Conducting Cool Season Prescribed Fires

The Kerr Wildlife Management Area Experience

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TEXAS PARKS & WILDLIFE

PWD BK W7000-2065 (3/04)

Cool season prescribed burns on the KWMA

In 1979, the Kerr Wildlife Management Area began a systematic prescribed burn program. Each year approximately 20 percent of the 6,500-acre management area is burned. All burns have been conducted in January and February when most plants are in a non-growing state (dormant). These types of burns are often referred to as “cool season” burns. The following is a compilation of the informational knowledge that has been gained over the past 24 years about integrating, conducting, and management of prescribed burns into total range and wildlife management program. *This document is intended to provide the general public with a working knowledge of prescribed burning in the Edwards Plateau ecoregion*. Those persons wishing to learn more about prescribed fire should contact persons trained in the use of prescribed fire from organizations such as the Texas Parks and Wildlife Department, the Texas Agricultural Extension Service, the Natural Resource Conservation Service, and the Texas Forest Service.

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What is a prescribed burn?

Prescribed burns are fires that are intentionally set under a predictable set of environmental conditions to achieve a desired result. Environmental conditions include humidity, wind speed, air temperature, amount of fuel, type of fuel, soil moisture, etc. A desired result may be regrowth juniper (cedar) control, brush pile removal, reduction of leaf litter, etc.

The Basics

It takes a combination of 3 major components to produce fire. They are heat, fuel, and oxygen. If any one of the components is missing, then a fire will not exist (Figure 1). In nature, there are 2 major *environmental* components that significantly affect fire behavior. They are relative humidity and wind speed.

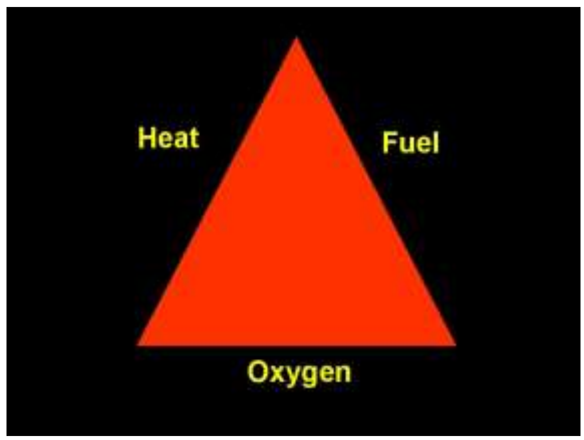

Figure 1. It takes a combination heat, fuel, and oxygen to create a fire.

Relative Humidity: Relative humidity is amount of moisture in the air. The amount of moisture in the air tends to absorb heat from the fire and denies the fire oxygen. It can be compared to spraying a fire with a water hose. Most range fires will not sustain themselves with humidities above 60 percent. In the Hill Country, humidity is high in the morning, decreasing during the day and increases again around 3:30 p.m. Prime burn times are between 11:00 a.m. to 3:30 p.m. when the humidity range is lowest for the day. Southeast winds from the Gulf of Mexico are generally associated with high humidities as are Northeasterly winds. Winds from the Southwest and Northwest are associated with drier humidities.

Rule of Thumb: For each 20-degree rise in temperature, humidity will halve. For each 20-degree drop in temperature, humidity will double.

Example: At the start of the day, the temperature is 30 degrees with a 60 percent relative humidity. It is predicted that the high temperature for the day will be 50 degrees, predicted relative humidity would be 30 percent.

Wind: Wind speed is another important component in the control of fire. Wind speed affects the fire in 2 major ways. First, it supplies the fire with increased amounts of oxygen. A person blowing on a fire that is not burning well will increase the intensity of the flame by "pumping" oxygen into the fire. Secondly, wind speed will increase the movement of fire.

As a weather front ("norther") approaches, winds from the southeast will begin to pick up. Just before the front "hits" winds generally switch from the southwest for a short period before changing to northwesterly wind. It is not advisable to burn within 24 hours of a frontal passage as winds and wind speeds can be erratic depending on the power and speed of the front.

Wind speed predictions by the weather service are for winds that will occur at a 20-foot height. It is not advisable to burn with an easterly wind component, as those winds shift erratically

Other Factors: Other major factors controlling prescribed fires would be air temperature, kinds of fuels, quantity of fuels, uniformity of fuel loads, and soil moisture.

Fuels: There are 2 kinds of fuels. They are fine fuels and non-fine fuels. Fine fuels consist primarily of dry grasses or small twigs that will burn up in less than 1 hour. Dry grasses are commonly called 1-hour fuels. A green grass plant is approximately 70 percent water and will not readily burn. Therefore, green grass should not be considered a fine fuel. Other fuels are called 10-hour fuels and/or 100-hour fuels based on how long it takes for them to be consumed. A 10-hour fuel may be a limb that has fallen from a tree or a small brush pile. A 100-hour fuel may be a large brush pile with stumps and tree trunks.

Fine fuels are the most important fuels because they carry the fire throughout the pasture. Approximately 1,200 pounds of fine fuel per acre is necessary to adequately carry a fire. An average grass height of 10-14 inches will be about 1,200 pounds. Because fine fuels are small, they can readily gain or loose moisture from the atmosphere. If the humidity is low (30 percent or lower), the fine fuel moisture will be low. If the humidity is high (60 percent or greater) the fine fuel moisture will be high. A general rule would be that as the humidity during the day begins to drop the fine fuel moisture would also decrease. Fine fuel moisture lags approximately 30 minutes behind the actual air humidity.

Non-fine fuels burn for a longer period of time and would represent possible long-term hazards when burning, especially near firelanes. Non-fine fuels near firelanes make it imperative to monitor weather forecasts for several days following a burn.

Air temperatures are important for prescribed burns in that higher temperatures are generally associated with lower humidities.

Soil moisture: Brush piles burn “hot” for a prolonged period of time. In 1984, a research program on the Kerr Wildlife Management Area set out to understand just how they burned. Ten heat sensors were placed in a brush pile and temperatures were recorded during a burn. One sensor was placed approximately 1 inch below ground level as close as possible to the center of the pile. Shortly after ignition of the pile, temperatures reached 1,800 degrees F. and varied between 1,600 and 1,800 degrees for the next hour before the pile "caved in" on itself. The pile then burned itself out the rest of the day at about 400-600 degrees F. Several piles were burned under that generalized scenario. In each instance, the sensor 1inch below ground level recorded temperatures similar to the others.

After several piles were burned, there was a .3-inch rain. The burning of the piles was stopped until the piles dried out. The remaining piles were then burned. All sensors recorded similar temperatures as before except for the 1inch below the ground sensor. It cooled approximately 6 degrees for approximately 30 minutes before it began to heat up. Subsequent burns followed the same scenario. Moisture in the duff of the pile provided evaporative cooling, much the same as an evaporative air conditioner works. The cooling occurred as long as the soil moisture lasted.

If piles are to be burned or "hot" fires are to be employed, then high soil moisture prior to the fire will cool the soil surface and speed recovery. For instance, small hand stacked piles that can be burned in less than 1 hour could be burned several days after a ¾ to 1 inch rain and still have a cooling effect on the soil.

Leaf Moisture: Leaf moisture is the amount of moisture within a leaf. Most dead leaves are about 30 percent leaf moisture.
Most leaves will not readily burn when leaf moisture is above 60 percent. Most green leaves contain well above 60 percent moisture except during drought periods. With the exception of juniper and liveoak, green leaf moisture is not a major consideration since most fine fuels are dead during the winter period. Liveoak canopy leaves near firelines can produce burning embers when leaves are dry. Green leaf moisture becomes important when burning through Ashe Juniper. If the objective is to control the juniper, low

leaf moisture makes it easier to control larger regrowth juniper. Leaf moisture also becomes especially important when Ashe juniper (cedar) is being used as a firebreak. In the vast majority of cases, juniper breaks can be used as effective fire breaks since large, mature junipers do not readily burn. The exception to this is when prolonged drought conditions reduce leaf moisture to below 60 percent. When leaf moisture in juniper falls below 70 percent some flaring of trees may occur (Figure 2). At 60 percent leaf moisture, some general ignition may occur especially on upslope burns due to the effects of preheating or when winds are greater than a sustained 20 mph. To calculate leaf moisture, remove a hand full of leaves (100 grams) from a juniper. Place the leaves in a paper bag and weigh the leaves on a gram scale. This is the wet weight. Place the leaves in a microwave oven and run for 15 - 30 seconds. Weigh the bag of dry leaves. Place the bag back in the microwave and run for 15-30 seconds. Check the weight again. If it's approximately the same weight, then the sample weight is the dry weight. *Caution: Don't over cook the sample*. Now use the following formula to calculate the percent moisture.

