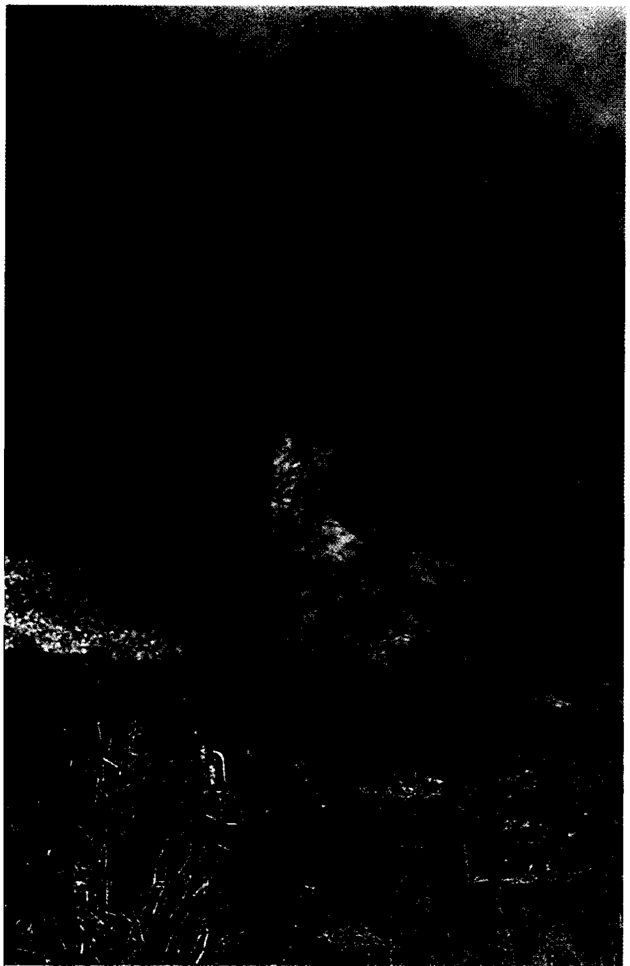

Prescribed Range Burning

in the Coastal Prairie and Eastern Rio Grande Plains of Texas

The Texas A&M
University System

Texas
Agricultural
Extension
Service

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Cover Photos:

Front - Prescribed burn in previously herbicide treated mesquite-whitebrush near Cotulla, Texas, February 26, 1979.

Back - Vegetation response May 1979 following the prescribed burn of February 26, 1979, near Cotulla, Texas. Note the openness of brush and excellent response of California cottontop (Digitaria californica).

PRESCRIBED RANGE BURNING IN THE COASTAL PRAIRIE AND EASTERN RIO GRANDE PLAINS OF TEXAS

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EQUIVALENT MEASURES

Metric Unit	*English Equivalent*
Centimeter	0.394 inch
Hectare	2.47 acres
Kilogram	2.205 pounds
Kilogram per hectare	0.893 pounds per acre
Kilometer	0.62 statute mile
Kilometer per hour	0.62 miles per hour
Liter	0.264 gallons
Meter	3.28 feet
Square meter	10.758 square feet
(Degrees centigrade x 9/5) + 32	Degrees fahrenheit

INTRODUCTION TO THE USE OF PRESCRIBED RANGE BURNING ON THE COASTAL PRAIRIE AND EASTERN RIO GRANDE PLAINS

Stephen J. Kleberg

Today's Symposium on Prescribed Range Burning is one of several that will be presented periodically throughout the state by the Texas Agricultural Extension Service. The main objective of today's Symposium is to provide an atmosphere in which there will be a free exchange of ideas and experiences on the topic of prescribed burning. We have some of the foremost speakers and researchers in this respective field here today to present the most up-to-date and pertinent information on the uses of prescribed burning as a range management tool. Range managers should take this opportunity to benefit from the exchange of ideas and experiences to be presented.and hopefully, they will be able to take some of the techniques on the uses of prescribed burning and apply them to their own unique situations.

The potential use of fire as a range management tool is becoming of increasing interest to range managers due to the ever escalating costs of alternative control methods. Fire is by no means a cure-all but if used wisely and with proper execution it can be a very useful tool. If used improperly, it can also have tremendously disastrous effects on rangelands.

There is still much to be learned about the use and application of fire as a range management tool. Whether a prescribed burn can be recommended for a particular situation depends on the site, composition of the vegetation, and the objectives of management. The application of prescribed burning should be integrated into an overall management plan with the primary reasons for the use of fire being to increase herbage yields, increase availability of forages, improve utilization of coarse grasses, control various parasites (such as ticks and liver flukes), stimulate early growth of grasses, removal of old growth, and improve wildlife habitat. Most of these objectives can be achieved simultaneously at a reasonable cost with a well planned burn.

Today's papers will help you develop a basis pro or con on the use of prescribed burning in the Coastal Prairie and Eastern Rio Grande Plains. Those of you interested in the uses of prescribed burning should try to extract as much information as possible from the wealth of knowledge to be presented and apply it to your particular situation.

We are very pleased with your attendance at this Symposium, and we are sure that you will leave today with many thought provoking ideas on prescribed burning. Please feel free to ask questions of the speakers, researchers, and ranchers here today, and be sure to avail yourself to the personal experiences of the ranchers on our panel this afternoon. We are all here to learn!!

THE HISTORICAL ROLE OF FIRE ON SOUTH TEXAS RANGELANDS

C. Wayne Hanselka

INTRODUCTION

The human species developed and evolved in a fire environment - the grasslands and savannahs of Africa and Asia (Komarek 1967). Early man learned to use fire (Sauer 1950) but yet feared, revered, and even worshipped it. Modern man retains many of these conflicting emotions as conditioned by experience and tradition. Fire is thought of today as a useful servant but, at the same time, is still considered an agent of destruction.

Pastoral peoples have historically used fire as a tool in clearing lands or otherwise improving pasturelands for their livestock. The advent of a more intensified agriculture and the need for more grass on smaller acreages coupled with the destructive aspects of wild fires has forced a change in philosophy away from the use of fire in land management. Increased technology in mechanical and chemical brush control techniques reinforced the attitude that fire was unnecessary and undesirable. Currently, however, a combination of factors are forcing yet another shift in attitudes back toward a reexamination of fire's potential on rangelands. Scifres (1980) lists several of these factors including economics, additional benefits, compatability with wildlife needs, and our improved understanding of fire ecology.

There is an increased awareness of the vast difference between controlled, prescribed burning and wild uncontrolled fire. Research over the past 20 years has increased our understanding of both the rewards and penalties of the use of prescribed fire. Techniques of prescribed burning have been developed and tested. Many land managers are now much more amenable to burning than in the recent past. This renewed interest, however, should be tempered with caution and understanding. The state of the art should be examined and all possible knowledge obtained before "striking a match".

The use of fire in range management may be examined on the basis of the historical record. As Malin (1953) stated, "The first task is to ascertain and classify the historical evidence; and not until that has been done can biological investigation proceed with much profit." With this in mind, the purposes of this paper are four-fold. They are:

(1) to explore the past and present aspect of south Texas ranges and explain changes that have occurred through time;

(2) to trace historical events that have had a bearing on the present vegetation;

(3) to develop a theoretical and conceptual framework on the role that fire has had in shaping the ranges of south Texas; and

(4) to develop a foundation for materials to be presented in succeeding papers.

The area under consideration is generally bounded by Interstate 35 on the west and northwest, U.S. 90 on the north, the Gulf of Mexico on the-east, and the Rio Grande on the south. This area encompasses the eastern portions of the Rio Grande Plains,the central and southern Coastal Prairies, and extensions of the Blackland Prairie vegetation regions.

PAST AND PRESENT GRASSLANDS IN SOUTH TEXAS

In order to analyze the influence a factor may have in ecological relationships, one must be able to isolate that factor and to measure any stimulus a change in factor intensity may have. Fortunately, we do have a historical record of fire in the south Texas area. We also have a record of general aspects of the vegetation over different portions of the area from 1580 to the present. In spite of inherent differences in observations and reporting by early travelers, a trend was established in vegetative change (Inglis 1964). Originally, the Rio Grande Plain was largely prairie that gradually was replaced by brush by the end of the 19th century. However, brush species have always been inhabitants of the area during historic times.

Pollen analysis from sites near Del Rio indicate that southwest Texas was relatively more moist around 8000 B.C. (Johnson 1963), but a drying trend had occurred by 2000 B.C. - 1000 A.D. Arid land trees and shrubs, such as mesquite, began to increase (Hester 1980).

The earliest historical records indicate that brush was, if not abundant, at least present in significant amounts. DeLeon, writing in 1580 of a Spanish land grant encompassing south Texas, described the country as:

> "...... an open country, with plains and few dense woods" ..... also, "there we find short pasture and the soil is alkali, with large and dense brush thickets . . . ..." (Duaine 1971).

Chapa (Duaine 1971) assisted DeLeon in exploring the Rio Grande near present day Reynosa in 1686. He described "level land" on the uplands but dense thickets within six miles of the river.

During the next 90 years several Spanish entradas traversed the Rio Grande Plains and Coastal Prairie regions of Texas. Captain Don Domingo Ramon traveled from near present day Eagle Pass to San Antonio in 1716 (Foik 1933). He described the area as "mesquite brush with plenty of pasturage." Alarcon (Hoffman 1935) crossed extensive prairies southeast of San Antonio in 1718. However, on the shores of Tres Palacios and Karankawa Bays, he reported "nopal groves (nogal?), some mesquites, and clumps of small oaks and chaparral." In 1722, the Aguayo expedition explored eastward from San Antonio to the coast. Pena, diarist for the expedition recorded that "we traveled...... through a woods sparsely covered with oaks and the rest of the way over a very level country" (Forrestal 1935).

Nicolas de Lafora, in 1766, traveled from Goliad to Laredo through the middle of the Rio Grande Plains (Kinnaird 1958). He reported abundant pasturage with some clumps of trees west of Goliad. However, once south of the Nueces river he recorded gentle hills with mesquite, nopal, and grass. Abundant pasturage with nopal and shrubs were found below the confluence of the Frio and the Nueces. A year later Solis traveled north from San Ygnacio, below Laredo, to Goliad and noted "prairies and hills dotted here and there with chaparral, mesquite, and prickly pear" (Forrestal 1931).

Jean Louis Berlandier made several trips through the Rio Grande Plains and Coastal Prairies in the late 1820's and early 1830's (Berlandier 1834). In general, the Rio GrandePlains were little changed from the late 1700's. Extensive prairies with mottes of brush were common. Stream beds were heavily wooded. He noted oak mottes in the Hochheim Prairie area, and recorded scattered mesquite and oaks on the upper Coastal Prairie. The lower coast was largely open grasslands with scattered brush.

Traveler reports are much more common in the late 1830's and 1840's after Texas gained its independence from Mexico and the country became more settled. Immigrant guides (Bonnell 1840, Ikin 1841, Lawrence 1840), soldiers (Churchill 1935, Smith 1917, McClintock 1930, Furber 1857), and military reconnaissances (Michler 1850, Hughes 1846) all noted aspects of the vegetation. Sibley (1967) pointed out that travelers crossing the upper Coastal Prairie were impressea by the abundant grasses, the "vast prairies," and the lack of trees. On the lower coast, however, they often noted clumps of oak, mesquite, and other brush species.

Throughout the latter half of the 1800's brush steadily increased in density (Lehmann 1969, Bogusch 1952, Inglis 1964) and/or visibility (Johnston 1963). For the past 100 years the Rio GrandePlains has been known as the brasada, monte, or brush country. The prairies referred to by early travelers have disappeared and have been replaced by a complex of about 281 brush species. The Coastal Prairie also has changed and is still changing. Open prairies have been reduced in size as brush mottes have grown larger and join together. More than 93% of the Rio GrandePlains and 34% of the Coastal Prairie (excluding cultivated land) has some degree of infestation of brush (Smith & Rechenthin 1964).

ECOLOGICAL FACTORS INFLUENCING VEGETATION

The vegetative complex in any area is the result of a multiplicity of environmental factors--primarily soil characteristics, climate, and biotic influences. The intensity and interactions of each will affect species composition, life form, and aspect of the vegetative cover. Local relief and topography will further modify each of these.

Soil

The south Texas area contains a diversity of soil types ranging in texture from fine sands to clays. The "Wild Horse Desert" is an area of deep eolian sands. Sandy loam soils are located throughout the south Texas region. These may be deep or fairly shallow underlain with a clay horizon. The northern and central Rio Grande Plains are characterized by moderately deep to deep, moderately coarse to coarse-textured mixed soils. Caliche outcroppings and gravel ridges are common. Calcareous clays characterize much of the Coastal Plain. Stream beds contain deep alluvial, loamy, mixed soils.

Climate

The general climate of the area is humid, subtropical with hot summers and cool winters. The frost-free period is approximately 260 to 330 days. Average annual precipitation ranges from 18 to 32 inches but varies from month to month and year to year. The primary rainfall peak, April, May and June occurs because of thunderstorm activity while the late August and September peak results from tropical disturbances in the Gulf of Mexico (Box, et. al 1978). Periodic drouths are common and frequently are severe. Eleven drouth periods occurred in the Mexican state of Coahuila from 1774 to 1863 (Harris 1975). Waldrip (1957) records extended drouths on the Rio Grande Plains in the years 1892-1902, 1916-1917, 1938-1939, and 1950-1956. Records indicate that rainfall amounts below 75% of average can be expected two out of every five years.

