire usually burns slowly downhill and quickly uphill, regardless of wind direction.

Conducting a Simple Burn

For this imaginary burn, we will use one acre of prairie surrounded by old fields of quack and brome grass. Wind is from the north, shifting northeast and then back north.

Some things to consider include: 1) where to get equipment, 2) whether the local municipality or fire department requires a permit, 3) having several plans for wind from different directions, 4) what to do if the wind shifts direction during the fire, 5) how to respond to an escaped fire, 6) what time of day you will burn, and 7) where you will put the primary firebreaks, and whether you can locate any secondary firebreaks that could contain an escaped fire.

Contact the fire department and sheriff on the day of the fire and explain your plans. Talk with the neighbors, since a fire department may be required to respond to a call despite prior assurance that it is a properly supervised fire. Take copies of any permits, write down the phone number of the nearest fire department, locate the nearest telephone or take along a cellular phone, and encourage the fire dispatch to call if any concerns arise during the fire.

Plan the sequence of burning firebreaks so that each completed firebreak reduces the risk of an escaped wildfire when the next firebreak is burned. Therefore, if wind is out of the north, burn the first firebreak on the south side at a right angle to the wind. If fire escapes while burning the other firebreaks, the north wind will drive the fire toward the south firebreak.

Burn the second firebreak on the west border using one of two methods; either a 10-foot-wide line of backfire burning at right angles (east-west) to the north wind, or a north-south line of fire burning to the east, while extinguishing flames burning on the west side of the proposed firebreak. This line of fire parallel to the wind is a flank fire, and since wind is shifting to the northeast, the flank fire burns as a backfire into the shifting northeast wind.

Flank fire is tricky to manage because a slight wind shift can transform it into a head fire. Remember, have no more than 40 feet of backfire burning at one time, lest an unexpected northwest wind transform it into a racing head fire. If a wind shift does bring about a racing head fire, it should burn out at the south firebreak if it's wide enough, while crew members put out the backfire to the north and east. Watch for patches of heavy fuel where fire can surge ahead, forming a bulge that the north wind could fan into a mini head fire. Strive to keep the fire line straight.

Make the third firebreak along the eastern border with either a 10-foot-wide fire burning northward into the wind, or a flank fire burning to the west. If fire escapes, it should burn out against the firebreaks on the south and west sides. If winds are variable, you may choose to burn a fourth break on the north end to encircle the site.

Now we're ready to burn the prairie. Walk the firebreaks to check for unburned fuel. In thickly matted grass, check by raking off the ashes to reveal either bare dirt or partially burned grass and burn the leftover fuels.

Gather the crew, explain the plan, and describe where each member should be. Station several people downwind and on the flanks to watch for spot fires started by glowing embers. Since people tend to stare at the main fire, remind them to look away toward the unburned areas. Review the fallback plan in case of an escaped fire and designate a person to phone the fire department. Remind the spotters that if enveloped by

thick smoke, they should crouch down where air is cleaner and move to a safe location. Never get in front of an escaped head fire.

Review current weather conditions, especially the relative humidity, and conduct a small head-fire test along one of the firebreaks to see if you think conditions are appropriate for the larger fire.

There are three basic patterns of ignition: ring fire, backfire, and strip head fires. With a ring fire the prairie is encircled with fire, which sweeps across the area (see figure 14.1). But first, firebreaks are widened with backfires. Two people drag fire along the inside edge of the north firebreak in opposite directions from the center. They continue dragging the fire along the inside perimeter of the east and west firebreaks, and halt at the southern end of the firebreaks. If wind is shifting south to southeast, the person dragging fire up the east border should stay several dozen feet behind the equivalent position of the person on the west border, so as to prevent smoke and fire from engulfing crew members on the west border.

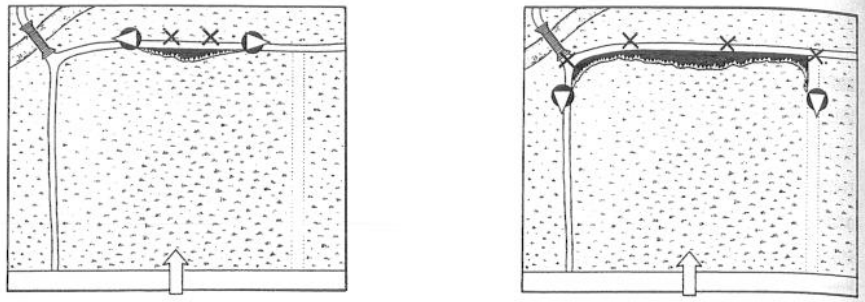
Make sure the downwind firebreak is wide enough to contain blown embers. You may want to use a couple of strip head fires to quickly widen it before starting to encircle the site with fire.