Figure 2. Ashe juniper "flaring" as result of low leaf moisture and sufficient fine fuels under the tree. With low leaf moisture, fine fuels can generate enough heat to crown the canopy. When the fine fuels are consumed, the canopy fire will not be able to sustain itself.

(Wet Weight – Dry Weight)/ Dry Weight X 100 = % Fuel Moisture)
Note: Fuel moisture can be above 100 percent

Topography: Topography influences wind direction by creating updrafts, down drafts, and changing wind direction. Figure 3 illustrates the effects of a hill on wind direction. Understanding such effects can be helpful in rapidly establishing a firebreak. A line of trees will often cause spoiling of air currents much the same as a hill. Draws or gullies will often channel winds and may redirect wind direction. Persons setting the fire should be aware of the topography and adjust how they are lighting the fire. For instance, a person is setting a backfire (a fire backing slowly against the wind). He is igniting 50 to 100 feet, letting the fire back into a pasture to widen the firelane. Before moving to the next 100 feet, he notices that the backfire is becoming a head fire due to a hill. He may rapidly light the backfire area several hundred feet, letting the fire headfire up the hill. When he observes the headfire starting to become a backfire again, he slows the pace to widen the fire.

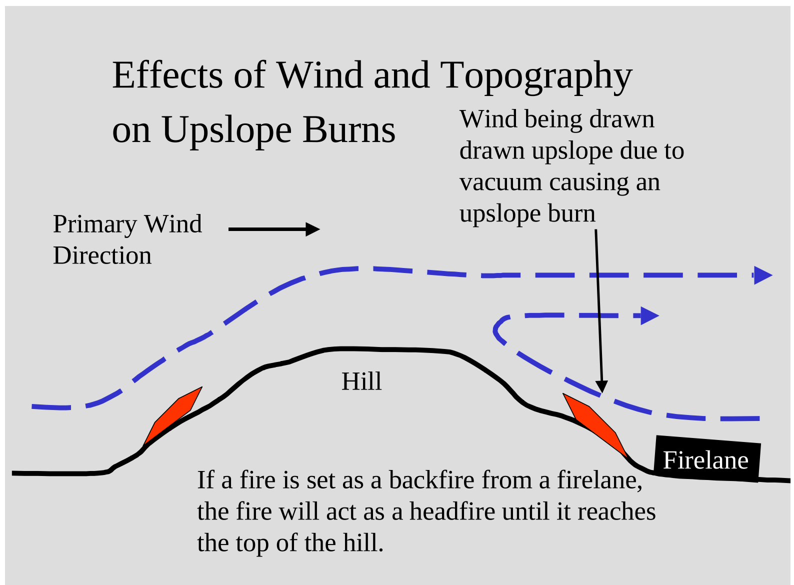

Figure 3. Effects of a hill on wind direction wind fire behavior.

Firelanes and Firebreaks

Types of firelanes. Firelanes fall into 2 broad categories – *Manmade and Natural*. The terms firelanes and firebreaks are often used interchangeably. In reality they are 2 very different things.

Figure 4. A pre-burned firebreak. This firebreak was burned under relative cool conditions.

Firelanes (also called *firelines*) are narrow strips in which burnable fuels have been removed. Backfires and/or some flanking fires should not be able to burn across a firelane. They can be 7 feet wide or wider. They are often used when igniting backing fires that will become the actual firebreak.

Firebreaks are much wider areas and are designed to stop headfires including burning embers (Figure 4). The width of a firebreak depends on the type of fuel being burned as well as the prescription for the type of fire. For instance, if the fuel is grass and wind speeds are less than 10 mph, a 100 foot strip that has been backfired is a good firebreak. If brush piles are being burned then a 300 - 500 foot firebreak may be necessary.

Natural firebreaks could be rivers, streams or lakes, rock ledges or shelves, as well as dense canopied vegetation with little grass understory to carry a fire. Areas with dense juniper (cedar breaks) meet this criteria. If cedar breaks are used as firelanes or firebreaks, then leaf fuel moisture should be above 70 percent (see leaf fuel moisture on page 7).

Manmade features such as roads or jeep trails, fields, or green mowed areas can be used as firelanes.

Both natural and man-made firelanes/firebreaks can be incorporated into an overall prescribed burn plan. If firelanes do not exist, then they must be installed prior to the burn. They can be mechanically installed using bulldozers, graders, or plows. Typically vegetation is removed to mineral soil. Care should be taken so that rolled soil does not cover sticks or grass that can act as bridges and will burn for several hours or days and possibly breech the firelane. Rocky outcrops should be visually checked to insure that no grass bridges are located between rocks.

Figure 5. Burning in a firebreak prior to a prescribed burn.

Mechanical firebreaks have one long term disadvantage, they can be highly subject to erosion. One way to avoid this is to “burn in” your firelines (Figure 5). This is often called “**wet lining.”** This can be done by using a pumper truck equipped with 2 hoses. Use the hoses to wet both sides of a pasture road. The center portion of the road is then “burned out” leaving a 6 to 7 foot firelane. Care should be taken to insure that water penetrates from the top of the plant to the soil surface to insure that the fire will not burn under the wet line. Humidities should be between 40 percent to 50 percent. Too low a humidity risks fire control effectiveness. Too high a humidity may leave grass bridges. These bridges can ignite under the lower humidity conditions when setting the main fire. One to 2 miles of firelane can easily be constructed in 2 to 3 hours using this method.

If pasture roads are not available, firelanes can be established by feeding cattle along fire boundaries during wet weather (Figure 6). Burning out between shredded strips using wet lines in the shredded area has also been effective. In areas where leaves and dry litter have formed, some prescribed burners are using gasoline powered leaf blowers to remove leaves to create a fireline.

Figure 6. Firebreak made by feeding cattle during wet weather.

During the winter, firelines can be created several weeks before the actual prescribed burn.

If the objective of the fire is to remove brush piles, firebreaks should be widened to 300-500 feet. This is usually done in the spring of the year after spring "green up" because green grasses do not burn well. Cattle should be grazed in the pasture to remove standing dry matter. Brush piles in the firebreak area can be safely burned at this time with 3 -5 mph winds and humidities around 50 percent. The pasture then can be rested to grow fuel for the following year. This area will be re-burned prior to headfiring the pasture.

Types of Ignition

Headfires: Headfires are fires that are moving with the wind. Headfires preheat the fuels in front of the flame causing ignition to be rapid and rate of spread relatively fast. Sparks can be blown to unburned areas ahead of the fire (Figure 7).

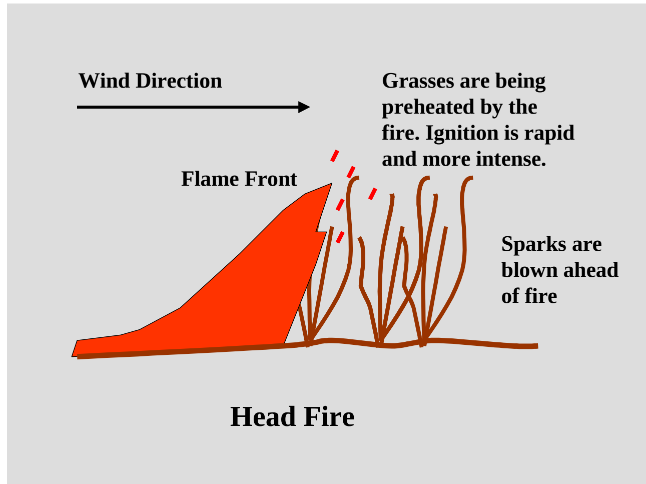

Figure 7. Headfires burn with the wind and preheat fuels in front of them.