Biotic

Prior to the 1700's south Texas vegetation was not subjected to significant grazing pressure. Bison were found in the northern portions of the Rio Grande Plain and the Coastal Prairie but were rarely found south of the Nueces. The primary grazing animal was white-tailed deer. A few pronghorn antelope were also found in the region.

Horses, cattle, and sheep were introduced by the Spanish in the early 18th century (Lehmann 1969). Domestic livestock escaped, survived in a feral state, and multiplied so that most travelers reported "immense herds of wild horses" (Bonnell 1840, Hollon and Butler 1956, etc.). Lehmann (1969), however, provides convincing evidence that livestock numbers were cyclic and never existed in numbers reported by early travelers.

Man has long existed in south Texas and northern Mexico (Epstein 1972). His influence on the ecology of the prairies will be discussed later.

Weaver and Clements (1938) proposed that vegetation is controlled chiefly by climate so that a "climatic climax" is eventually obtained. Disturbances would cause an earlier seral stage to establish and the process would repeat itself. Successional theory thus allows for forest, Savannah, and grassland climax communities under varying climate regimes. McBryde (1933) analyzed the vegetation of the Carrizo Sands in Texas and concluded that edaphic factors influence the composition and local distribution of plant associations and effects of climate are reflected in gradual changes. Wedel (Humphrey 1962) has carefully analyzed and evaluated our knowledge of grasslands and concluded that climate is the major factor in determining vegetation. Some local conditions, such as hard pans, may maintain grasslands.

These viewpoints have their detractors however. Sauer (1950) believes that there is no evidence to support a climatic grassland climax. He cites different areas with similar climates supporting woodlands, brushlands, and grasslands. Moist prairies can support forests and arid plains can support xerophytic brush and shrub species (Stewart 1956).

Ecological characteristics of south Texas indicate that a shrubland climax should be the dominant vegetative complex. The mixed brush and Acacia ridge associations are probably the climatic determined communities in south Texas. Species composition and aspect are modified by soil characteristics and past management. If this was the case, some non-geographic ecological factor was responsible for the formation and maintenance of reported grasslands. A considerable number of writers believe fire has been a major determinant of early south Texas grasslands (Bray 1901, Cook 1908, Humphrey 1962, Johnston 1963).

HISTORICAL ASPECTS OF FIRE

If, indeed, fire has exerted an influence on south Texas vegetation the question remains as to what extent. Characteristics of fire such as causes, occurrences, and effects need to be examined in order to answer this question. The causes of fire may be divided into human and non-human (natural) sources. Occurrence characteristics, such as season of the year, frequency, extent, and intensity influence the impact fires have had on vegetation. Fire effects should be reflected in the relative tolerance of species to fire, adaptive mechanisms, and the visible aspect of vegetation.

Causes and Occurrences

Natural events kindled fires long before the advent of man in south Texas. Fuel, oxygen, and an ignition temperature source are the necessary ingredients. The first two components were relatively plentiful during most years. Natural heat may have come from several sources. Volcanic activity can be ruled out. Spontaneous combustion in canebrakes has been reported (Kilgore 1980, Bayley and Odum 1976). Canebrakes are relatively common in the upper Coastal Prairie and fires in these brakes have caused extensive prairie fires (Anon. 1834). In Texas, it is doubtful if many situations allowed fuel buildup and the heat necessary for combustion except in these brakes.

Wilcox (In Lott and Martinez 1953) perhaps was searching for causes when he suggested the possibility of "sparks from flint stones striking together as they were thrown by the running hoof of some animal." He does mention lightning as a source of fire in prairies near Laredo.

Lightning discharges have bombarded the earth daily throughout its history. These vary in number in both time and space in tune with global weather patterns (Komarek 1967). Komarek (1968) designates the south Texas area as part of the "central grasslands lightning fire bio-climatic region." It is an area of intense thunderstorm activity and the tall and midgrasses of the area are highly flammable. These factors combine with low rainfall, erratic weather patterns, many severe dry lightning storms, and searing droughts to form a highly critical fire environment (Komarek 1968). Given the fairly continuous fine fuel supply of grasses found on the Coastal Prairie under these conditions, lightning-caused fires probably were frequent. Records indicate that an average of 1 to 5 fires are ignited by lightning in this area per million acres each year (Schroeder and Buck 1977). Today, Texas Forest Service records indicate that only 1.2 to 2.2% of modern rural fires in Texas are started by lightning. In 1977, 2.2% of 4,929 fires covering 449,867 acres involved lightning (Ken Burton 1980).

The incidence of grass fires must have increased dramatically when humans settled in south Texas. Archeological evidence suggests that the Rio Grande Plains has beenoccupied throughout the period of 5000 B.C. to 1000 A.D. (Nunley and Hester 1966) and into the 1500's (Hester, et. al 1975, Hester, White, and White 1969). The numerous groups of interior Indians belonged to a Coahuiltecan cluster whereas Karankawa bands roamed the coast (Newcomb 1961). Karakawas were present from the late prehistoric period until the mid-1800's (Campbell 1958, Cherry and Torrance 1973). There is some evidence of commerce between the coastal and inland Indians. Seashells have been found in interior middens (Hester 1970).

The Coahuiltecans occupied a well-defined area of south Texas but led a wandering life dictated by food supplies (Newcomb 1961). Their use of fire ranged from ceremonial to insect control. Alvar Nunez Cabaza de Vaca (Smith 1871) related that, in 1534, coastal Indians burned smoky fires to drive off mosquitoes. Also,

> "The Indians of the Interior have a different method, as intolerable, and worse even than I have spoken of, which is to go with brands in the hand firing the plains and forests within their reach, that the mosquitoes may fly away, and at the same time to drive out lizards and other like things for them to eat . . . ..They are accustomed also to kill deer by encircling them with fires. The pasturage is taken from the cattle, by burning, that necessity may drive them to seek it in places where it is desired they should go."

Ehrenberg (Churchill 1935), Newcomb (1961), and Hodge (1907) all relate instances of burning of grasslands for hunting purposes. DeLeon (Duaine 1971) gives a lengthy discourse on Indian customs in the 1600's including their use of fire for food preparation, signaling, and ceremony. Solis (Forrestal 1931) inspected the Goliad and Refugio missions in 1767 and reported on Indian uses of fire.

The early Spanish entradas are strangely silent on the subject of fire.

Berlandier (1834) indicates that south Texas was occupied by roving bands of Lipan Apaches and Comanches in the late 1820's and 1830's. The country around Gonzales was "the abode of Tonkawas, Karankawas, and Comanches." He makes several references to burning of the prairies by Indians. Berlandier (1834), on the Nueces River between Laredo and San Antonio, reported that the Mexican soldiers journeying with him "fired the prairies in order to lodge more freely." Also, northeast of San Antonio that:

> "camp fires that travelers leave there sometimes, stirred by the winds, are communicated to the grass, the latter set fire to the trees, and the forest is set aflame. The fire produces great ravages."

Later he wrote that on the Coastal Prairie near Refugio:

> "......rattlesnakes fleeing the grassy areas which were on fire, that the Indians or the travelers had destroyed."

The majority of travelers in Texas in the 1830's described only the area north of the Nueces River since few journeyed across the unwatered land south of the river. Most travelers mentioned the presence of fire on the upper Coastal Prairie. Thomas Drummond, a naturalist, apologized to a colleague for the lack of insects in Texas due to "frequent burning of these lands" (Geiser 1937). Others refer to the use of fire as a management practice (Parker 1836, Anon. 1834). Mary Austin Holly relates an experience of a friend purposely igniting the prairie near present day Freeport (Hatcher 1933).

Benjamin Lundy, an abolitionist with dreams of locating a sanctuary for freed slaves, traveled south Texas and northern Mexico in the 1830's (Lundy 1847). Near Agua Dulce creek he observed that ".....trees would soon grow up, in the lower places, if the fires were kept down." He also remarked on smoke in the air due to the Indians burning the grass on their hunting grounds near Gonzales.

Ehrenberg (Churchill 1935), while traveling to San Antonio during the Texas revolution, records a prairie fire attributed to Indians. He later escaped the Fannin massacre and described his path between the Guadalupe and Lavaca rivers as a "bare plateau, the grass on which had recently been burnt."

The advent of the 1840's brought a renewed surge of travel across the Coastal Prairie and onto the Rio Grande Plains. Naturalists, settlers, immigrant guides, and soldiers recorded incidents of fires on the prairies. Ikin (1841) refers to the "annual burning of dry grass on the prairies....." The Reverend A.B. Lawrence (1840) describes the prairies and explains the lack of timber is due to accidental or purposeful burning. Bracht (Schmidt 1931) bemoaned the fact that Texas had a lack of forested land. His observation was:

> "That region produces excellent grass and possesses rich black

soil. He who knows these regions will have observed that, as soon as the needless prairie fires cease, small brush and young forests appear within a space of few years without the assistance of man."

Explorations and activities associated with the war with Mexico brought many persons into the south Texas area and Rio Grande Plains proper. Settlers were using fire to "burn weeds and old pasturage, so as to make room for new grass' on the upper coast (Hollon and Butler 1956). Accidents and carelessness probably remained the primary human cause of fires south of the Nueces. Bollaert observed prairie fires near the Nueces in 1844 (Hollon and Butler 1956). Hendricks (1919) observed that the prairie had burned as the result of escaped campfires near the San Miguel Creek and the Rio Frio.

General Taylor's troops marched from Corpus Christi into Mexico in the spring of 1846. Several members of this army reported on evidence of fire south of Corpus Christi. McCall (1868) saw burned prairie near Agua Dulce; Smith (1917) and Henry (1950) both reported that Mexicans had fired the prairie in front of the army; and McClintock (1930) reported areas burned south of San Patricio by fires spread from soldier and Indian camps. Furber (1857) also observed as he crossed the sands of Kenedy and Jim Hogg counties that "the vast prairie had recently been run over by fire, and the young grass had not well sprung up."

In the 1850's, Frederick Olmsted (1857) traveled through Texas. He recorded that a companion was attempting to burn off a small circle of grass so a camp fire could safely be used. A gust of wind caused the fire to escape and spread across the prairie. He also recorded evidence of a recent fire near Gonzales and, later, "saw the sun go down, buried and swollen, in the smoke of a distant prairie fire." Olmsted also described a man "firing the prairie" between the Guadalupe and San Antonio rivers near Victoria.

Further south, in 1852, Bartlett (1854) observed a prairie fire near the western edge of Kleberg County.

Burning for pasture improvement was still practiced in the 1880's (Holdsworth 1980, John M. O'Brien 1980). Accidental burns also occurred with the accompanying attitude that fire was detrimental (Meek, quoted in Lehmann 1969). Range conditions were changing on the Rio Grande Plains so that by the turn of the century Smith said that "grasses exist so sparsely that the destruction of brush and cactus by fire is almost out of the question....." Burning was still practiced on the Taft Ranch near Sinton in 1909 (Stephens 1964).

Fire Characteristics

Characteristics of fires such as season of burning, frequency of burning, the extent of area and intensity of the fires can, in most cases, only be inferred from the literature. The often fragmentary, biased approach of writers leaves an incomplete record of such characteristics. Each will be discussed separately.

Season: It is logical to assume that most fires occur during periods when fuel is dry. In south Texas this occurs most often in the summer and winter months. Thunderstorms are more common in the summer so lightning-caused fires would occur most often at that time. Mosquitoes are most troublesome during the summer so insect control fires would have been set by the Indians during these months. Hunting fires on the Rio Grande Plains were probably limited to late winter and spring as de Vaca (Hallenbeck 1940) relates the Indians subsequently subsisted on prickly pear tunas and various sea foods.

References to winter and spring fires outnumber summer and fall references three to one. Fires were set twice a year for management purposes (Hollon and Butler 1956, Ikin 1841) on the upper Texas coast. Parker (1836) stated:

> "The prairies are all burnt over twice a year -- in mid-summer and about the first of winter....."

Frequency: The only inference that can be made in regard to frequency of fires is discussed above. Ikin (1841) refers to the annual burning of pastures. Bracht (Schmidt 1935) uses the term "frequent fires in winter."

Extent: Presettlement prairie fires were evidently large and extensive. On the Coastal Prairie, with no natural fire breaks except streams, the continuous fuel load could feed a fire for miles. The Rio Grande Plains was similar except in the more arid portions where shallow ridge vegetation may have formed a discontinuity. This would limit fires to the valleys, ramadero sites, and hillsides. Stream beds usually did not provide sufficient fine fuel to carry a fire.

LaSalle's company (near present day Jackson County) traveled over "plains that had been burnt" (Joutel 1714). Drummond (Geiser 1937) complained that the whole country from the Rio Colorado to the Guadalupe (a distance of 80-90 miles) was barren of grass because of a recent burn. In 1838, a member of a recreational outing intentionally set fire to the prairie near the mouth of the Brazos with the result that a "line of flame extended right and left 8 or 10 miles" (Hatcher 1933). Similar fires were reported near Rnahuac that burned for over a week over a wide area (Anon. 1834). Ehrenberg (Churchill 1935) described a range fire between San Antonio and Gonzales after which his company marched an entire day.