Now the crew leader must determine if the firebreaks are wide enough to contain a head fire set along the southern border. Finally, a head fire is dragged across the south end, and crew members put out the backfire burning southward. Be sure that everyone is ready for the head fire because it can burn with incredible speed and heat that will keep everyone dozens of feet away. Station people around the perimeter to watch for fires creeping across partially unburned portions of the firebreak and for spot fires ignited by airborne embers.

A ring fire gets the job done quickly, creates a strong, hot updraft that disperses smoke, and burns areas of sparse fuel where fire must jump from clump to clump. However, once the head fire gets a good start, it is a power unto itself, and only wide firebreaks will stop it. The strong updraft can carry glowing embers farther than a backfire. So watch for spot fires downwind of the head fire, especially in brushy areas where glowing wood embers persist longer than grass embers.

A second technique is to backfire the entire area (figure 14.2). It's a relatively easy type of fire for inexperienced crews to control, but watch for 180° wind shifts that would fan creeping backfire into running head fire. A disadvantage involves the slow progress of backfire, which might travel 30 feet in ten minutes while a head fire could travel 200 feet. This added time for backfire increases the chance of a wind shift before you're through. The advantage is a reduction in the density of smoke released at any one time, although a disadvantage is that smoke tends to stay near the ground because there isn't a strong thermal updraft to disperse it.

Figure 14.1. Ring fire.



a. Backfire set

b. Backfire completed

c. Flank fires

d. Beginning the head fire

e. Ring completed

f. Head fire moves quickly

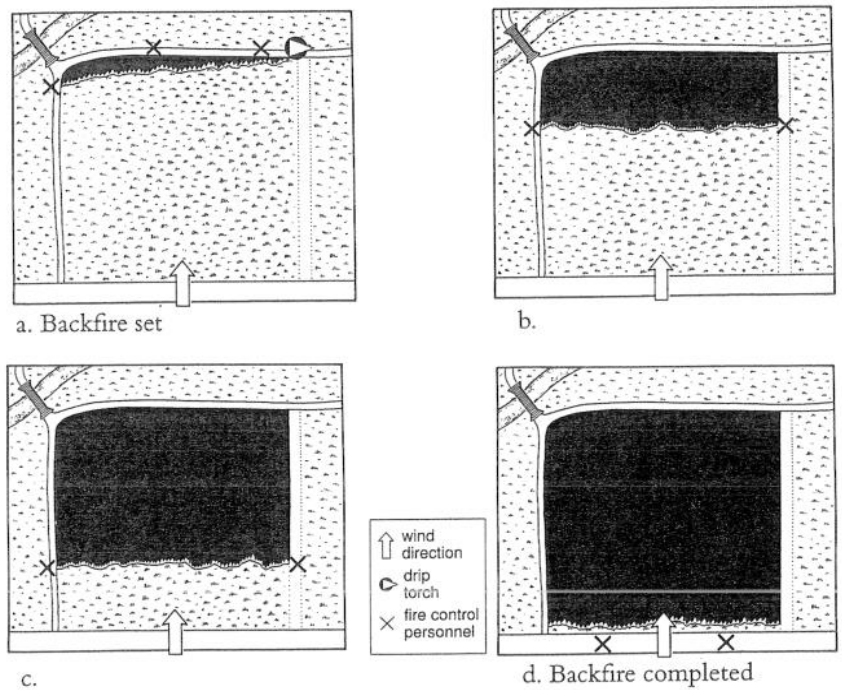
g. Head fire meets backfire

h. Fire completed

The third technique (figure 14.3), strip head fires, is probably the most versatile method of prescribed burning. The downwind firebreak is widened with the backfire so the first strip head fire won't jump across, and then each strip head fire is set upwind and at a distance chosen to keep flame length and fire intensity at a comfortable level. The strips can vary from 20 to 150 feet wide, and you adjust fire intensity by varying the width with changing weather or fuel conditions. Small areas of heavy fuels can be backfired.