Backfires: Backfires are fires set to burn against the wind. These fires do not preheat the fuels ahead of them as opposed to headfires that do preheat fuels. This makes fuel ignition much slower with fewer embers being blown with the wind. Because they are moving against the wind, the rate of spread is much slower than a headfire (Figure 8). Backfires are usually used in conjunction with firelanes to back the fire into a pasture to safely increase the width of a firelane into a firebreak. They are also used to “cool down” a fire in areas with excessive fuel loads.

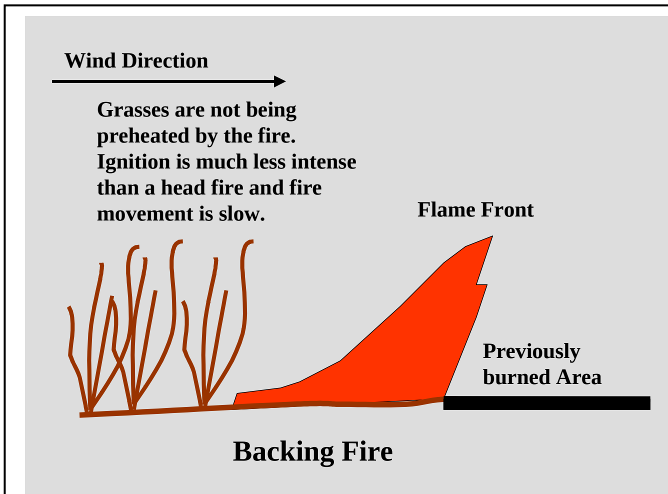

Figure 8. Backfires move against the wind. They do not preheat fuels and are much less intense fires.

Strip headfires: Strip headfires are lines of fire that are set perpendicular to the wind and parallel to each other. They are used to rapidly burn an area after backfires have created blackened safe areas (firebreak) along the firelanes to stop a headfire. When environmental conditions are within prescriptions, strip headfires can be used to burn large areas very rapidly (Figures 9 and 10).

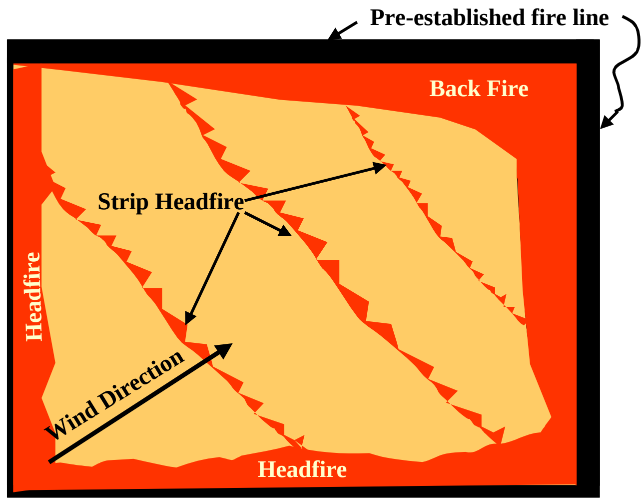

Figure 9. Strip headfires are lines of fire used to rapidly burn out pastures.

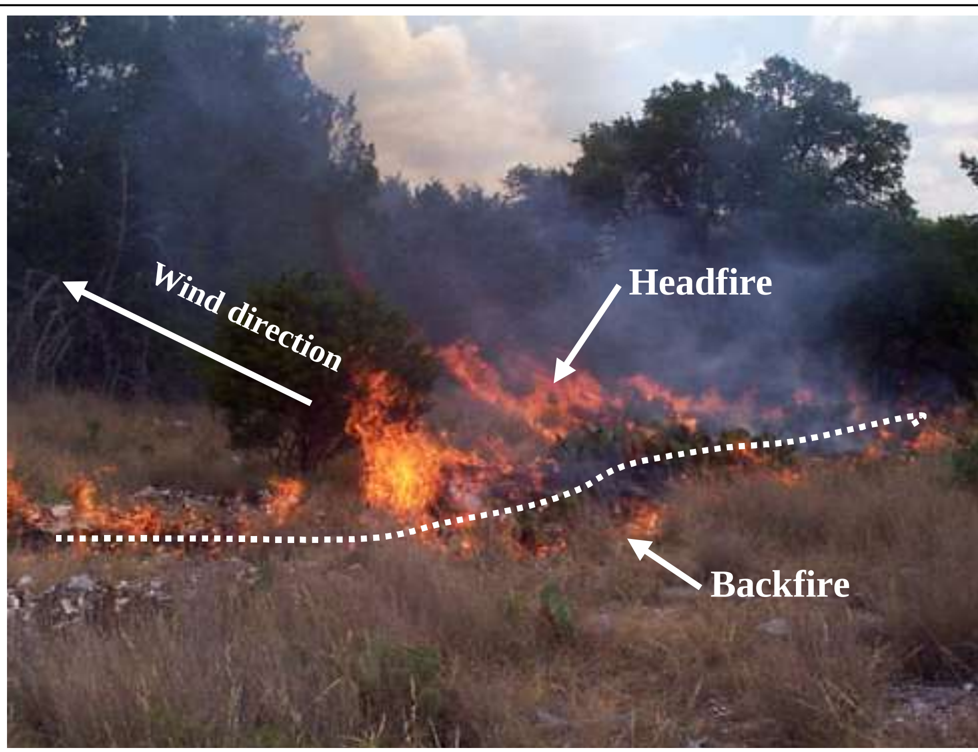

Figure 10. Strip headfire. Note the difference between the intensity of the headfire vs. the intensity of the backfire.

Spot fires: Spot fires are small fires that are set at intervals (Figure 11) throughout a pasture. These fires will increase in size and become headfires. Spot fires become headfires, flanking fires, and backfires before coalescing. They can be used to conserve fuel when setting a fire. They do not burn a pasture as uniformly as strip headfires and create more of a mosaic burn.

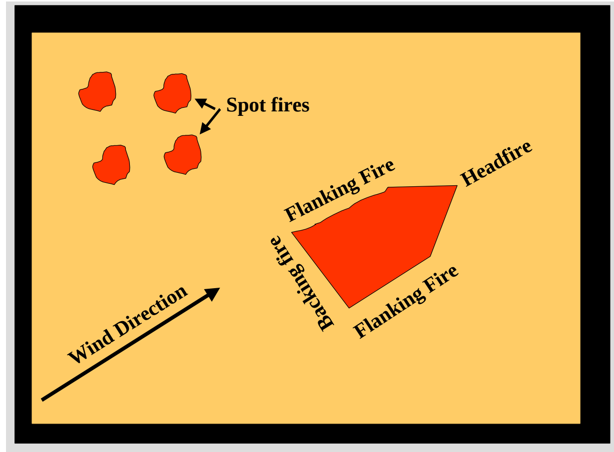

Figure 11. Spot fires are fires set at intervals and allowed to burn together.

Flanking fires: Flanking fires are fires that are moving parallel to the wind. They are generally less intense than headfires yet more intense than backfires (Figure 11).

Parallel Strip fires: Two parallel strips of fire are often used to "burn in" firelanes by using a sprayer with 2 hoses to spray 2 parallel lines 8-10 foot apart. Drip torches are used to ignite 2 parallel strips of fire immediately adjacent to the inside of the wet lines. The 2 fires will heat the air between the flames causing a vacuum that will draw the 2 lines of fire toward each other and away from the wet line (Figure 12). This technique can also be use to reverse the flame front away from sensitive areas. This technique is only good under low wind conditions.

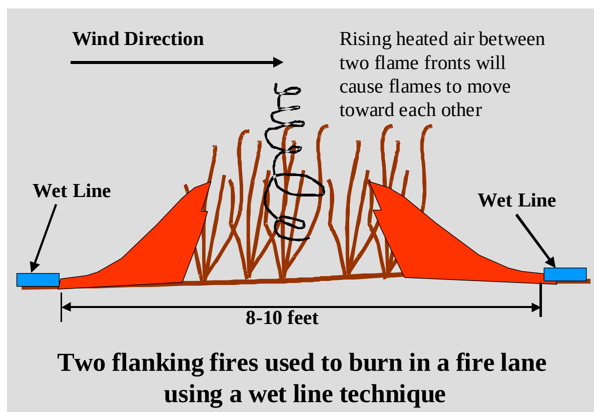

Figure 12. Parallel strips of fire (Modified flanking fires) are often used in pairs to create firelanes.