Taylor's army often marched for a day over burnt prairies (Smith 1917). McClintock (1930) stated:

> "The troops and Indians had left fire where ever there was water, which getting in the dry grass had burned over the whole surface of the country. In places no grass was to be found for a distance of 20 to 30 miles."

These accounts should not be regarded as unusual. In August, 1980, a range fire between Sonora and San Angelo burned nearly 40 square miles (Corpus Christi Caller-Times 1980). A recent fire in Coahuila, Mexico, burned 17,000 acres.

Intensity: Intensity of fires depend on fuel loads and strength of the wind. In the Coastal Prairie fire fuel load is usually high and winds from the Gulf are strong enough to create a fairly intense fire.

Such may not be the case over much of the Rio Grande Plains. The area is subject to periodic drouths and fuel supply varies. However, even the poorer range sites (shallow ridge) in Jim Wells County during unfavorable years had the capability of producing 1000 lbs. of forage/acre (Menzenmayer 1979). This is enough fuel to carry a moderate fire. The more favorable sites during wet years could produce up to 8000 lbs. of forage/acre/year. Sites in Starr County could produce from 300 lbs. to 6000 lbs. per acre depending on the year (Thompson, Sanders, and Williams 1972). Intensity of fires would have varied from area to area and from year to year. Valley areas would have been more susceptible to hot fires in three out of five years because of drouth patterns.

Range fires were evidently very common in south Texas. Most fires occurred during the drier months of the year and probably covered large areas. They were fairly frequent, burning the same area regularly. Intensity varied with fuel load. Prior to grazing, enough fuel was generally present to carry a fire hot enough to affect woody vegetation.

Effects of Fire: Several characteristics of grasslands result directly from the influence of fire. Species composition will reflect those plants most tolerant to frequent fires. Fire tolerant plants have developed survival mechanisms that resist fire influences. Also, frequent fires may alter the visible aspect of an area--the appearance of the vegetation.

The climax grass species in south Texas are mostly warm season, perennial bunchgrasses. The interior, more arid regions supported buffalograss and curly mesquite grass. All of these grasses are relatively fire tolerant. Common native grasses today include the windmillgrasses, threeawns, fall witchgrass, and some lovegrasses. Under a burning program and good management, desirable native grasses such as plains bristlegrass, California cottontop, pink pappusgrass, and vinemesquite will reoccupy the site (Scifres 1980). This situation shows that the desirable, nutritious native range grasses of south Texas can withstand fire, are assisted by it, and probably developed under it.

The shrub complex in the area also exhibit mechanisms that enable it to tolerate fire. Ninety-five per cent of the upland shrubs on the Rob and Bessie Welder Wildlife Foundation in San Patricio County sprout from the root crown when the top is removed. Others, such as live oak, have the ability to root sprout and form large colonies.

The visible aspect of vegetation in south Texas has often led to confusion in the literature. The extensive prairies were often visibly dominated by grasses but actually contained many small shrubs (Furber 1857, Bartlett 1854, McClintock 1930). Several travelers in early Texas remarked that the brush exhibited a "peach orchard" effect (Malin, quoting Marcy in 1854 [1953],Lundy 1847, Lawrence 1840). The pruned lower branches and lack of undergrowth could well be the effect of fire. Wright, Bunting and Neuenschwander (1976) reported that a fire within 1.5 years of seedling emergence would kill up to 100% of the survivors but not harm the mature trees. Holdsworth (1980) remarked that ".....there was a bush here and there......The mesquites were what we called 'gotch'......you could see under them for some distance." Secondary succession and grass regrowth could also lower invasion success of mesquite and other shrubs (Scifres, Brock, and Hahn 1971).

Brush was often noted on the shallow caliche ridges. The lower grass production in these areas would negate a continuous hot fire. Blackbrush and other shrubs were well established here (Holdsworth, 1980) and were not damaged to a great extent by fire.

LAND USE, REDUCTION OF PRAIRIE FIRES, AND VEGETATIVE CHANGE

Lehmann (1965) describes the Coastal Prairie as an assemblage of prairies bounded by woodlands. Early travelers on the Rio Grande Plains spoke of thickets and mottes of brush. In the late 1800's these woodlands and thickets began to close together. This basically has been a function of several interacting factors.

Cattle and sheep have been pastured in south Texas since 1717 (Lehmann 1969). Their numbers have fluctuated according to climatological, sociological, and political conditions. Localized overgrazing took place, particularly near the few watering areas, but generally was not a problem. Livestock consumption of beans, pods, and other fruits from shrubs and the deposition of these seeds in the overgrazed areas assisted in vegetative change. The nomadic livestock could move to new pasturage thus deferring used areas. Most of south Texas was fenced by the 1890's, and fencing did much to promote brush increase by restricting livestock movements and promoting overgrazing (Bogusch 1952).

At the turn of the century ranges were being plowed, farms were being established, and roads were being built. This had the effect of isolating many previously large blocks of rangeland. Ranchers were becoming increasingly careful of fire and discouraged its use.

The previously good grass cover had restricted seedling establishment of brush. Seeds were held off the ground and periodic fires destroyed them and young seedlings. Larger plants were top killed. Grazing allowed this cycle to be broken. Fires eventually were reduced because of lack of fuel and rancher diligence. As a result, woody plants began to spread. Evidence of this is occurring today on Kansas bluestem prairies protected from fires (Bragg and Hulbert 1976).

The evidence from historical and modern sources points out that interactions of climate, soil, and land use, as modified by fire, have created the vegetational complex we have today. Lehmann (1969) appears to be correct in his view that brush spread as white man settled the country--and broke the age-old cycle of fire.

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RANGE AND RANCH MANAGEMENT CONSIDERATIONS FOR PROPER USE OF PRESCRIBED BURNING

Wayne T. Hamilton

Highlight

The proper use of prescribed burning by ranches requires use of logical management processes involving planning, organizing, direction and control. Burning differs from other improvement practices primarily in the lead time that is necessary to accomplish preburn objectives, such as accumulation of fuel load, and the direct involvement of ranch personnel rather than skilled contractors. Other preburn considerations in the planning and organizing processes include equipment, personnel, notifications and preburn patrols. The actual implementation of a prescribed burn requires little time, but may be the product of many months of preburn preparations and activities. Postburn management considerations include postburn patrols and grazing control. After the fire is installed, successful results depend on grazing management to allow adequate replacement of ground cover and recovery of the key forage species. Managers who contemplate the continued use of prescribed burning can systemize burns and grazing management to provide "built in" pre- and postburn deferments.

Preburn Considerations

Developing a Rationale for Burning

The first step for a ranch manager considering prescribed burning is to thoroughly answer the question: Why, where, when and how should I burn? It is advisable at this point to arrange for competent technical assistance for an "on-the-ground" inspection of the areas being considered for prescribed fires.

Why burn? Fire is an alternative tool which is not necessarily applicable to every situation or for use as the sole range improvement approach. It may be best used as a follow-up practice to a mechanical or chemical method. Deciding where and when to burn involves not only consideration for fire characteristics to match range management objectives, such as the need for reclamation versus maintenance burns, but necessitates a plan for building fuel load and handling the associated forage loss in livestock operations. Diverting herbaceous vegetation from "feed to fuel" is a critical consideration in the planning process. "How to burn" is a process of technical decisions resulting in a comprehensive fire plan to ensure the best results with minimum risks.

Effective application of prescribed burning on ranches requires adequate lead time to accomplish the necessary steps for preparation, installation and postburn management of pastures selected for burning. For example, considerable time may be required to build a fuel load adequate to carry the fire. Fuel preparation should begin several months ahead of the target date for burning. Thinking through the rationale for burning with good technical assistance early in the process allows plenty of time for preburn preparations and less chance of costly oversights or poor results from a last-minute effort.

Once ranch management has properly decided on the use of prescribed burning in a range improvement program, there should also be a strong commitment to successful completion of the practice. Follow-up deferment of grazing, for example, is just as important as properly executing the steps necessary for preparation and installation of the burn. Well managed ranges not only allow maximum benefits from the initial burn, but give a continuous capability to effectively use fire as needed for maintenance of range improvement.

Planning

Foremost of preburn functions for ranch management personnel is effective implementation of the planning process. First among planning considerations is the forage needs for livestock, both pre- and postburn. Preburn forage concerns result from the need to defer grazing of pastures scheduled for burning to build or retain the necessary fuel load. This means deciding where to place cattle on the remaining range or pasture resources. It would be counterproductive to overgraze some pastures for significant periods in order to build fuel for a fire in another pasture.

It is not recommended that less than an entire management unit be burned because of overuse of forage by livestock on the burned area during the postburn period. If less than a whole pasture is scheduled for the fire, it should be fenced to allow control of the preburn fuel development and recovery after the burn. Such fencing may be a low-cost, temporary structure which can be easily removed and reused for other areas. Most ranchers, if they begin planning for burns well ahead of the target date, can find places to go with livestock for the time that may be necessary to defer the pasture planned for burning.

The whole idea of building fuel is to use it for the fire, and if the burn is successful, it will leave the pasture bare. While we have seen very quick recovery of forage on some burns, there is always the chance, because of dry weather, that such areas will require several months for preburn carrying capacity to be reinstated. Even though the dry forage that was burned may have been low in nutritive value, it was forage that cannot be counted on until nature replaces it. In the case of late winter burns, regrowth can be fairly well predicted if soil moisture content is good. On summer burns, however, the dry fuel is a product of dry conditions which forced dormancy. Regrowth is dependent on rainfall, which may come promptly, or may not. In my opinion, ranchers contemplating summer burns should plan for the contingency that significant regrowth may be delayed until the following spring.

Another part of planning is assessing vulnerability to erosion or undesirable vegetation shifts. We are fortunate on the Coastal Prairies and Rio Grande Plains to have fairly level lands, but even so there is a potential for increased soil loss by erosion when the land is bare. Generally, steeper slopes will be more susceptible to erosion, and probably length of open soil exposure will be greater from summer than from late winter or early spring burns. A vigorous weed growth can occur on burned areas, depending on weather conditions. We have observed this following late winter burns, for example, when temperatures stayed low and soil moisture high, promoting weed development over grass. It was easily cured in one instance by "flash" grazing[1/] to remove the weed overstory, but it takes management observations and timely actions to make the needed moves.

Planning also involves development of the actual fire plan, which will be described in other parts of this symposium. The sooner the plan can be developed, the sooner arrangements can be made for specific preburn preparations.

The costs associated with burning should be considered. Burning costs include those for personnel, costs of deferment and the building of special facilities, such as fencing and fire lanes. There is a common misconception that burning for range improvement costs little or nothing. It may be less expensive compared to other practices, but it is surely not free. Ranch managers should identify all costs associated with burning projects and keep track of them for economic analysis and future budgeting.

The ranch will undoubtedly have access to some of the equipment needed for conducting prescribed burns, but it is unusual when additional personnel or equipment is not needed. A list should be made of the individual items required and responsibility assigned to see that they are obtained. This is a part of the planning process, as is assignment of personnel, notification of authorities, and final preburn patrols. Each of these areas should be examined as they concern ranch management.

Equipment

A part of working with competent technical assistance early in the planning process will include aid in decisions concerning fire lane needs, such as location of fire lanes, their width, and possible methods of construction. If the ranch does not have the equipment to do the job, they will have to arrange for it and timing of construction is often an important concern. Fire lanes built too early may have to be re-run prior to the fire. It has worked well for us on several occasions to cut fire lanes immediately prior to the fire and to have the contracted equipment stand by as fire holding equipment during the burn. This adds a measure of safety and allows flexibility in case a late decision is necessary because of wind shifts or other reasons, to add lanes for further division of pastures or for extra safety precautions.

1/ "Flash" grazing is the use of a high density of livestock on an area for a short time period in order to remove a competing vegetation without significant damage to the desirable species.

Maintainers are probably the most preferred equipment for fire lane construction. The function of ranch management is to assure the availability of such equipment and to supervise construction in accordance with the fire plan. Most fire lanes can be run on existing right-of-ways or ranch roads, but occasionally they must be built through brush too heavy for a maintainer without bulldozer work, so this equipment should be arranged for in the correct time sequence. A maintainer and occasionally a bulldozer are two primary tools needed for many burning jobs that are not a part of standard ranch equipment. A possible substitute for the maintainer would be a large, wheeled tractor and heavy disc plow, but a technical advisor should be consulted on the suitability of available equipment.

Fire lanes can be sources for accelerated erosion the same as any new right-of-way or road cut. In fact, because of the possibility of added runoff from the pasture following burning, erosion can be intensified for a short period. Adequate provisions for erosion control structures should be made as needed.

Other equipment the ranch may want to have available includes a pumper truck from one of the local fire departments. In some cases, these trucks can be made available with a crew if adequate lead time for arrangements is allowed. Resupply water source was provided on one job by a large water truck belonging to a drilling company working on the ranch.