The person igniting the strip fire should discontinue each strip well before it reaches the oncoming firebreak, especially if fuel is heavy near the break. The drip torch should then be tipped up (or extinguished) and carried to the point where the backfire from the previous strip meets the firebreak. Here the person carrying the drip torch begins a flank fire that will burn a necessary break up to the point where the next strip will start (see figure 14.3c). The reason for this practice is that otherwise the suppression crew would have to control a head fire immediately adjacent to the firebreak, an unnecessarily difficult and risky challenge except under very mild conditions. Normally the suppression crew controls only backfires and flank fires. Head fires are controlled by backfires or wide firebreaks.

Figure 14.2. Backfire.



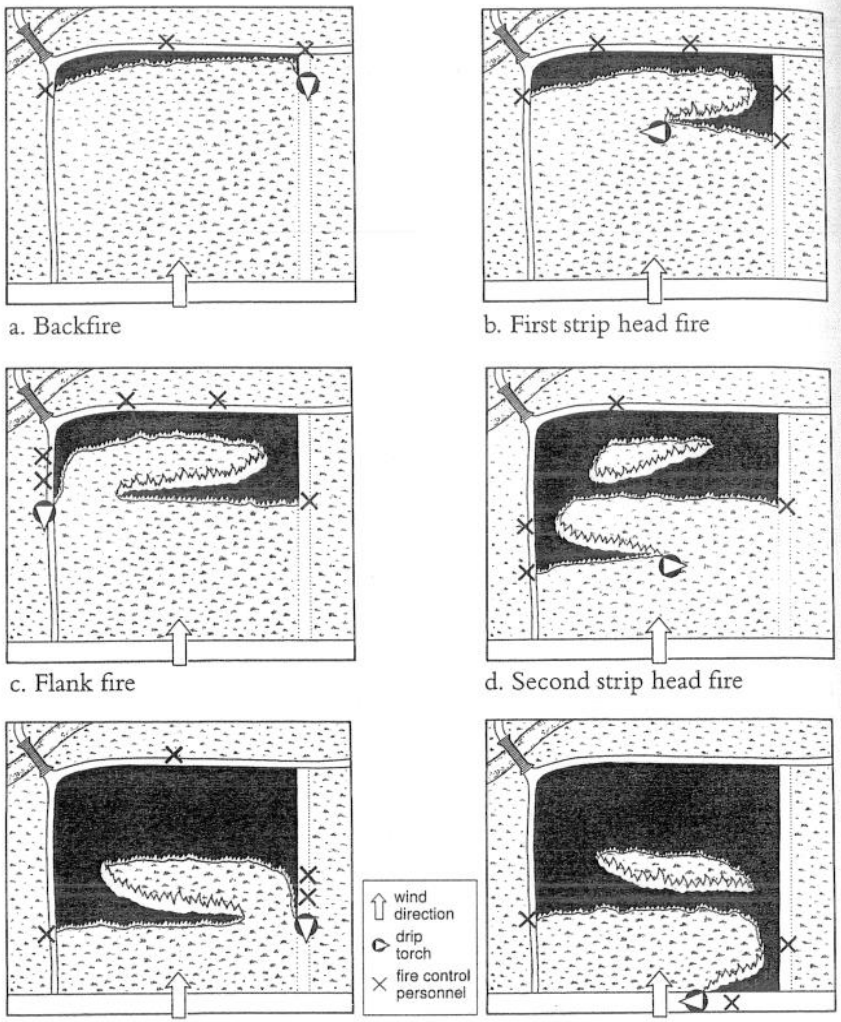
a. Backfire set

b.

c.

d. Backfire completed

Figure 14.3. Strip head fires.



a. Backfire

b. First strip head fire

c. Flank fire

d. Second strip head fire

e. Flank fire

f. Final strip head fire

The greatest fire intensity occurs at the convergence of a head fire with backfire of the previous strip, where they interact to produce the largest flames, highest intensity, and greatest thermal updrafts. When three or more strips are burning, interaction can create unexpectedly fierce fires, especially when fuels are heavy, winds are light, and strips are closely spaced. Keep fire lines relatively straight and at a right angle to the wind, because a deep curve in the line allows fires on either side of the curve to come together and produce intense local fires.

With thorough planning and an experienced crew, there is no reason why a prescribed burn need ever escape. But planning for escaped fires is

part of good preparation. All burn plans should locate all hazards near the site (fuel storage areas, homes, adjacent areas of dense fuel, roads where drifting smoke would be a problem etc.) At the beginning of each burn determine which of such hazards would be in the path of an escaped fire during that day's burn, and alert the crew to any special considerations. Determine under what conditions it would be necessary to call the fire department or police, and designate a person to do so.