Circle ignition: By igniting fires in a circle such as around motts of trees, fire intensity within the circle is increased. This technique can be used to burn through liveoak leaves or other hard to burn areas.

Upslope vs. downslope burn: Fires burning up a hill are called an upslope burn. Fires burning down hill are downslope burns. Upslope burns more easily preheat vegetation (much the same as increased wind speeds) and burn hotter and faster than on level land. Down slope burns are much less intense and move slower than upslope burns.

Burns in draws or gullies: Fires in draws or gullies tend to trap heat and under certain conditions may increase wind speeds and redirect wind currents. Care should be taken when burning across draws.

Prescriptions:

Prescriptions: For thousands of years fire was an integral part of the Hill Country ecosystem. Over time different plants developed different responses to fire. For instance, juniper (cedar) is a non-fire tolerant plant. It does not take a great deal of heat to kill a juniper less than 1" in diameter. If heat can be held uniformly around the base of the plant for about 6 seconds, the cambium layer will be "baked" and the juniper will die within the next several weeks. Prior to European settlement, junipers grew in areas protected from fire or that did not burn frequently. Examples of such areas were overgrazed areas along streams and watering sites, areas with shallow soils, areas with sparse vegetation, or steep canyons.

Oaks have thicker bark than juniper and can withstand a greater degree of heat.

Some grasses such as little bluestem, and vine mesquite are favored by fire. Some plant seeds require that the seed coat be damaged by fire to allow moisture to enter the seed for germination i.e. redbuds and other legumes. The hotter fires favor some seeds that require contact with mineral soils such as Spanish oak and flameleaf sumac.

As range managers began to study the effects of fires on various plant species, it became obvious that by burning under certain environmental conditions, they could select for or against certain plant species. Burning under a set of environmental conditions to achieve an objective is called a ***prescription.***

Common Prescriptions

To control juniper less than 1.5 inches in diameter without harming other woody species
Fuel load – minimum of 1,200 lbs. of grass per acre (grass about 1 foot tall).
Humidity – 25-30%
Wind speed – 3-5 mph

All prescriptions were developed using a sling psychrometer. There are often 5 to 15 percent differences in humidity readings between electronic and sling devices. Electronic devices generally read lower.

To burn through Shinoak motts
Fuel load – minimum of 1,200 lbs. per acre.
Humidity – 20-25%
Wind speed –5mph.

To burn through liveoak motts
Fuel load – minimum of 1,200 lbs. per acre.
Humidity – 20%
Wind speed –5mph.

To burn through brushpiles
Fuel load – minimum of 1,200 lbs. per acre.
Humidity – 40-60%
Wind speed –3-5mph.

To add nitrogen and phosphorus to invigorate range plants
Fuel load – 1,200 lbs. per acre.
Humidity – 25-30%
Wind speed – 3-5mph.

Figure 13. Cedar control 4 months following a prescribed burn.

Juniper (Cedar) Control: Prescribed fire will control 80-90 percent of the juniper less than 1.5 inches in diameter (Figure 13). The problem is that fire has to get to the base of the juniper to be able to "girdle" the base. On first time burns in most pastures, fuel loads are often very broken and not all plants are exposed to fire. It often takes 2 -3 burns to build enough uniform ground vegetation to carry the fire to the base of the plant. Fires that move too fast past a juniper will not allow heat to remain around the base long enough to kill the plant.

Uniformity of fuel and large rocks and shallow soils: If the vegetation was mechanically controlled prior to a fire, the resulting soil disturbance and rocks "raised" will cause the fuel load uniformity to be highly variable. This broken fuel load will break up the fire front resulting in less than optimum cedar control (Figure 14). Juniper growing next to a rock can also affect the girdling of junipers. The fewer the rocks the better the juniper kill. Following the fire, many junipers will turn brown within days. However, it often takes several weeks (sometimes months) for some of the junipers to die.

Figure14. Shallow, broken soils will influence the dynamics and effectiveness of a fire.

Second or third burns in a pasture often result in better juniper control than first burns because fuel loads are more uniform. *"It takes a fire to make a fire"* is a common saying among those who do a great deal of burning. Fire redistributes nutrients, resulting in more uniform vegetation.

Immediately following the fire is the best time to "handcut" junipers that were not killed by the fire. The ground around the junipers is exposed and small plants are more easily seen and cut.

Brush piles: Burning brush piles, especially juniper, is relatively more hazardous than burning grass (Figure 15). Grasses are consumed in 5 - 10 minutes. Brush piles generate a great deal of heat and burn for longer periods of time. They sometimes require a greater degree of manpower and resources to control. Brush pile areas should be burned following spring "green up" using the fire prescriptions listed previously. If piles are in adjacent pastures and close to firelines, livestock can be grazed in those pastures prior to burning to reduce fuel loads (grass) between piles. This will reduce the possibility of grass fire ignition. When controlling mature juniper, many people will use a bulldozer to push juniper into piles. These piles often have limbs or stumps covered with dirt. Covered debris can easily burn for 1 - 2 weeks creating a long-term fire hazard. With newer mechanical methods of controlling juniper such as skid loaders with hydraulic shears, juniper can easily be cut and allowed to lie on the ground (not stacked) without excessive soil disturbance. As the leaves from the downed juniper began to fall, the juniper limbs act as a protective cage, allowing grasses to grow. The vegetation in the cages will act as fuel to burn up individual piles. If junipers are sheared within a few months prior to a burn, the leaves will still be on the plants at the time of the burn. They will act as a fuel bridge to carry a fire. Therefore, mechanical brush control programs should be planned 2 - 3 years prior to the fire to allow for adequate

Figure 15. Brush piles burn hot and can throw sparks.

grass growth (fuel); or, it must be timed to be 2 - 3 months prior to the burn so that the juniper maintains its leaves to carry the fire. Otherwise, the juniper should be stacked to assure complete combustion.

Burning through leaves:

Figure 16. Post oak leaves are easily burned.

Leaves come in 3 basic forms – flat (live oak), crumpled (Spanish oak), and somewhere in between (shin oak). Burning through flat leaves is a great deal like burning a telephone book. There is not much oxygen between the leaves and moisture is trapped between the leaves making them hard to burn. Spanish oak and blackjack oak have crumpled leaves, much the same as a crumpled piece of newspaper. There is more oxygen between the leaves and they do not hold as much moisture. Burning through these leaves is much easier than burning through liveoak (Figure 16). Leaves are the fine fuels that carry the fire through oak motts. Fires need to be “hotter”(e.g. lower relative humidity, greater wind speeds) to carry through live oaks motts. Much cooler fires will carry underneath Spanish oaks, blackjack oaks or post oaks. It is easier, therefore, to get fire to regrowth juniper under Spanish oaks than under live oaks. A specific prescription is needed to meet different management objectives for different vegetative types (Figure 17).

Figure 17. Unburned liveoak mott on left with thick leaf litter. The picture on the right shows grasses intermixed with regrowth live oak following a burn.