An essential part of any prescribed burn is communications equipment. Citizens band radios are very helpful. Designated vehicles of the fire crew should be equipped with radios, and hand sets for the fire starters are advisable, particularly for large burns. Most ranches do not have this amount of communications equipment, but can arrange for it with proper lead time.

Ranch owned equipment, such as pickups, cattle sprayers, water barrels and sacks, and hand tools, such as shovels, are usually readily available for burn jobs. Do not have more equipment than is needed on a burn job, but be sure that what is needed is on the job and that it works.

Personnel

Ranch managers have the job of seeing that the people on their payroll are in the right place at the right time, and that their roles are well identified and fully understood. In some cases the ranch manager will be the fire boss. However, a crew is quite often made up of people from at least two sources. The manager must be a part of planning when roles are identified so he can fit ranch people into required fire crew positions with the proper authority to function in their roles. This most often involves providing the necessary time away from other ranch responsibilities. Ranch people must know who the fire boss is and that they are working for him on the day of the burn.

There will likely be other people on the scene for large scale burns, such as equipment operators and fire department personnel. Ranch managers have the job of seeing that these folks fit into the overall plan. These people know him and are on the ranch at his request. It is the manager's place to coordinate their activities through directions of the fire boss. Just as important as having the required people to properly execute a prescribed burn, is not having unneeded people. Burns have a way of attracting people, and while they may be well-meaning, they can get in the way and cause confusion.

Notification

The function of ranch management in preburn notifications is important. The legal requirements involved with permits from the Texas Air Quality Board will be discussed later, and such clearance is a ranch responsibility. Foremost of others to notify are neighbors-- especially on the downwind side! We are fire conscious, in fact, fire fearing people, and excite very easily when smoke is spotted on the horizon. Unannounced fires can cause considerable distress and inconveniences to neighbors. You can bet they will come to the scene, and this adds confusion when you need it least. I believe neighbors also have a right to standby for protection of their own resources in the event of wildfire. I have had a backup crew of neighbors on the other side of a common fenceline during burns, and I believe we both appreciated this arrangement. What neighbors do not appreciate is to drive hell-bent to a fire with a crew and equipment that should be doing something else only to find out it is a prescribed burn. The relief to know that the fire is under complete control does not totally offset the resentment at being unnecessarily inconvenienced, or not having had a chance to decide on protective measures for their side of the fence.

Another notification I strongly recommend is the Sheriff's office. Calls from concerned observers of the fire most frequently come to the Sheroff's office. A knowledge of burning activities will not only dispell undue concern, but also place the county facilities in a better position to assist in control if they are needed. A visit with the County Road Supervisor as to location of his equipment on the day of the burn is an added safety measure.

Local fire departments should be notified if they are not involved directly in the burning activities. Burns near highways should be planned for wind directions which will carry the smoke away from the highway. However, because of the unforeseen possibility of a wind shift, the Department of Public Safety should be notified if the burn is less than a mile from a highway.

There are people associated with ranches that may have structures in pastures scheduled for prescribed burns. They should receive notification and perhaps be included in preburn inspections. One such group would be oil and gas lessees where wells or storage facilities are involved. These people may make needed preparations, thus relieving the ranch of certain responsibilities involving their structures if they have proper notification.

In South Texas there are other facilities associated with hunting common to most pastures, including stands and sometimes cabins or other buildings. Many stands are on metal legs which would not be damaged by fires. Some cabins, however, might be vulnerable to damage if vegetation has grown up adjacent to the structure, which is often the case. Fire lane protection might be provided for such facilities or hunters notified to take their own precautions.

Preburn Construction and Patrols

Preburn preparations may be accomplished over a period of time leading up to the fire. The ranch manager will not be concentrating entirely on the burn during this time as he goes about the multitude of other duties required to run the ranch. This is why a final preburn patrol or inspection is needed.

Preburn patrols should check out protection of such items as feeders which may be in the pasture. These can often be dragged onto tank dams or other locations safe from the fire. Wooden portions of pens and chutes should be adequately protected. Attention should be given to highline poles in the pasture. These might require fire lane protection, and can provide a division in the pasture if desirable.

Fence protection should be checked along the outside perimeter of the pasture. Ranches often have traps, water lots and wing fences off of pens or traps which may not be noticed in the process of cutting fire lanes on the perimeter and when establishing major inside divisions.

If fire lanes have been completed prior to the final inspection, the preburn patrol should assure that these lanes are carefully covered for fuel "bridges" the fire might use to escape. Such bridges are simply vegetation which has not been completely removed. Creek bottom or other low, rough areas and corners where a blade could not cut effectively are the first places to look. A fire lane, like a chain, is no better than its weakest spot. A relatively insignificant looking area of uncut material can carry the fire if conditions are right. Such spots may need to be re-run, or taken out by hand.

Reliable weather forecasts can save time and money by preventing "setting up" for a burn only to have unfavorable conditions. Moving equipment and people unnecessarily is expensive. Fire weather forecasts for Texas are provided by the U.S. Weather Bureau in Fort Worth, Texas. People who use these forecasts regularly, such as Dr. Henry Wright of Texas Tech University, say the forecasts are much more reliable than local weather forecasts.

Postburn Considerations

Postburn Patrols

Ranch management responsibilities immediately following the burn begin with postburn patrols. Once the main body of the fire has burned out, attention can be diverted from concern about direct control to assurance that the Pasture can be left without further concern for danger. It may be a relief to know that the initial burn has been successfully contained, but this should not lead to complacency about the remaining threat as long as live coals are adjacent to unburned pastures. In fact, the danger can be greater if crews and equipment are dispersed too early.

Burning is usually done with winds in the range of 6-15 miles per hour. However, we have seen on several occasions where winds were kicked up from nearby thunderstorms after a burn, or by frontal passage. These wind speeds may gust from 30 to 40 miles per hour, creating a whole new situation as concerns the movement of firebrands out of the burned area. Burning logs and smoldering piles well within the burned pasture present very little threat except in the most severe conditions. Attention can be focused on the outside pasture perimeter where long-burning materials are separated from fresh fuel by only a few feet of fire lane. Postburn patrols can effectively put out such fires by wetting them down, or opening them up so that they will burn out quickly while under surveillance. Some ranchers post a night-long patrol on burned areas where threat to homestead and headquarter facilities is great.

Another function of postburn patrols is to check protected facilities in the pasture, such as fence posts and highline poles. This crew should finally make a complete check of all water gaps and fences where livestock from adjacent pastures could get in.

Grazing Control

The biggest element of postburn control is grazing deferment, and close control of grazing for the growing season following the fire. Burned areas are particularly vulnerable to heavy overuse by livestock. All vegetation is fresh, succulent and highly preferred by livestock over the same species on unburned areas. Deferment should provide time for the key species on the area to establish adequate leaf area and reinstate vigorous growth. It is difficult to predict a specific time for this requirement, since a lot depends on rainfall following the burn. There is no substitute for close observations by ranch management to decide when the burned area can be reopened for use. If less than an entire pasture is burned, and stock are placed in the pasture, the burned portion is invariably grazed heavier than unburned areas. Management must decide essentially on whether to give up the whole pasture, fence off the burned portion or key grazing use only to the burned portion.

The vegetative composition shifts should be watched very carefully following burning. We have seen desirable grazing plants increase in abundance following burning. This usually dictates a reassessment of the key species to use for determination of range proper use. If the burn is not separately fenced, the burned area may be used as the key grazing area and a key species picked on this area to use for deciding when to move livestock. It should be repeated that burning of entire pastures, or the use of temporary fencing, is the most practical management solution.

Grazing Systems and Burning

Much of our early burning will probably depend on decision deferments to build fuel and provide postburn rests, rather than systematic grazing management schemes. This type of deferment usually means that a decision must be made each time as to where to move stock, unless a reserve pasture is provided for such use. Reserve areas of forage are always good insurance and many ranches have pastures or even cropland that can accomodate the stock from an entire pasture for extended time periods.

There is one systematic grazing approach that is particularly well suited to "building in" prescribed burning or other range improvement practices which require deferments. The system is short duration grazing (SDG), a one herd system featuring short grazing periods and building adequate rest periods through the use of several pastures. The more pastures available for the herd, the longer the rest before grazing again occurs on the same pasture. Pastures can be selected for burning simply on the basis of time required to build adequate fuel load since the last grazing use. The deferment is automatic, since only one pasture in the system is being is being used at one time. If necessary, the burned pasture can be skipped in its regular grazing rotation to allow adequate postburn deferment. This reduces the rest period on the other pastures by the length of grazing time alloted to the burned pasture, but would likely insignificant where 120 to 150 day rest periods are involved. For example, in an 8 pasture system with 140 days of rest and 20 days of grazing, the rest period would be reduced to 120 days for one cycle by skipping any one pasture in the rotation.

A Merrill 4-pasture, 3-herd system is perhaps less likely to conveniently accomodate needed preburn and postburn deferments. Assuming however, that fuel load was sufficient at the end of a grazing period, the regular deferment could be used to rebuild forage. Another alternative would be to hold cattle out of the deferred pasture for longer than the normal 4 month rest period. This would change the rotation of rests, however, and may not be desirable. With the exception of SDG systems, it is probably better to reserve extra forage requirements in a supplemental pasture. Each ranch is different and management must work out the specific details to best fit the situation.

Summary

Burning is really no different in the demands on ranch management than any other range improvement practice, or other elements of general ranch operations. It requires planning, organizing, direction and control. These are the basic functions of all managers.

If burning has a current uniqueness, it is because it is "new" as a range improvement technique because of renewed interest, and is assumed to be a greater risk than other accepted practices. We have all become largely dependent on contractors for mechanical and chemical brush control methods. Burning, on the other hand, can be done by ranch personnel and will involve us more directly until contractors become available.

There is a real opportunity to get in on the "ground floor" of burning technology and add the benefits from prescribed fires to the alternative methods for long term range improvements. The key to success for ranch managers will be their management skills as they are applied to the practice in their own ranch environment.

Ranch Checklist for Prescribed Burning

The purpose of this checklist is not to try and list all of the items needing attention from ranch management for every burn. Instead, it is intended to ennumerate areas of concern common to most burns, so that they will not be inadvertently overlooked. It is strongly suggested that the checklist be amended to fit each situation.

Ranch Checklist and Generalized Time Plan

I. Preburn Considerations (1 - 2 years preburn)

A. Rationale for the burn

______ 1. Purpose (brush management, rough removal, etc.)
______ 2. Place (target pastures identified)
______ 3. Timing (cool or warm season, tentative date)
______ 4. How to burn (preliminary fire plan including fire lane design)
______ 5. Preburn pasture treatments meeded and timing (mechanical, chemical, deferment)
______ 6. Legal aspects (ranch liabilities)

B. Planning for the burn (6 months to 1 year preburn)

______ 1. Determination and location of alternative forage needs for livestock
______ 2. Setting of required dates for preburn removal of grazing animals based on fuel load requirements
______ 3. Consideration of vulnerability (erosion, wildlife)
______ 4. Final fire plan preparation
______ 5. Budgeting costs of burn

C. Equipment arrangements (1 month to 3 months preburn)

______ 1. Contracted equipment (i.e., bulldozer, motorgrader)
______ 2. Locally available (i.e., pumper truck)
______ 3. Communications (CB radios or other)
______ 4. Ranch owned (cattle sprayer, water trailer, water barrels)
______ 5. Dates firm for equipment work to be completed

D. Personnel (1 month to 3 months preburn)

______ 1. Fire boss designated and authorization provided

_______ 2. Assignment of ranch personnel, time provisions and training if necessary
_______ 3. Considerations for other people needed

E. Notification (2 weeks to 4 weeks preburn)

_______ 1. Texas Air Quality Board (if required)
_______ 2. Neighbors
_______ 3. Sheriff's Office and County Officials
_______ 4. Fire Department
_______ 5. DPA (if advisable)
_______ 6. County Commissioner
_______ 7. Oil and gas lessees
_______ 8. Hunters
_______ 9. Others

F. Preburn construction and patrols (1 week to 2 weeks preburn)

_______ 1. Construction of fire lanes according to fire plan
_______ 2. Removal of remnant livestock
_______ 3. Facilities protection

______ a. feeders
______ b. pens
______ c. highline poles
______ d. oil and gas structures
______ e. fences
______ f. hunting facilities
______ g. inspection of completed fire lanes (if constructed more than 30 days preburn)
______ h. REFER TO FIRE PLAN FOR PREBURN ITEMS AND ACCOMPLISH AS INDICATED IN REQUIRED TIME FRAME
______ i. other

G. Weather information and final inspection (week of the burn)

_______ 1. 7 day forecast
_______ 2. 24 hour forecast
_______ 3. Final inspection (fire lanes, facilities protection, etc.)