In the case of an escaped fire, determine where that day's wind would take it, and locate the nearest natural firebreak like a road, river, or plowed field that might stop a racing fire. Then divide into two groups and work on opposite flanks of the escaped fire. Extinguish the edges, and work toward the middle so as to narrow the line of fire, while the leading edge of the head fire burns toward the natural firebreak. Be alert for burning debris blown across the firebreak, starting new fires.

A backfire set along the edge of a narrow firebreak like a small stream, ditch, or trail might widen it enough to halt a wildfire. But usually a backfire is a last resort to limit an out-of-control fire, because you must race to the area selected for the backfire, work directly in the path of the racing wildfire, and then get out of the way. And because you're working fast, there are more chances for mistakes. Worst of all, flames from the backfire could creep across a small, natural firebreak, creating two fires out of control. A partial solution is for two people to stay at the natural firebreak and set the backfire if needed.

Do not get directly in front of the head fire, because a gust of wind could cause flames to leap ahead, engulfing you in the heat and smoke. Wind-driven embers could start another fire dozens of feet beyond the main fire, trapping you in between.

Finish up by extinguishing the smoldering hot spots. Turn over logs to check the undersides, because wind can fan smoldering wood into flames hours after you're gone. Check for fire at the base of wooden fenceposts, trees, railroad ties, and poles. Conserve water; get it directly on the hot spot. Work in pairs; one person rakes away ashes or turns a log, while the other wets it down. Look for smoking clumps of bunch grass because these plants may die if fire in the center is not put out. It may not seem necessary to extinguish all the little smoldering fires, but it is good public relations to be thorough.

Finally, inventory equipment so nothing is lost.

Hazards

This final section introduces an assortment of difficulties that could arise on a controlled burn.

Overconfidence is always the number-one hazard. A controlled burn can change into a wildfire in less than a minute, and the typical reason is inattention and inadequate planning. People take their skill in handling fire for granted if they work with it for several hours, but conditions change during the day. An unexpected gust combined with lower relative humidity can dramatically change fire behavior, and the crew must be ready to respond instantly. Everyone must bear in mind that fire is a dangerous tool. It can be controlled but not tamed. *Every fire is a potential wildfire.*

Pines are often found near remnant dry prairies, and the pitch exuding from wounds is easily set ablaze and difficult to extinguish. On the other hand, many pines are surprisingly well adapted to fire. Needles may scorch and wither, but new ones emerge each spring from buds that seem immune to all but the hottest fires. Late spring fires after new needles emerge are sometimes hazardous because the high resin content of fresh needles is quite flammable. Also, ground fires often smolder under the surface of the needle duff and flare up several minutes after you're sure it's all out.

Fire and cutting are ways to control brush, but only the tops are killed and the brush resprouts. Burning through brushy grasslands causes problems, because embers from dead branches are carried by hot thermals across firebreaks. This is an increasing hazard as relative humidity drops below 50 percent, because above 50 percent spot fires rarely occur. Burning embers may travel 10 to 100 feet or more depending on wind speed and fire intensity, so plan your ignition pattern and firebreaks accordingly. By cutting down sparse patches of brush ahead of time you can deter embers from rising on hot air currents. However, if the brush is thick, you'll want to burn brush piles when there is snow or wet conditions. Another factor to consider is that the multiple resprouts of cut brush are often more heavily damaged by fire than single stemmed saplings. The leaf litter trapped in the center of the multiple stems burns hot, and thin-barked young growth is easily damaged by the heat.

The renewed vigor shown by some woody invaders after a fire can be discouraging, because it often takes three consecutive years of fire to significantly reduce the density and vigor of many woody species. A relative humidity around 30 percent is considered ideal to inflict maximum damage, but sometimes experienced managers can conduct safe low-humidity fires (below 25 percent) in brushy prairies. Keep in mind that the moisture content of woody material reacts more slowly than grass to relative humidity and rainfall, so fire safety and intensity are influenced by moisture conditions in the days preceding the fire in addition to current

conditions. A succession of windy days with exceptionally low humidity coupled with no rain makes for extreme burning conditions. Burning at such times should be avoided by anyone without extensive experience.

Because oak leaves persist through the winter without decomposing, a breeze can carry burning leaves across firebreaks. The solution is wide firebreaks and alert crew members around the perimeter. Black oaks often hang on to their leaves all winter, and so a tongue of flame can ignite the leaf-laden branches, making for a good deal of excitement.