Smoke management

Smoke management: Smoke can travel long distances and has the potential to carry particulates. It can be rather dense and become a visual hazard on highways. To avoid this possibility, fires should not be set before 9 a.m. and should essentially be completed 2 - 3 hours before nightfall. Most headfires should not be set after 3:30 p.m. to allow for the majority of the volatile fuels to burn completely out before 5:00 p.m. The reason for this has to do with the way smoke rises. Smoke (warm air) rises through cooler air. On the average morning, surface air is cooler than upper air. This is called a temperature inversion. Smoke (hot air) rises through the cooler air. As the smoke rises, it hits the warmer air and cannot rise any higher. It begins to travel parallel to the ground. Often in the morning the temperature inversion can be low to the ground. As the day progresses, surface air warms more than the upper air and rising air currents (convection currents) carry the smoke upward. In the evenings, as the surface begins to cool (weakening the convection currents), cooler upper air begins to flow downward carrying smoke layered air with it and settles in low areas (Figure 18). This settling of smoke can reduce visibility on roads and can be a breathing irritant. To avoid this, fire weather forecasts include an item called ***mixing height***. As the air heated by solar radiation rises, it displaces cooler air that sinks. This sets up a vertical circulation pattern. The height to which vigorous mixing due to convection currents occurs is called the ***mixing height***. Fires should not be started when the mixing height is less than 1,500 feet. ***Transport winds*** are average winds that occur from the surface to mixing height and will also aid in smoke dispersal. If you multiply the mixing height in meters times the transport winds in meters per second you will get a number. This number is called the Ventilation Rate. Any ventilation rate number above 2000 means you will get smoke dispersion. However, numbers above 4000 are preferred

Figure 18. Smoke management is an important component of a prescribed burn.

Fires should not be set so that winds will blow smoke across a highway

Seventy percent of green material is moisture. Burning through green grass can generate a great deal of smoke. If there is a possibility that a fire may generate excessive smoke that could cross roads, highways, or interstates, local traffic control authorities should be notified and warning signs and flagmen used to control traffic. Fires next to roads should be started late enough to avoid an inversion yet early enough to be completely burned out before nightfall. **Fires should not be set so that winds will blow smoke across a highway**. Using the prescriptions given and with wind speeds less than 10 mph, smoke should rise fairly rapidly and be safely above the highway after burning 300 - 400 yards into the pasture.

Fire weather forecasts:

Prior to any prescribed burn, it is imperative that a fire weather forecast be obtained to insure atmospheric conditions will be such that they will *achieve the objective of the burn and will fall within safe burn conditions (Figure 19).*

Obtaining fire weather forecasts can be as easy as calling the National Weather Service and obtaining pertinent weather conditions from a fire weather forecaster. If you have access to the Internet, the following Webb address will give you pertinent weather information:

http://www.boi.noaa.gov/FIREWX/SATFWFEWX.html

The following is an example of data presented on the webb page.

	TODAY	TONIGHT	FRI
CLOUD COVER	PCLDY	MCLEAR	MCLEAR
PRECIP TYPE	NONE	NONE	NONE
CHANCE PRECIP (%)	0	0	0
TEMP (24H TREND)	65	41 (+3)	75
RH % (24H TREND)	32 (-21)	100 (0)	28
20FTWND/AM(MPH)	N 4		SW 3
20FTWND/PM(MPH)	E 1	SE 4	SW 5
LAL	1	1	1
CWR	0	0	0
HAINES	2	2	2
MIXING HGT(FT-AGL)	1679		4954
TRANSPORT WIND(KTS)	N 2		SW 10

.EXTENDED...
.SATURDAY...MOSTLY CLOUDY. LOWS IN THE LOWER 50S. HIGHS IN THE MID 70S. SOUTHWEST WINDS 5 TO 10 MPH.
.SUNDAY...MOSTLY CLOUDY. PATCHY MORNING FOG. LOWS IN THE LOWER 50S. HIGHS IN THE LOWER 70S. EAST WINDS 5 TO 10 MPH.

.MONDAY...MOSTLY CLOUDY. SLIGHT CHANCE OF SHOWERS. LOWS IN THE UPPER 40S. HIGHS IN THE MID 70S. SOUTH WINDS 10 TO 15 MPH.
.TUESDAY...MOSTLY CLOUDY. CHANCE OF SHOWERS AND THUNDERSTORMS. LOWS IN THE LOWER 50S. HIGHS IN THE LOWER 70S. SOUTH WINDS 10 TO 15 MPH.
.WEDNESDAY...MOSTLY CLOUDY. CHANCE OF SHOWERS AND THUNDERSTORMS. LOWS IN THE UPPER 40S. HIGHS IN THE MID 60S. NORTH WINDS 5 TO 10 MPH.

For a more detailed explanation of the fire weather forecast go to
http://www.srh.noaa.gov/ewx/html/FireWxinfopage.html

Figure 19. A fire weather forecast will provide a burn boss with the information necessary to conduct a safe burn. Note that the smoke is rising vertically and few sparks are being produced. This is due to the burn being conducted with the proper prescription.

Prior to any fire, a burn manager should be aware of rainfall patterns several months prior to the burn. Drought conditions will influence leaf moisture, soil moisture, and fire behavior.

Prescribed burns are more than just a fire.

Prescribed fires are objective driven. Common objectives would be regrowth juniper control, brush pile removal, litter removal, thinning of live oaks, prickly pear control, etc. To be a useful management tool, prescribed burns must be an integral component of an organized range management system. For example, to have an effective juniper control program in the eastern portion of the Edwards Plateau, pastures should be burned on a 5-year rotation. This means that 20 percent of a ranch will be burned annually. It also means that in order to burn a particular area, that area (pasture) should not be grazed during or after the growing season in order to produce the fine fuels necessary to carry the fire. That necessitates a flexible livestock management program. If 20 percent of an area is to be burned each year and protected from grazing, that would dictate that a ranch should have at least 5 pastures of approximately equal size and carrying capacity. The ranches' livestock stocking rate would be based on the carrying capacity of 4 pastures. Grazing systems such as Short Duration, or High Intensity, Low Frequency systems work best with prescribed burn programs (Figure 20).

Figure 20. The pasture to be burned should be removed from the grazing system the growing season before the fire. Rotational grazing systems add flexibility to fire management programs.

When a pasture is burned, both nitrogen and phosphorus are released acting as a fertilizer for new vegetation. Deer as well as livestock seek out burned areas with newly fertilized vegetation for grazing. To prevent overgrazing on burned sites, livestock grazing must be controlled by fencing. Deer and many exotics cannot be removed from low fenced pastures. To prevent over browsing by deer following a prescribed burn, deer numbers should be reduced to below carrying capacity prior to the burn.

Getting ready for the burn:

Planning for the actual burn begins in April. A decision is made at that time on which pasture will be burned next winter. Livestock grazing plans should be adjusted starting in June so that the pasture will not be grazed until after the burn. A generalized plan for the burn should be formulated at this time. The plan should consider how firelanes will be installed, wind direction of the fire, volatile fuels near the perimeters of the fire, critical structures needing protection, and sensitive vegetation. For instance, if a southerly wind is going to move the fire in a northerly direction, the pasture just north of the target pasture could be grazed in the late fall to reduce fuel loads along the northerly firelines (see firelines). If necessary, deer blinds or other mobile structures should be moved to safe areas. Dead standing trees along the firelanes should be cut and moved a safe distance into the burn area.

Figure 21. Portable spray pumps are necessary tools for controlling prescribed burns.

Equipment needed for the burn:

Basic equipment needed:

∗1 200-gallon or larger sprayer designed to slide in a 4x4, ¾ ton pickup (Figure 21). This unit is used for installing firelines and used to suppress any spot fires. It is held in reserve during the actual burn, and is intended for

fire suppression only. It will assist the smaller pumper units if needed.
∗2 100-gallon slide in sprayer for either a jeep or pickup. These light pumper units move behind the fire ignition team and are used as minor fire suppression if necessary.
∗1 fill pump with hose.
∗4 drip torches (Figure 22).
∗4 5-gallon gas cans for drip torch fuel. These cans should be clearly marked for drip torch fuel only
∗Fire weather kit with a minimum of 1 sling psychrometer (humidity guage), a wind gauge, and pencil and paper to record data (Figure 23).
∗A minimum of 1 radio for each vehicle, person lighting the fire, and person checking the firelines (Figure 24). It is highly desirable to have a radio for all persons on the burn.
∗Chain saw and juniper loppers

Figure 22. Drip torches burn a fuel mixture of diesel and gasoline. They are the primary source of ignition for prescribed burns.

Figure 23. On the left is a fire weather kit that uses a sling psychrometer to calculate humidity and wind speed. On the right is an electronic weather recorder.