II. Postburn Consideration (immediately postburn)

A. Postburn patrols of burned areas

_______ 1. Fire-brands
_______ 2. Poles and posts
_______ 3. Smoldering piles
_______ 4. Livestock access

B. Grazing control (completed for period to 1 year or longer postburn)

_______ 1. Deferment period provided
_______ 2. Observations of vegetation changes
_______ 3. Decision to restock pastures

______ a. appropriate stocking rate
______ b. projected grazing period
______ c. follow-up observations

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PRINCIPLES, REQUIREMENTS, AND TECHNIQUES FOR PRESCRIBED RANGE BURNING

Larry D. White

INTRODUCTION

Prescribed burning has been described as "the skilled application of fire to natural fuels under conditions of weather, fuel moisture, and soil moisture that will attain confinement of the fire to a predetermined area and, at the same time, produce the intensity of heat and rate of spread required to accomplish certain benefits... A basic objective of such burning is to employ fire scientifically in order to realize maximum net benefits at minimum damage and acceptable costs" (Lotti 1971).

Prescribed burning by definition follows a set of guidelines that establishes the condition under which a fire will be set to a specific area of range. The prescription cannot be developed nor techniques, etc., decided upon until realistic objectives of using prescribed fire are defined and the minimum safety standards realized to conduct the fire of necessary intensity on the area prescribed.

Obviously, the safest fire is one set under cool conditions, with good soil moisture for rapid desirable plant regrowth, steady winds, stable weather conditions, with large firelines around the area, adequate fuel quantity of uniform continuity, and burned with back or strip firing techniques.

Rancher objectives often require a more intense flame front and/or faster rate of spread to reduce shrub density and canopy cover especially if fuel quantity is light or patchy and the area to be burned is relatively large. The hotter fire set under more flammable conditions increases the risk of escape if necessary precautions are not taken. The prescription then must balance the damage needed to kill undesirable plants and the ability to contain the fire to the area specified. These must be considered in light of the normal growth cycle of vegetation, dry fuels, weather cycles, local weather and conditions most optimal to kill unwanted plants and to safely conduct the fire.

PRINCIPLES FOR USING PRESCRIBED FIRE

Prescribed burning principles encompass operative elements of fire applied in a specific manner and timed to obtain desired vegetative responses. Also, the principles of sound business and ranch management must be applied if the practice is to be a benefit to the entire enterprise.

A rancher must follow three basic steps for conducting a successful burning program: (1) thorough planning, (2) application of fire to the specified area, and (3) sound range, livestock, and wildlife management prior to', during and following the burn(s).

As Whitson (1980) stated, "The 80's will likely require ranch managers to operate ranch firms as an efficient business if they are to identify opportunities and take economic advantage of them... The successful ranch manager... must spend more time in analysis and in planning future actions. He will be required to properly apply sound decision making principles." This is never so true as in prescribed burning programs since planning and decision-making followed by proper actions are critical. This is a flammable tool where timing often determines the benefits derived; hence planning must be complete and an orderly process followed and coordinated for the operation to be safely conducted. Most managers are more concerned about conducting the actual fire than whole ranch planning, but the latter cannot be emphasized enough.

Prescribed burning principles must encompass conduct of a safe, planned fire as well as proper timing of the burn to obtain management objectives. Both fire behavior and vegetation characteristics and known responses must be adequately evaluated and a prescription developed to produce the needed fire characteristics under local conditions to obtain necessary responses. Each fire, due to local climatic variations, vegetation features, topography, etc., is different and unique. Therefore, only general prescriptions and benefits can be described, but with experience each rancher can learn to achieve successively better results with each burn. The principles of fire effects on vegetation and fire behavior must be understood for planning to be realistic.

FACTORS AFFECTING VEGETATION RESPONSE TO FIRE

Burning affects vegetation through the consumption of aerial portions of a plant, heat effects, and residual mineral products. Heat effects and residual mineral products induce different species reactions. Some species are relatively resistant to fire and can withstand temperatures which may be detrimental to other species. Usually, grasses are better adapted to withstand burning than woody plants because of differences in location of meristematic tissue (terminal buds and cambium). Hence, prescribed burning may be used to advantage in removal of some undesirable woody vegetation or greatly reduce its impact on forage production.

A number of factors are highly important in determining the susceptibility of woody plants to heat damage from a fire. Some of the more commonly described factors are: (1) intensity and duration of the fire, (2) season of burning in relation to phenology, physiology, and carbohydrate reserves of a plant, (3) frequency of burning, (4) insulating characteristics of the cortical covering, and (5) sprouting ability (Buchman 1962, Hare 1961, Hughes and Knox 1964, Jameson 1959, Sampson and Schultz 1957, Stoddart and Smith 1960). Davis (1959) suggested that if the intensity of a fire is not detrimental to all plants, susceptibility is related to: (1) the initial temperature of the vegetation, (2) the size of the plant exposed to the fire and its morphology, (3) the presence, thickness, and character of the cortical cover (bark),

(4) the branching and growth habit, (5) the rooting habit in relation to the soil temperature profile during the fire, (6) organic material covering the mineral soil and its insulating and flammability characteristics, (7) flammability of the foliage, (8) stand habit in relation to ease of fire spread, and (9) season and growth activity.

Probably the one most important survival characteristic for many plants is the ability to produce new shoots following damage. Sprouting is a response following injury or death of part of the tree or shrub caused by fire, cutting, disease, or physiological disorder. In general, those plants not capable of sprouting following a fire are more easily killed than sprouting plants.

In those plants capable of sprouting, the physiological condition at the time of damage often determines the number and vigor of sprouts. Usually, the amount of physiological activity can be related to seasonal changes. Many researchers have concluded that the susceptibility of a plant to fire is highly related to the season of burning (Aldous 1934, Arnold 1963, Hare 1961, Stoddart and Smith 1960, Woods 1955, and others). The maximum effective period for kill of most plants by burning is at the time of year when carbohydrate reserves are lowest and spring growth has taken place without replenishment of the reserves (Hawley and Smith 1960, Hare 1961, Klingman 1961, Sampson and Schultz 1957, Woods 1955); however, conditions may be too green to conduct a successful burn. The carbohydrate reserves for some evergreen plants may be lowest prior to winter dormancy, reversed from that of deciduous plants (woody plants that lose leaves each year) (Hare 1961, Woods 1955). For deciduous plants, carbohydrate reserves are usually lowest during late spring and early summer (Hare 1961, Hawley and Smith 1960, Kramer and Kozlowski 1960, Klingman 1961, Woods 1955).

Observations on phenological development (seasonal growth and development cycle) of plants usually indicate the periods of most active physiological activity. West (1965) reports that the greatest damage to shrubs is accomplished by burning "when the new leaves have shot and the trees are green and actively growing." Bud break in deciduous shrubs usually marks the onset cf vigorous shoot growth and a lowering of food reserves, until the carbohydrates begin to assimilate in greater quantity than that which is being utilized. With the development of leaves, flowers are often initiated and can further reduce food reserves.

Morphological characteristics of plants often determine the amount of susceptibility following fire. Hare (1961) reviewed several studies indicating that susceptibility following fire is related to plant size. Usually, large plants require a more intense fire for complete kill and small plants are more easily heated to lethal temperatures. Also, the direct relationship of size to age is important. As age increases, size usually increases.

With increases in size and age, sprouting ability in relation to bud formation will often change. "Shoots almost invariably develop from dormant buds that were originally formed on the leading shoot of the seedling and grew outward with the cambium but previously failed to develop into branches" (Hawley and Smith 1960). However, each year the dormancy of a bud must be broken enough to allow slight elongation, otherwise the cambium and cortical covering soon bury the bud until it is impossible for the sprout to develop (Hawley and Smith 1960, Kramer and Kozlowski 1960). "Both the thickness of the bark and the possibility of interruption of the bud trace increase with age" (Hawley and Smith 1960), hence reducing potential sprouting from dormant buds of some species. Also, increasing age and diameter result in rapid decline of vigor of stump-sprouts (Hawley and Smith 1960). Sampson and Schultz (1957) state that "young thin-barked trees are often easily killed by fire... mature trees are more resistant while old, decadent ones may be easily killed."

The location of dormant buds in relation to the distribution of fire intensity is important to sprout development and plant survival. Sprouts may be produced from any or all of three positions on a shrub or tree: (1) the base of the plant (which is most common), (2) root suckers, and/or (3) adventitious buds along the branches or trunk (Hawley and Smith 1960, Kramer and Kozlowski 1960).

The sprout location is apparently dependent upon: (1) the genetic characteristics of the species, (2) the intensity of the fire and resultant damage to the area or areas capable of sprouting, and (3) the weather conditons necessary for sprout development.

Sprouting ability varies among species of plants in accordance with the genetic-physiological characteristics of each species. However, some environmental influences are very important in determining the vigor and development of sprouts. Very important is the moisture content of the soil and its effect upon the stresses in the plant.

Soil moisture content, as it affects physiological activity of plants, is believed highly important in determining sprout development in several shrubs (Lillie, Glendening and Pase 1964). Lack of available soil moisture can cause a delay in sprouting for periods as long as two years after a fire (Plumb 1963). Soil moisture also affects heat penetration during burning, hence heat damage to tissues capable of sprouting (Davis 1959). Most studies report that greater penetration of heat from a fire occurs during periods of low soil moisture (Davis 1959) and during normal high soil temperature conditions.

Under favorable weather conditions, sprouts usually grow rapidly and result in a rapid recovery of the crown. However, rapid recovery of "sprouters" is most often attributed to "the inheritance of extensive root systems and large supplies of carbohydrate" (Hawley and Smith 1960, Sampson and Schultz 1957).

White (1968) showed mortality of creosotebush (Larrea tridentata) to be related to season of burn with highest mortality obtained in June and July. High mortality was attributed to high fire intensities especially heat penetration in the soil to the basal sprout zone and poor growing conditions following the fires. The single most important factor was total amount of heat generated (fire temperature - duration) in the soil.

FACTORS AFFECTING FIRE BEHAVIOR

In general, fires of sufficient intensity and duration can kill all vegetation, ragardless of species. However, species usually respond differently to lower intensity fires in which other factors determine susceptibility.

The intensity of a fire and subsequent severity of damage to vegetation is frequently related to the amount, type, moisture content, size, and distribution of accumulated fuel. Also, topography and weather conditions, such as wind speed and relative humidity, greatly influence fire intensity and duration.

Fire temperature and duration experienced by meristematic tissues are influenced by species characteristics related to heat penetration. In general, temperatures of about 120" F for approximately one hour are considered the beginning lethal temperature for most tissues (Davis 1959). As the temperature is increased, the time necessary for temperature to be lethal moves slowly from infinity and approaches zero very rapidly. "Lethal temperature," without the time factor, is a poor indicator of the relation of fire or heat intensity to tissue survival (Hare 1961). The movement of the flame front (rate of spread) and its vertical heat distribution is affected by microclimate and major factors of wind, fuel, and topography.

Fire can be set any time fuels will burn; however, in view of safe and effective use of fire, a more exact set of conditions must be specified. The three essential elements for a fire to occur are: (1) fuel (quantity, flammability, and dispersed adequately to carry the fire over the area), (2) heat to cause ignition, and (3) oxygen supply. Inadequate amounts of any one of these will cause a fire to go out or impossible to start. Usually, the fuel characteristics and weather conditions under which a fire is set will determine the heat intensity generated, rate of fire spread, development of spot fires, amount of dead and live fuel consumed, and smoke dispersal. The techniques and weather conditions used to burn an area will control these fire characteristics and enable the burn to be conducted safely. The variables most influencing fire behavior are: (1) topography, (2) fuels, and (3) weather.

TOPOGRAPHY

Topography is important in relation to prevailing winds, influence on local weather patterns, steepness of slopes affecting preheating and rate of spread, and aspect that affects local microclimate which determines solar heating, soil moisture, fuel moisture, foliage temperatures, vegetation characteristics, etc. Winds are channeled up canyons with increasing speed as slope increases and increasing turbulence around and over features (Figure 1). Eddy currents over the crest of a hill, trees and around objects create different fire intensities, rates of spread, and direction of fire front movement. These can also create fire whirlwinds that can carry sparks, burning debris, or flames across a normally safe fireline (Figure 2). The fire whirls are small tornadic winds of counter clockwise circulation created from intense hot spots and rapid rising air at a concentration point.

Generally, topography affects wind behavior and heat buildup that in turn determines to a large extent the flame front movement over the area. Prescribed burning requires successful prediction of these wind patterns so that prefire control measures can be undertaken to safely contain the fire. In the Rio Grande Plain and Coastal Bend of Texas, topography is not extremely rough and therefore not as critical as in the Edwards Plateau and Davis Mountain areas. However, turbulence and eddy currents near a fireline affect containment as well as firing procedures. Winds blowing over the area are influenced by every irregularity. Location of firelines should be along gradients with the least turbulence and lower fuel quantities. In addition, winds in valleys and slopes move upward during the day due to surface heating and downward at night due to sur-face cooling unless prevailing winds are strong enough to overcome local conditions. Hence, a headfire up a valley late in the afternoon may turn into a backing fire during the night and reverse direction 180 degrees.

WIND

Wind behavior is determined by weather systems such as fronts and pressure cells. This macroclimate is then altered by local conditions.

Winds associated with frontal weather systems will shift direction as the front approaches and passes over (Figure 3). The winds shift in a clockwise direction. The wind change in a cold front is usually sharp and distinct (Gaylor 1974). Ahead of the front the wind in south Texas will be from the southeast moving to the southwest as the front approaches. Wind speed increases, often gusty, and turbulent just before the front passes. After passage of the front, the wind direction is usually from the north but may be unstable for some time. High and low pressure cells associated with the front will determine wind direction. Winds around a high pressure cell move in a clockwise direction and vice versa for a low pressure cell.