Fire whirlwinds can transport burning material and ignite new fires. The solution is alert crew members and the knowledge that whirlwinds happen most often when winds are light (3–8 mph), fuel concentrations are heavy, and head fires meet backfires. Whirlwinds also occur when fire burns up a lee slope and over a ridge into the wind.

A hollow or cracked wooden pole (e.g., a telephone pole) or tree (dead or alive) can ignite, creating a chimney fire, in which fire in the base creates a draft up the hollow center that burns like fire in a fireplace. Even a hollow log on the ground can act as a horizontal flue and send embers several hundred feet. A surprisingly small flame licking punky wood can start it smoldering, often not noticeably for fifteen or twenty minutes, and smoldering rotten wood is extremely difficult to extinguish. Cutting a tree down is about the only really effective way to stop a chimney fire; otherwise, you'll need lots of water and maybe a ladder. Hollow-tree fires can sometimes be moderated or extinguished by sealing the base with moistened dirt, which is most effective for hollow trees with no opening at the top. Therefore, create firebreaks around problem trees by raking away excess grass, wetting down the trunk, and burning a firebreak around the base.

Some people recommend removing hollow trees before conducting a prescribed burn, but these trees are homes for flying squirrels, raccoons, woodpeckers, bluebirds, and many other animals. Alternatively, you could deal with chimney fires as a natural phenomenon, particularly because some plant species reproduce best on ground scorched by hot fires. Allowing logs to burn out naturally also reduces future fire management problems. Watch for burning timber that might fall across firebreaks or roll down slopes, and remember that fires that die back in the evening may smolder and revive dramatically the next morning as temperatures rise.

Low telephone lines can be damaged by the heat of a head fire, so burn under lines with a backfire. Use caution around power lines because the carbon in a thick blanket of smoke billowing through the lines can allow bolts of electricity to arc across.

In a dry year, organic marsh soil can catch fire, so don't burn in a

marshy area if the soil is dry. Peat fires are extremely difficult to put out and can burn for months. Be aware of sphagnum in certain wet prairie marshes which could be destroyed by fire in a dry year.

Fire in a thick mat of Eurasian old-field grasses is difficult to put out, because it smolders under the surface. When you use a fire swatter on a backfire in the thick mat, embers fly out from under and spread the fire (this is a particular problem with reed canary grass). A fire broom is especially effective on a backfire in matted grass, because it sweeps under the edge of the mat and gets directly at the hot spot. Water from a backpack pump is deflected by the dense mat, and fire beneath will continue to smolder. Water is most effective if you work from within the burned-out area and spray it back beneath the mat, directly on the hot spot. However, the burned-out area of a backfire is very smoky.

A hazard with burning firebreaks in matted grass moistened by dew or rain is that the dry upper layer burns off while the unburned moist grass beneath is exposed to the drying action of wind and sun. Later on, flames can creep across the firebreak, using these patches of partially dried grass.

It is hazardous to burn through areas of poison ivy, because smoke particles carry the irritating oil from dead leaves and woody stems. Contact with this smoke causes a rash on sensitive people, and if inhaled, causes serious complications in the lungs. This appears to be more of a problem with summer and fall fires and when burning brush piles containing poison ivy debris.

Burning late in the spring season when vegetation is green will produce lots of smoke. Avoid breathing this smoke, because it can make you sick. Often you can attack a smoky head fire from inside the burned area, and from that position wind carries smoke and heat away from you. If you get caught in a cloud of smoke, crouch down where air is cleaner and move to a safe area.

Extremely low relative humidity (less than 20 percent) makes for very hazardous fire conditions. A light gust of wind can take a small fire raging out of control, because there is so little moisture in the grass to slow ignition. Remember, moisture contributed by humidity slows a fire because some heat is used up drying out the grass before it will ignite.

Roads and trails are excellent firebreaks, but beware of bridges and leaf-filled culverts, where soggy leaves can smolder overnight until a fresh breeze spurs the fire through it and out the other side, creating a horizontal chimney fire.

A fence line of brush with too little litter to maintain a backfire cannot be trusted to stop a head fire, which can generate sufficient heat to ignite the tips of dead branches and send burning debris across the break.

As you gain experience with prescribed burns, you learn that there isn't one single best way to conduct one. Instead, you learn the basics of fire behavior, just as you might learn human behavior, and then treat each fire as an individual.

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