∗Chain or cable to pull burning stumps or trees
∗Maps of the area to be burned with prominent features and check points clearly marked
∗Matches or lighters for each person. Matches should be *"Strike anywhere"*
∗Drinking water in each vehicle
∗First Aid Kit
∗Gloves
∗Gasoline for engines in a ***clearly marked*** can

Figure 24. Hand held radios are a necessity for coordinating prescribed burn activities.

Nice to have equipment:

∗Extra slide in sprayers
∗Fire rakes and slappers (a juniper switch is a good subsitute)
∗4 wheel ATVs
∗Radios for all persons at the fire
∗Fire weather stations that automatically record data
∗Cell phones for off site communications if necessary
∗Fire-retardant clothing
∗Handheld GPS systems with pre-programmed way points
∗A wetting agent such as dishwashing soap
∗Mobile water storage tanks
∗Leaf blowers and/or leaf rakes

Things to consider:

Livestock grazing: High intensity grazing systems are highly compatible systems to use with prescribed burns because of their flexibility in adjusting grazing schedules and stocking rates (Figure 25). The more pastures in a grazing system, the greater the management options. Prescribed burns should be total pasture burns if possible. Animals prefer grazing burned areas and will overgraze burned areas if not controlled. They also select for hotter burned areas over cooler burned areas. Being able to control grazing following a burn will greatly influence the positive or negative effects of the burn. Pastures should be rested from grazing beginning in June prior to the burn to insure adequate fuel loads that are as uniform as possible. Uniform fuel loads insure fire can reach targeted plants.

Figure 25. Livestock grazing systems offer a great deal of management flexibility with prescribed burn programs.

Animal numbers: Animals such as deer and most exotics cannot be excluded from most pastures before or after a burn. These animals also prefer to utilize plants from burned pastures. In order to control their impact on the burned pastures, animal numbers should be heavily reduced prior to the burn (Figure 26). Reduction


Figure 26. Animal numbers need to be controlled prior to a prescribed burn.

to ½ the normal carrying capacity is desirable. Also, the larger the burned area, the less the probability of over browsing by deer. If areas less than 300 acres are to be burned, it becomes very important to insure herd reduction prior to burning.

Red flag areas: Red flag areas are those areas in close proximity to firelines that would pose a possible threat for the fire to bridge or jump the filelines. Examples of red flag areas would be

(1) Dead standing trees that could "Chimney" after ignition and allow sparks to blow across a fireline (Figure 27).
(2) Old rotted logs or slash that burn for relatively long periods following ignition.
(3) Drainages that will funnel winds and increase their speeds.
(4) Areas where leaves or light litter have built up near firelines and could easily blow across the lanes.
(5) Certain types of vegetation such as yucca and agarito tend to burn hot and throw sparks. Broomweed and plants of similar shape can act as rolling torches when the main stalk of the plant is burned in two.
(6) Rocky areas with grass bridges that can burn across firelines.
(7) Areas where topography will not allow fire control equipment ready access. These may be steep hills or deep draws or bluffs.

Figure 27. Burning dead standing trees near firelanes are red flag areas and should be monitored to prevent possible fire escape.

Deer blinds and other buildings: If deer binds or other volatile structures are present, plans must be made to either remove them or to preburn grasses a safe distance around the buildings under favorable conditions (50 percent humidity, little wind) prior to the main burn.

> One of the common mistakes made on a prescribed burn is the redirection of fire equipment to protect facilities during a fire. Facilities should be made safe before igniting the main fire. Fire fighting equipment should remain on the fire line.

Telephone poles, and other utilities Telephone and electric poles seldom will catch on fire during a prescribed burn, however, to be safe, the area around the pole should be pre-burned.

Gas and oil wells: If these types of structures are present on a property, contact the owners prior to prescribed fires.

Road driveability and access to critical areas: Fire equipment must be able to easily drive around the perimeter of the fire. Roads and trails need to be maintained for easy access. Steep draws, gullies, and bluffs often are obstacles than cannot be negotiated. Provisions to have fire control equipment pre-positioned on both sides of an obstacle should be made.

Water sources and refill times: Water sources can be water storage tanks, lakes, rivers, or rural water systems. All water should be as clean as possible to avoid clogging pumps and spray nozzles. Centrifuge pumps can handle trashy water better than other types of pumps. Water sources must be easily accessible to vehicles and fill pumps. If water systems are used, fill rates should minimally be 50 gallons per minute or greater. If fill rates are less than desired, water storage tanks/troughs must be obtained and water pre-positioned for easy use. An open top, round 6-foot X 20 inch trough will hold 300 gallons. Most fill pumps will pump 150-200 gallons per minute. Water sources should be within 10-15 minutes of the farthest site within the burn. Sprayers should be "topped off" each time they pass a water storage area.

Surfactants: Wetting agents (surfactants) are added to water to "break down" the surface tension of a drop of water. They make water "wetter". "Wetter" water will penetrate plants, woods, burning logs etc. better than "standard water". A good wetting agent is dish-washing soap. Add just enough to the water so that soap bubbles are not formed (1-3 percent mix). This means less water is required to put out stubborn fires such as hollow trees. If sprayers are being drained nightly, many persons do not add surfactants to the water unless needed to put out stubborn fires. This is a cost saving measure.

Location of ignition fuel sources: In general, drip torch fuel mixtures consist of 30 percent gasoline and 70 percent diesel. All fuel should be premixed before starting the fire. A rough rule of thumb would be 1 gallon of fuel per 25 acres to be burned. A 600-acre burn would require 25 gallons or 5 five-gallon cans. These cans can be distributed with the various vehicles to insure distribution throughout the burn. In the event that not enough fuel was premixed, there needs to be a ready supply of gasoline and diesel close by.

Figure 28. Qualified personnel who understand fire behavior and ignition techniques are essential in maintaining fire control.

Qualified personnel: On all burns, 1 qualified person is in charge. This is the ***burn boss***. This is the person solely responsible for conducting the burn. The decision to burn, how the burn is conducted, who does what, and when they do it, is the burn boss's decision. The burn boss should be the person with the most training and fire experience. In addition to the burn boss, there should be 2 teams of a minimum of 3 persons each. Each team should consist of at least 1 person operating a drip torch (Figure 28), 1 person driving a sprayer/pumper and 1 person patrolling the fireline. That is a total of 7 persons. On burns larger than 300 acres, it is advisable to have 9 to 12 people to assist with widening the firelines, assisting in strip ignition, and fire suppression if necessary. The more people, the larger the area that can be burned in a short period of time. All personnel should have a good working knowledge of fire-suppression equipment operation. Those persons doing the actual lighting of the fire should be trained fire specialists. Knowing fire behavior under changing fuel loads, fuel types, and environmental conditions is a learned skill which determines how much fire to light at one time as well as how wide to extend a break before lighting the next segment of the fire.

Local fire authorities and local rules: Before any burn, the local county fire authorities need to be notified about the date of the burn, the location of the burn, authorities to contact before responding to a fire call as well as how to contact them. This insures that they do not respond to a call from persons unaware of the prescribed fire. Furnishing authorities with a map of the area to be burned is beneficial. Besides local fire departments, the sheriff's department and highway patrol officials often receive calls from the public and should be informed. Especially in urban areas, persons charged with monitoring air quality, should be notified. If smoke is expected to blow across a highway, law enforcement or traffic control personnel should be asked to monitor roads/highway traffic.

Method of ignition such as helicopter or ground: If burns are going to be relatively large (1,500 acres or greater), helicopters using helitorches may be used. The use of helicopters as a primary means of ignition is recommended only on very large areas and under control of highly experienced personnel. Helitorches are capable of laying down a 1 mile line of fire in 2 -3 minutes. Because of expense, co-ordination problems, and lack of qualified personnel, the use of helicopter ignition is not recommended.

If large areas (greater than 600 acres) are to be ignited using drip torches, adequate equipment and personnel will be needed to handle a rapidly ignited fire.

Communications: All persons on the fire should have radios. Having 2-way communications among all persons and the fire boss is a very important tool. Radios are used to control the sequence of ignition of the fire, request assistance for fuel or fire control, report fire status, request weather data, report burn conditions, etc. Radios should be capable of reaching all points of the fire area plus reaching the main telephone contact with county fire officials.