Wind has three qualities that affect a fire: (1) velocity, (2) direction, and (3) gustiness. A steady even wind produces a sustained fire spread in one direction (Gaylor 1974). "The fire will form a narrow pattern if the wind speed is high or a triangular shape (burn) if the wind speed is moderate! Gusty winds cause erratic fire behavior and spread the fire in several directions which is unacceptable in prescribed burning.

All natural surfaces are more or less rough and therefore exert frictional resistance to the movement of the air above them. The frictional

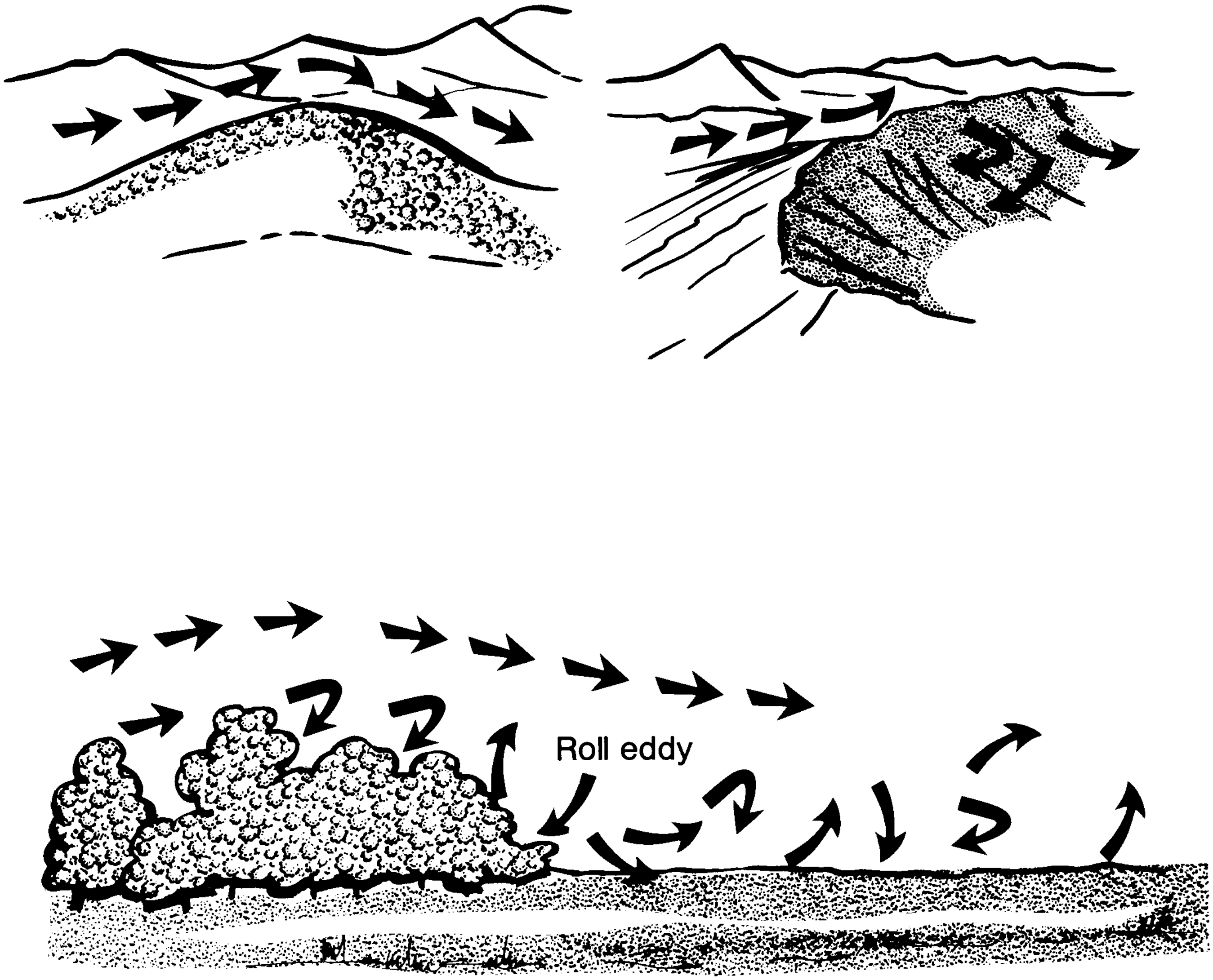

Figure 1 Topography and vegetation features cause wind turbulence resulting in roll eddies where distinct changes occur. Open grasslands or fields develop higher surface temperatures creating thermal turbulence and whirlwinds when prevailing winds are light. (Adapted from Schroeder and Buck 1970)

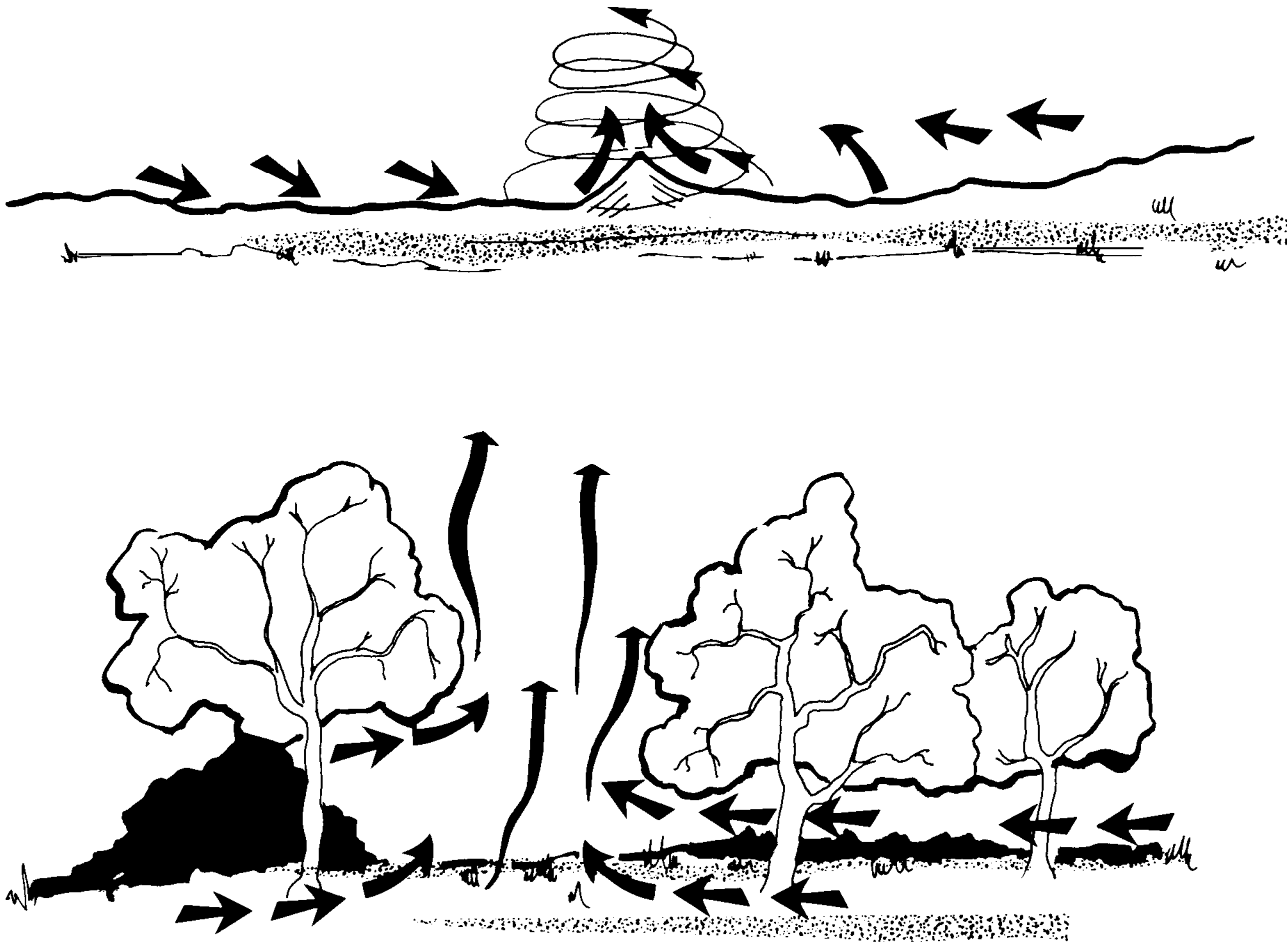

Figure 2. Whirlwinds result when localized superheated air near the ground rises rapidly. Heat generated by intense hotspots in a fire can cause a firewhirl to develop. Firewhirls are common on the lee side of a ridge where the heated air is sheltered from the general winds. Irregular flame front movement in flat terrain encountering fuel accumulations can produce whirlwinds. Openings such as fire lines and grass areas in brush stands can act as chimneys under light wind conditions. (Adapted from Schroeder and Buck 1970)

Figure 3. Prevailing wind direction depends on the location of fronts and high and low pressure cells.

resistance decreases with the distance from the surface or obstruction;- hence wind speed usually increases above brush canopies and in openings (Figure 4). The height, density of plant crowns and density of brush plants affects wind velocity. The more open the stand, the higher the wind speed near the ground surface and vice versa. In addition, eddy currents commonly occur on the leeward side of brush/opening boundaries (Figure 1). These currents can result in a fire backing until the major wind direction develops the flame front into a head fire. At the same time, a fire set at the zone of eddy formation can create two head fires moving in opposite directions and carry flames and embers into the adjacent brush stand. Wind moving across an open expanse into a brush stand will tend to push flames into the understory as well as over the canopy, resulting in considerable heat buildup on the windward side. The leaves on trees and brush significantly reduce wind speeds within the canopies. Unless sufficient fuel occurs within a brush stand, wind velocities may be insufficient to move the flames properly and the fire may go out or not be intense enough to damage the brush.

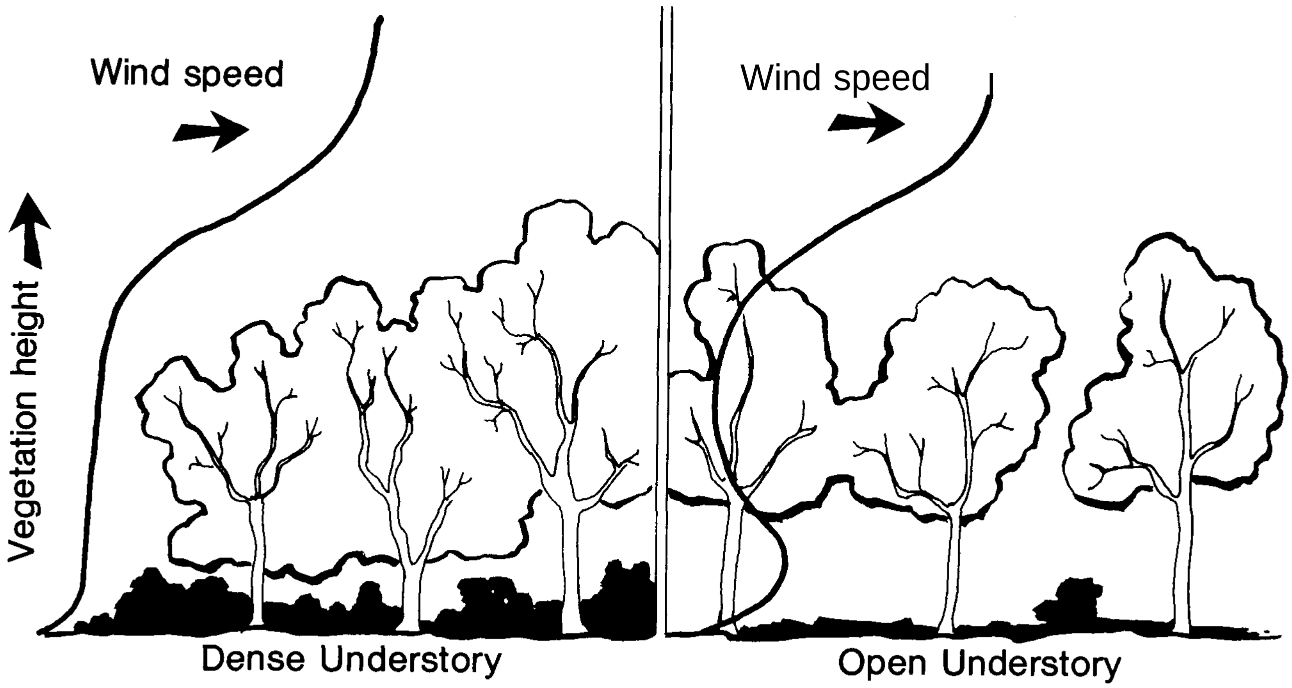

Figure 4. Vertical wind profiles in forest or brush stands show that the crown canopy is very effective in slowing down wind movement. In stands with an understory, the wind speed is nearly constant from just above the surface to near the tops of the crowns. Above the crowns, wind speed increases much like above level ground. In stands with an open trunk space, a maximum in wind speed is likely in the trunk space and a minimum in the crown area. (Schroeder and Buck 1970)

Mechanically cleared firelines that create openings can produce unusual eddy currents and wind speeds not characteristic of the main fire. These erratic currents should be predicted and trouble spots identified before igniting the major fire.

Local eddies are also common on the leeward side of each tree or brush canopy. These eddy currents near a fireline can cause unusual uplift of embers and result in spot fires. Also, eddy currents increase the heat build-up and duration of the fire creating a local hot spot which, if planned, can be used to advantage. Roll eddies are created along ridges and bluffs.

Wind is the most variable and least predictable fire weather element (Gaylor 1974). Yet it can be predicted if burning is conducted under relatively stable weather conditions with knowledge of frontal weather systems and effect of high and low pressure cells. Since prescribed burning requires setting a line of fire that naturally burns over a prescribed area, wind direction and wind speed prediction are necessary. The wind speed will generally determine the rate of spread and flame height plus uplift of embers and burning material. Therefore, wind speed must be sufficient to carry fire easily through the fuels but not high enough to jump the upwind control lines. Wind direction must be consistent to avoid a backfire becoming a headfire or the headfire hitting a control line designed for a less intense flame front. Also, wind is necessary to carry the needed oxygen for combustion to take place. Insufficient oxygen results in poor combustion, less heat generated, and poor prescribed burns.

Usually, large fires will create their own winds around the convection column of smoke, heat, and flame front (Figure 5). Whirlwinds can be created by this sudden on-rush of air. A headfire moving into a backfire can result in two headfires meeting and creating an intense hot spot (Figure 6). Wright (1980) recommends against burning backfires into headfires and against burning across ridges because of possible development of firewhirls, especially in volatile fuels.

FUEL

"Fuel is any organic material, either living or dead, in the ground, on the ground, or in the air that will ignite and burn (Gaylor 1974). The flammability of a fuel is determined by the burning characteristics of individual materials and their combined effects. The dead fuels ordinarily promote the spread of a fire. Wright (1980) considers two basic fuel types--low volatile or high volatile (fuels containing ether extractives such as waxes, oils, turpenes, and fats). "Low volatile fuels such as grass are relatively safe to burn, whereas high volatile fuels are explosive and create serious firebrand problems." In addition, light fuels such as grass, small branches and most small brush pick up atmospheric moisture quickly and give it off quickly, hence these are fast burning fuels. Logs, stumps, large branches, etc., by contrast are heavy fuels and take up or give up moisture more slowly thus being slow burning fuels. Greater periods of atmospheric drying (several days) are required for prescribed burns to consume these heavy fuels. Within

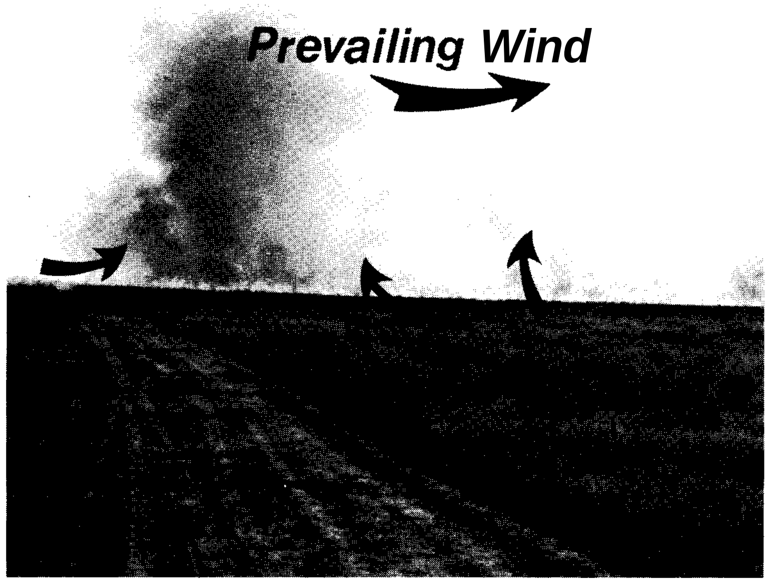

Figure 5. Headfire creating its own wind patterns. Notice uniform fire front and straight uplift of smoke. Flank winds and winds in front of the fire formed roll eddies into the convection column. Winds in front of the fire moved opposite of the flame front and prevailing wind movement. Roll and eddy currents in front of fire created a whirlwind. (San Pedro Ranch burn February 26, 1980)

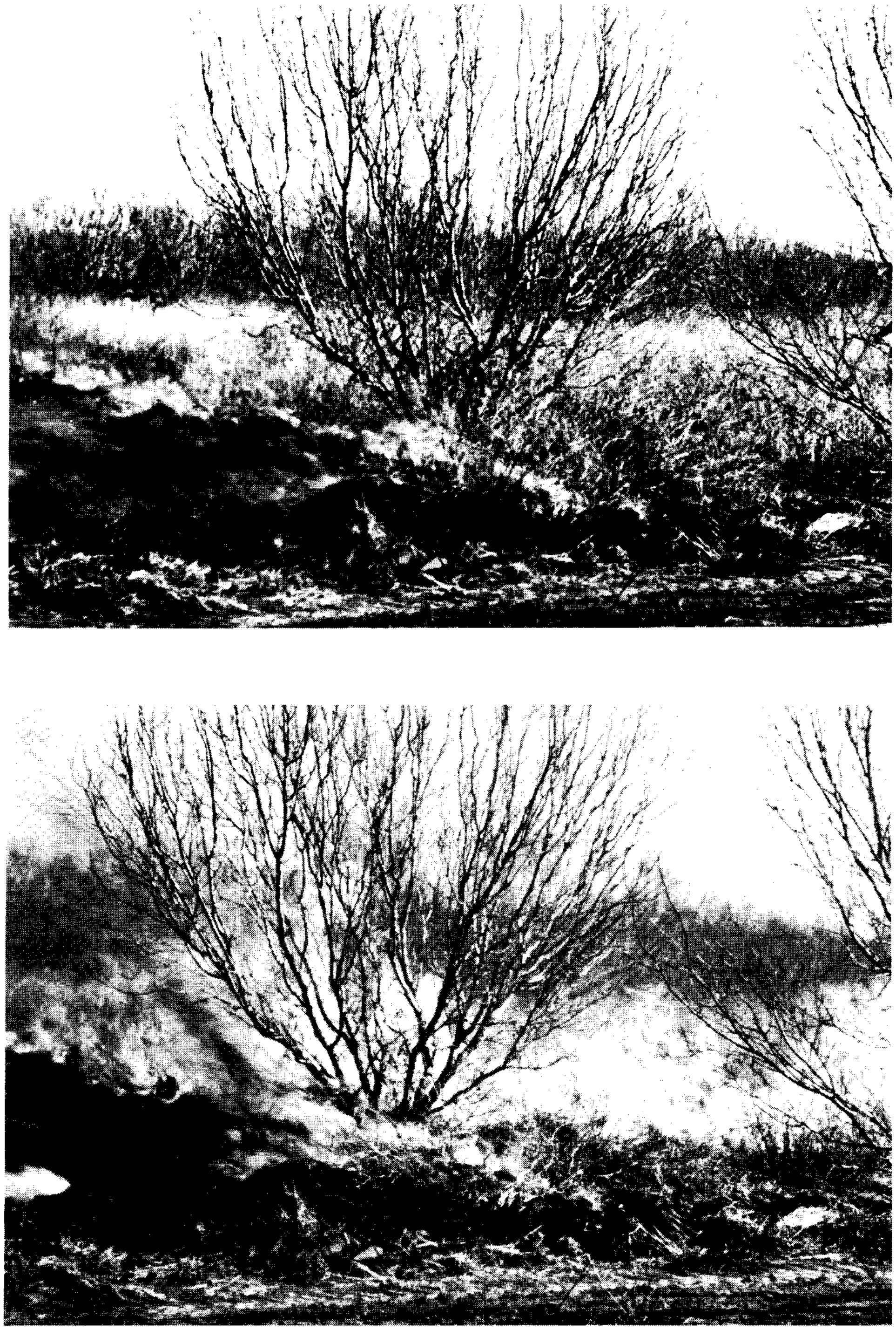

Figure 6. A backing fire (top) with a strip fire being set. The headfire running into the backfire created an intense hot spot (bottom). The strip headfire can be used to evaluate potential flame height from the major headfire as well as potential firebrand problems and speed the widening of an effective fireline.

a half hour, fine fuels may be dry enough to support a hot prescribed burn.

The quantity of fuel that will burn determines the total heat that can be developed during a given fire. The total heat generated determines fire spread, intensity, and duration thereby determining the fire effects on the burn area. Also, the total heat generated determines the convection column characteristics and fire generated weather.

Normal growth patterns of vegetation coupled with weather conditions determine the phenology of fuels. Normally, green fuels are very difficult to ignite (exception being some highly volatile fuels with considerable waxes, etc.) hence succulent green grass is a good fire barrier, but as it cures it becomes flammable. "Cured grass provides the most flammable fuel, and under the right conditions it has the highest rate of spread of any of the fuels" (Gaylor 1974).

Fuel continuity (the distribution of fuel over an area) determines the ease of fire spread between fuel particles (Figure 7). A patchy fuel will have definite breaks in the ground cover causing fire to follow fuel patterns and not move as a single flame front. Usually patchy fuels result in little heat near the base of shrubs and trees and large areas left unburned. Uniform fuels permit a prescribed fire to spread rapidly and uninterrupted over the area imparting similar heat loads to all areas including those occupied by unwanted vegetation.

The moisture content of fuels largely determines the rate of combustion and ease of ignition. It is a product of past and present weather conditions. Temperature, humidity, wind, precipitation and dew, season, time of day, topographic location, and microclimate all have a bearing on fuel moisture at a given time. Fuel moisture changes more rapidly in dead and fine fuels than in living and heavy fuels. Completely dried grass will crackle and easily break into pieces when crushed in the hand. Dry twigs will snap and are brittle.

"The threshold moisture in which fine fuels will or will not burn in sunlight . . . is about 33 percent . . . Below 20 percent fine fuel moisture has relatively little effect on fire behavior in comparison to wind speed and relative humidity" (Wright 1980). "Below 5 percent fine fuel moisture (relative humidity less than 20 percent) spot fires are certain, whereas spot fires are rare when fine fuel moisture is above 11 percent (relative humidity greater than 65 percent)" (Wright 1980). Fine fuels burn easily with about the same intensity when relative humidity is between 20 and 40 percent (Wright 1980). As the relative humidity moves above 40 percent, the rate of spread of a fire slows considerably resulting in less uniform and intense fires. The potential of spot fires is low when relative humidity is above 50 percent or ambient temperatures are below 60 degrees F.

The diurnal change of ambient temperature and relative humidity creates different fire behavior potentials (Figure 8). The relative humidity is higher late at night and early in the morning because the temperature is

Figure 7. Patchy fuels (top) are more difficult to ignite than a uniform fuel load of sufficient quantity (bottom). Highly flammable conditions are required to burn patchy fuels of 1000 pounds per acre or more, require more effort and expense, and have less heat buildup near the bases of shrubs to provide an effective kill. Successive burns will allow greater dispersion of fine fuels under the shrub canopies. Prescribed burning for maintenance of high producing buffelgrass pastures (Watson burn, La Salle County) is easier and has many advantages. Hot fires can be produced.