Weather recording: One person on the burn should be assigned to record weather conditions during the fire. This should include humidity, temperature, wind speed, and time of day. Data should be recorded at 30-minute intervals. A fire weather kit should be purchased for this purpose. The kit includes a **sling psychrometer** with water bottle, a wind measurement device, and tables to convert data (dry bulb and wet bulb readings) into humidity readings. Weather readings and predictions should be downloaded from the internet 24 hours prior to the day of the burn, the day of the burn, and after the burn.

Planning and conducting the actual burn

A generalized burn plan is presented in figure 29. In this plan, the burn will be conducted with wind from the southwest blowing to the northeast. For this burn, it is assumed that an 8-10 foot fireline has been pre-burned around the target area (See firelanes). All personnel(minimally consisting of the burn boss and the 2 ignition teams with pumpers and observers) will start in the northeast corner.

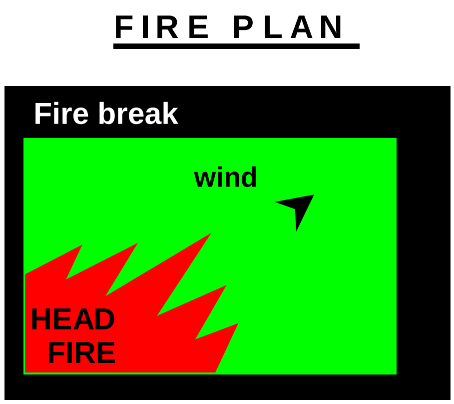

Figure 29. A generalized burn plan.

One team will begin to backfire and widen the fireline while moving south. The other team will begin to backfire and widen the fireline while moving west (Figure 30). Backfires should be ignited at the junction of the fireline and fuel so that the fire immediately begins to back up. If fires are started 2 - 3 feet from the firelane, the fire will be a headfire and not a backfire. If the flame extends over 1/3 of the fireline width, the fireline is too narrow and the fire should be stopped until lower wind

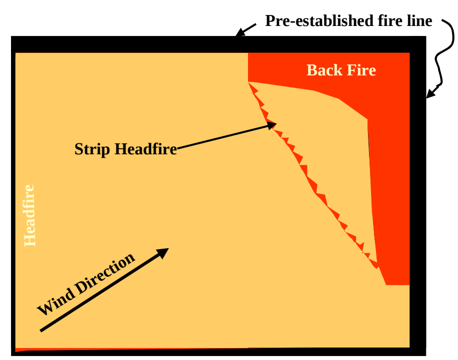

Figure 30. Beginning the backfire. Securing the North and east flank. And beginning strip firing.

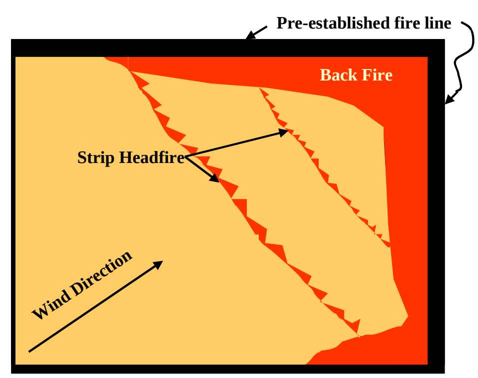

Figure 31. Extending the firebreak and beginning the headfire. East flank is secure. Second strip fire is installed.

speeds exist or until the fireline can be widened. Depending on fuel loads and uniformity, 30 - 60 yard stretches can be started and allowed to widen 50 to 100 feet before lighting the next increment. As the fire begins to widen, a second drip torch can be used to start a strip headfire fire 5 - 15 feet behind the backfire to speed up the widening of the backfire area. If a second drip torch is not available, the lead drip torch can go back down the fireline to widen the fireline. This can continue until the length of the fireline is completed and a safe distance is blackened into a firebreak. Once the backfires are complete, the lighters can start burning on the downwind side (Figures 31, 32, and 33). This will be a headfire. Strip fires, flank fires, or spot fires can then be used to complete the fire. The most common is a strip headfire. For planning purposes, figure 2 -3 hours for a team to backfire 1 mile. If a fire is started at 11:00, the backfire should be completed by 1:00. This leaves approximately 2 hours to strip headfire the pasture before the humidity begins to increase (Figures 34 and 35).

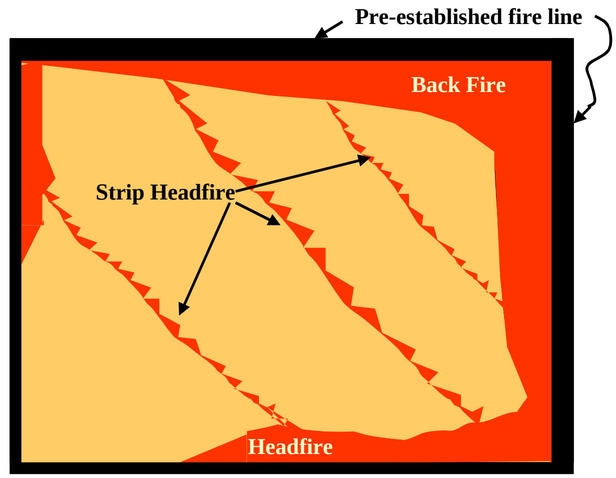

Figure 32. Backfires complete. Headfires and strip headfires almost complete. Third strip fire is installed. North and east flanks are secure.

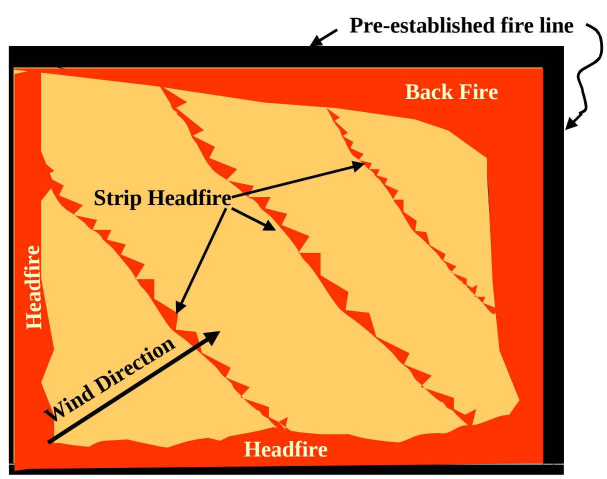

Figure 33. Backfire and headfires complete. The burn area is surrounded and is now comparatively secure.

Figure 34. A strip headfire is used to quickly burn a pasture under desired environmental conditions.

Figure 35. Strip headfire moving through a pasture.

Managing after the burn

Just as important as the burn itself is the management after the burn. There are certain plants that do well after “hot” burns, certain plants that do well after “cool” burns, and certain plants that don’t do well at all. Burning releases nutrients, which in turn

Figure 36. The picture on the left consists of cool season vegetation in a non-burn area adjacent to a burned area consisting of warm season plants.

grows a greater volume of plant material following the burn. It also controls/reduces undesirable plant volume. Doubling the volume of the more desirable grasses and forbs following a fire is not uncommon. Certain plants such as little bluestem, vine mesquite, sideoats grama, falmeleaf sumac, Texas redbud, and perennial forbs can be increased dramatically following a fire. In most cases, a pasture can be grazed by May or June following the burn. However, in the case of severely, long-term overgrazed ranges, a longer period of rest may be desirable to insure the reseeding of more palatable grasses (Figure 36).

A rotational grazing system can greatly control both grazing intensity and duration following a fire and is a very useful tool to manage for rapid recovery following a fire.

Selectivity of grazing: Animals are selective grazers/browsers. Cattle are primarily grass eaters. Deer are forb and browse consumers and eat grasses only when they are young and tender. Sheep, goats and most exotics also prefer forbs or browse but will readily consume grass. A major exception to those statements happens following a fire. There is a mineral release following a fire that has a fertilization effect on plants. This fertilization effect increases the palatability of a large number of plants to a variety of animals. Hot burns release more minerals such as nitrogen and phosphorus than cooler burns. Animals tend to select for plants growing in hotter burned areas preferentially to cooler burned areas (Figure 37). If the objective is to revegetate areas quickly, grazing pressure on the hotter areas should be monitored closely.

Figure 37. Excessive browsing on hackberry following a brush pile burn.

Figure 38. Recovery of a brush pile burn 2 years following the prescribed burn.

Brush Piles Areas: Brush piles burn “hot”(over 1000 degrees Fahrenheit) and tend to "sterilize" the soil making vegetative recovery very slow. Most brush piles burned on flat areas, with deeper soils will revegetate within in 2 - 4 years (Figure 38). Shallower soils on steeper slopes may take as long as 9 - 10 years. Brush piles on steep slopes are subject to unacceptable erosion. Placing old hay or other mulches on these sites will help stabilize these areas.

Grasses and forbs: Plants such as little bluestem do well after a burn. Little bluestem is a highly palatable grazing plant until July. After that the palatability rapidly decreases. In order to utilize little bluestem while it is highly palatable, cattle should be rotated through the pasture in April, May, or June. Cattle will utilize the grass. Forb production will be stimulated following grass reduction. Deer will then utilize the increased forb production (Figure 39).

Figure 39. Little bluestem growth 2 years following a prescribed burn.

Prickly Pear: In pastures with fairly uniform fuel loads, burning through prickly pear will remove the spines. Cattle should be placed in the pasture

Figure 40. Cattle being placed in a pasture immediately following a burn for prickly pear control.

immediately following the fire. They will readily consume the prickly pear thus aiding in its control (Figure 40).

Juniper (Cedar) Control: Not all juniper is killed during the fire. Immediately following the fire is a good time to mechanically remove small regrowth juniper. The plants are exposed and are more easily cut.

Browse Species, Root Sprouting, and Selective Grazing: Most browse plants handle the cooler fires very well; however, as fires become "hotter" some of the browse may be top killed. Plants such as hackberry, bumelia, redbud, cherry, grape, all the oaks, and many others will rapidly root spout, often growing several feet in a year. Other plants such as sumacs, redbuds, and cherry trees as well as some oaks will not only root sprout but will show increased germination following a fire. Some seeds such as Spanish oak, black nightshade or poke salad need nutrient rich bare ground to germinate (Figures 41-45).

Figure 41. Pokesalad growing in a hot burn area (brush pile).

Figure 42. The picture on the left is bumelia regrowth 1 year following a burn. The picture on the right are the same plants 2 years following the burn.

Figure 43. Flameleaf sumacs 3 years following a hot fire.

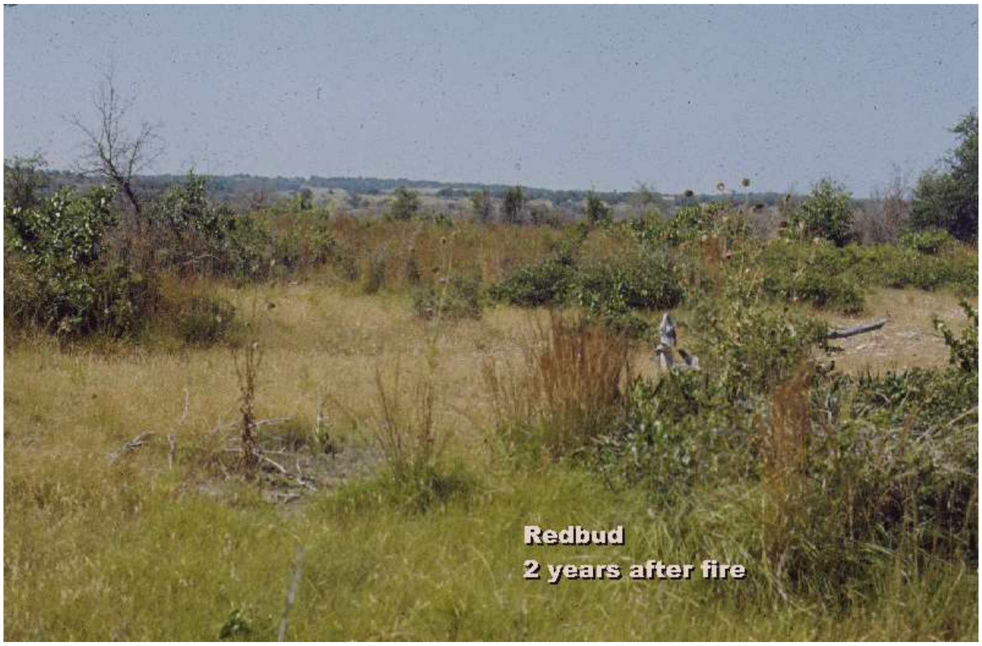

Figure 44. Redbud growth following a prescribed burn.

Figure 45. Flameleaf sumac growing from an agarito bush that was top killed by fire.

Legal Considerations:

There are 2 important pieces of legislation that govern prescribed burning.

Right to burn: Prescribed Burn Bill (HB 2599) has 2 basic provisions. It provides the landowner the right to burn and it sets up a burn board responsible for the certification and training of certified burn personnel. It has been supplemented with HB 1080 which deals with insurance considerations and with HB 3315 which deals with permitting of burns during county burn bans. To view this law, go to the following webb site:

http://www.agr.state.tx.us/pesticide/burnboard/pes_pbbmain.htm

Air Quality: Prescribed burns fall under the Air Quality Act. The Texas Commission on Environmental Quality governs this act. A publication titled *"Outdoor Burning in Texas"* lists rules and regulations for prescribed burns. It basically addresses 3 major areas: (1) It separates the definition of a prescribed burn from a controlled burn. (2) It regulates the start and ending time of a prescribed burn to avoid inversions. (3) It also defines certain counties along the Gulf Coast where regulations and permitting rules are exceptions to prescribed burn rules. In general, it says that fires should not be started before 1-hour after sunrise and head fires should be completed by 1-hour before sunset. It also states that minimal wind speed should be at least 6 mph and not greater than 23 mph, that smoke should not obstruct highway traffic, and that fires should not be set within 300 feet of a residence. The publication can be downloaded at **http://www.tnrcc.state.tx.us/publications**.

Anatomy of a wildfire

Large brush piles can be hazardous to burn. They can remain a source of unplanned ignition for days following the initial burn. A brush pile was burned on the morning of March 28, 1984. Spring greenup was well under way. The pile was completely burned out by 9:00 a.m. with the exception of some of the larger limbs and stumps, which were smoldering. The pile was located about 50 yards from 400 acres of mature juniper. As the day progressed, humidity dropped to 9 percent and winds were light. At approximately 3:00 p.m. winds begin to pickup from the southwest with sustained winds between 20-30 mph. Wind gusts were up to 49 mph. The smoldering fire blew embers into the green grass, which had just enough dry grass to carry the fire to a nearby draw (drainage) containing small piles of dry debris. The debris flared, carrying the fire to the canopy of the juniper. Instead of the heat escaping upward, high winds blew the heat into the next tree starting a general canopy ignition. The canopy fire began to move in a northeasterly direction. Over the next 30 minutes the wind begin to shift from the northwest moving the now ¾ mile long fire front to the southeast. The humidity rose to 15 percent. Between 3:30 p.m. and 4:30 p.m., 320 acres of mature juniper was burned by canopy ignition. The fire began to go out after 6:00 p.m. when it moved into an area with dispersed fuel loads, humidity began to increase, and wind speeds began to decrease below 10-mph winds. Drought conditions had persisted since October of 1983. Low soil moisture, very low humidities during the day, and sustained high winds were the major contributing factors to the fire (Figures 46-49). No flanking fires were observed during the burn. The fire was dependent on the heat of one tree being blown into the next tree for ignition.

Figure 46. Area of mature juniper prior to a canopy fire in 1984.

Figure 47. The same juniper area following the 1984 canopy fire.

Figure 48. Pasture in Figure 46 one year following the canopy wildfire. Note the strip of juniper skipped as a result of the background hill disrupting the wind.

Figure 49. The same area as figure 48 four years after the wildfire.

Further Reading

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