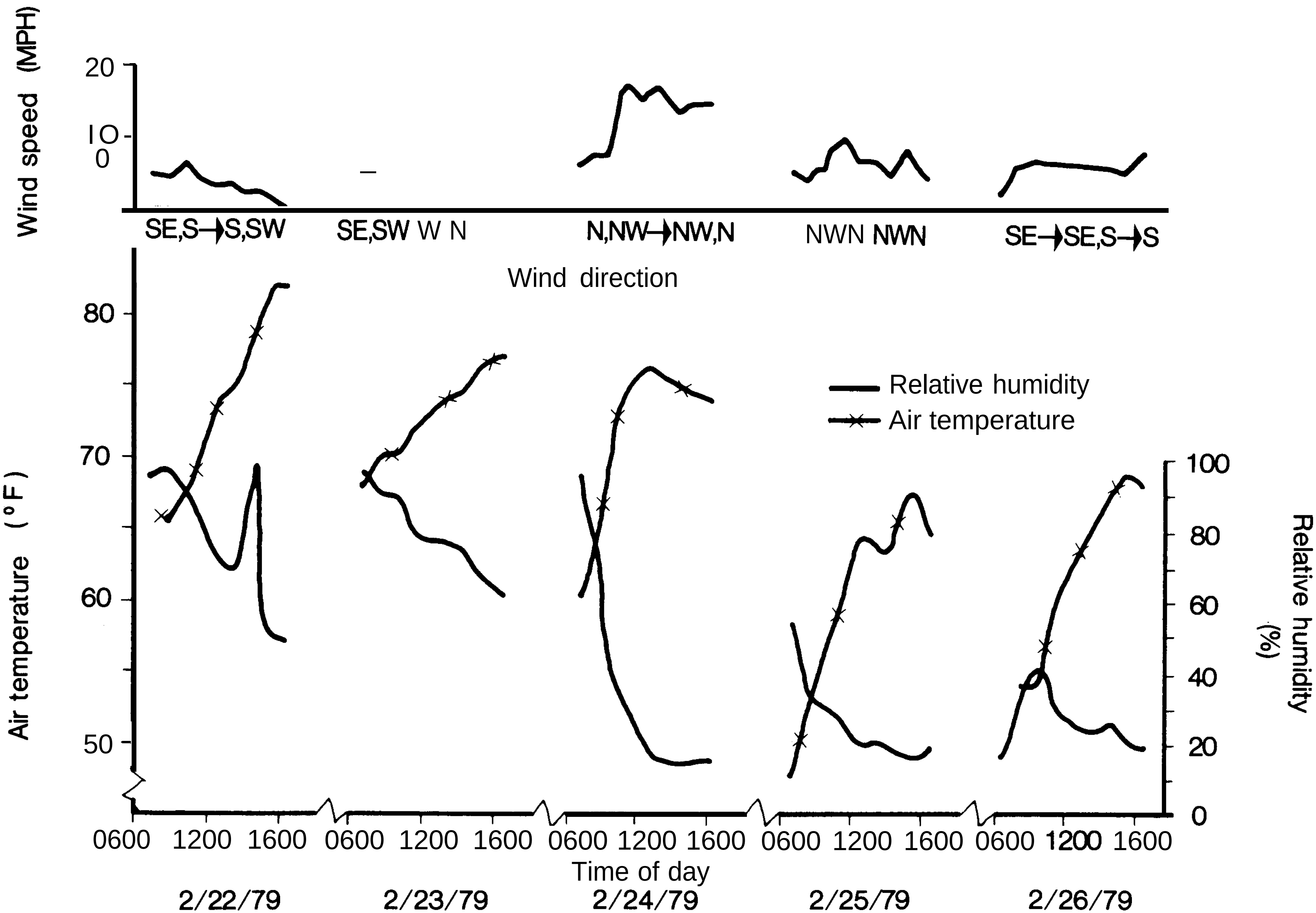

Figure 8. Weather conditions prior to and during the Cotulla Airport burn.

lower; the relative humidity decreases as the temperature increases during the day and then increases as the temperature decreases at night. The openness of a brush stand and the amount of shade created by the vegetation will affect the relative humidity near the soil surface. Intensity of the fire and rate of spread both react to the diurnal change and change in microclimate created by canopy cover. Except under extremely dry conditions, brush stands will burn slower and less intense (unless heavy fuels are ignited) than open grassland areas.

REQUIREMENTS FOR SAFE AND EFFECTIVE PRESCRIBED BURNING

The key requirements of the prescribed burning process are: (1) skilled application of fire, (2) containment of the fire, (3) fire behavior and characteristics to accomplish certain objectives, (4) minimize adverse side effects, and (5) at an acceptable cost. The planning process in developing the prescription for the burn must consider all aspects of information and skills available. The actual burn requires the skillful application of fire behavior principles under existing conditons of weather, fuel, manpower, equipment, terrain, etc.

Stated another way, prescribed burning employs the principles by which fire operates to create the desired effect. The fire plan or prescription defines the requirements and techniques needed to conduct the burn and accomplish management objectives. Also, the expertise available may require the most cautious approach for a safe fire at the expense of effectiveness until sufficient experience is gained. In addition, the first and second burns may be preparatory to subsequent burns which will produce the desired benefits.

The basic principles affecting fire behavior are employed by the fire boss in developing a realistic fire plan, prescription, and conducting the fire on any given day. The fire plan identifies the overall objectives for the ranch as well as for each pasture and range site. In addition, a single burn is usually only a part of a burn program encompassing several pastures. The sequencing of burns to add safety and allow hotter fires where needed should be included. If a frequent burn rotation is contemplated for a ranch, groupings of adjacent pastures would have a specific plan identifying the best wind direction and conditions to burn primary range sites. Since each range site will burn differently, several burns within a pasture may be needed for near complete coverage. Hence, some range sites may require prior treat: ment in order to effectively conduct a broadcast burn. In reality, seldom can entire pastures be burned with one fire if several range sites are encompassed. Ideally, entire management units should be burned to avoid overconcentration of livestock. Stocking rate should be based on actual acreage burned rather than pasture size.

Most ranchers want to attack the most brush infested pastures first; however, these are the most difficult to burn. First priority should be on maintaining the most productive pastures. Hence, emphasis should be on burning pastures and/or range sites that have good grass fuels with an open stand of brush regrowth. Also, this will allow a rancher to develop experience with prescribed burning under more favorable conditions. In addition, the expense of a burn generally will be higher the more difficult it is to conduct. Pastures already heavily infested with brush will lose carrying capacity more slowly than pastures of high production where brush is starting to dominate.

Burning when the brush regrowth is young and when fine fuel loads are near maximum can more effectively maintain high production ranges. Heavy brush stands will require 2 to 3 burns before most rancher objectives are realized. The area selected for burning should also be the better producing sites, hence the net return per dollar invested should be higher.

As Scifres (1980) points out, fire used in conjunction with other brush treatments may be more advantageous. The other brush treatments can create the open canopy, brush kill, and herbage production needed for efficient maintenance burning. The systems concept is being emphasized:

> Use of fire in the systems is more than simply a combination of treatments or the application of fire for maintenance purposes. Brush management systems consist of coordinated treatment sequences using proven techniques applied in an orderly manner to achieve specific management objectives. The management objectives cannot be totally achieved by any one of the system components if applied singly because the systems are designed specifically to take advantage of the unique strengths of each method while minimizing their characteristic weaknesses. Thus, systems are designed to yield synergistic results, that is for a greater production response (or the same production response at a lower cost) to be achieved than should be expected based on responses to the methods when applied individually. Moreover, the systems approach allows a high degree of flexibility in treatment application. If planned well, systems employing fire allow timing of treatments to take maximum advantage of weather conditions.

Herbicides, roller chopping or shredding, chaining, etc., have been used to reduce the brush cover and produce fine fuels for prescribed burns. When combined with prescribed burning, then effective life of the more expensive control method can be lengthened, improving the economic returns over single method range improvement (Scifres 1980).

The day of the burn can be considered judgment day. For the fire boss must make the judgment whether to burn, the follow through with constant re-evaluation judgments on fire behavior, ignition, control, etc., during the fire. After working in wildfire control and prescribed burning for the last 23 years, this is still a time of concern for me and need for constant alertness. No prescription can be followed to the letter but must be adapted by the fire boss each moment prior to, and during the burn. The fire boss utilizes the weather, terrain, fuels, and fire behavior with limited man input to accomplish the job. When these conditions are right, the job is easier.

Observed fire behavior should be used to change the fire plan if needed. Such changes may be necessary to maintain control of the fire or to alter intensity to accomplish specific management objectives. Once the fuel is burned the opportunity for that season is gone for better or for worse. An opportunity lost to burn may be a serious constraint to future actions; however, patience must be practiced if successful burns are to be achieved. Use small test fires to evaluate fire behavior each time fire conditions change. The test fire can summarize the existing conditions and potential outcome of' the larger burn before commitment is made. Use of on-the-spot weather measurements are a necessity.

FIRE PLANNING

Fischer (1978) outlined the types of information needed in a specific fire plan as follows:

1. Physical and biological characteristics of the area to be treated
2. Land and resource management objectives for the area to be treated
3. Known relationships between preburn environmental factors, expected fire behavior, and probable fire effects
4. The existing art and science of applying fire to the area
5. Previous experience from similar treatments on similar areas

Even though a rancher may not write out all of these topics, the information must be fully evaluated, understood, and used to develop the guidelines for firing the area. Use of the fire plan format should "guide the prescribed fire planner through the important steps for planning successful fire use" (Fischer 1978). The fire prescription tells what kind of fire is needed and identifies the conditions under which it must be burned. The burning plan describes the actual conduct of the fire on the ground including ignition procedures, location of control crews, location of firelines, etc.

BURN PRESCRIPTIONS

Prescriptions can be very specific or general depending on constraints imposed by the environment, man, etc. Generally, a prescription will define the range of guidelines resulting in satisfactory performance and benefits from using fire on rangeland. The number one priority must be safe controlled use of fire. If the fire cannot be safely contained to the specified area, benefits will be overshadowed by adverse reactions from neighbors, lack of forage for livestock, destruction of facilities, etc. The second objective of effective use of fire to meet management goals must be developed realistically within the above requirements.

A "safe fire" is impossible to define because there is always some risk, but the amount of risk depends upon the judgment, planning, training, and conduct of the entire operation. As the art of applying prescribed burn principles are learned and judgment in interpreting and predicting fire behavior improves, more intense fires and greater flexibility in prescriptions can be utilized.

Fire like any control practice damages certain features of the area treated. It is the calculated, balanced, and successful application of fire that determines the benefit to cost outcome. A textbook prescription must be modified to match the area to be burned as well as the expertise of the personnel to be conducting the fire. In many situations prescribed fire is not a viable practice and other techniques must be employed. Fire is most easily used as a maintenance practice prolonging the productivity achieved by other range improvement operations. The more difficult the burn, the greater amount of effort ususally required to accomplish a burn and the less predictable the fire because of the need to have more flammable conditions.

Depending on the management objectives, many combinations of conditions can be used to conduct a prescribed burn; experience is vital in selecting "proper" conditions, Fire behavior is similar under the same weather and fuel conditions, hence with experience a rancher can develop confidence in using several prescriptions. However, the difficulty will arise if weather prediction is inaccurate and conditions change after a fire is set. Then, it's a new ball game.

Scifres (1980) identifies two major burn objectives and general burn conditions:

> Most burns in the Rio Grande Plains can be classified by objective as <u>maintenance</u> or <u>reclamation</u> efforts. Maintenance burns are applied with the objective of suppressing invading woody plants, removing "rough" vegetation, removing excessive litter, etc., whereas reclamation burns are usually applied to reduce a heavy brush cover. Maintenance burns may be relatively cool fires initiated under high (greater than 70%) relative humidities and low wind speeds. Reclamation burns are harsh, hot fires applied under low relative humidities (less than 30%) and relatively high wind speeds (greater than 10 miles per hour) to ensure movement of the fire front across the fine fuel and into the woody plant crowns. The initial reclamation burn is usually not uniform because of the lack of fine fuel and discontinuities in the fuel load. However, damage to the brush canopies results in herbaceous plant release and an improvement in fuel load and continuity for the second burn. With proper management the second and third burn may be expected to proceed uniformly, and result in maximum herbaceous plant release. After that burn, maintenance burning may be used to suppress woody plant regrowth and promote range condition improvement.

Wright (1980) believes broadcast burning should not be attempted when fine fuels are less than 1000 pounds per acre; even though the fire may carry with less fuel, management objectives are seldom met. Using a fixed headfire wind direction, Wright (1980) recommends on South Texas mixed brush, burning out firelines (ZOO feet wide) in January and February when relative humidity is 40 to 60 percent, air temperature is 40 to 60 degrees F, and wind speed is less than 8 miles per hour (Figure 9). In February or March, ignite the main headfire along the southwest boundary when relative humidity is 25 to 40 percent, air temperature is 70 to 80 degrees F, and windspeed is 8 to 15 miles per hour.

Coastal prairie burns have been successfully conducted by "simultaneous" headfires and backfires from a single dozed fireline (Figure 10). A 50 to 100 foot wide area was backfire burned before igniting the headfire. This allows flexibility in wind direction and potentially more suitable burn days during a season than when a plan requires a specific direction. Also, adjustments in firing can compensate for shifts in wind direction with the latter technique. The recommended wind speed was 8 to 12 miles per hour, relative humidity less than 70 percent, and air temperature greater than 60 degrees F.

Successful demonstration burns in mixed brush and buffelgrass and Kleberg bluestem ranges with brush invasion have been conducted in LaSalle, Dimmit, and Zavala Counties during 1979-1980. Burns at the Cotulla Airport, LaSalle County, were conducted on previously herbicide treated mixed brush. The standing dead whitebrush (Aloysia lycioides) plus fine fuels (3037 pounds per acre) created hot fires that released California cottontop (Digitaria californica) and buffelgrass (Cenchrus ciliaris). A backfire/headfire technique was utilized for the afternoon burns on February 26, 1979. Weather conditions were: air temperature 72 degrees F, soil temperature 58 degrees F, relative humidity 35 percent, wind speed 8 to 10 miles per hour, and wind direction from the south to southeast. A firewhirl was created in the southwest corner when the headfire and backfire met. The ten foot dozed fireline would not have been sufficient if the area to the west had not already been burned; however, this was considered when the firing plan was adopted. A one foot fireline on the east side was sufficient to set the headfire (Figure 11).

The burn was timed to take advantage of stable wind and atmospheric moisture conditions following a cold front (Figure 8). The cold front passed the Cotulla area on February 24. Burns could have been conducted on February 25 utilizing a north wind; however, the southeast winds tend to be more stable depending on the speed of frontal movement. Also, if the front had stalled and backed up, wind shifts could have occurred on the 25th. In addition, the decreasing relative humidity on the 24th and 25th allowed drying of fine and heavier fuels before the burn was conducted.

The Winston Ranch burn in Zavala County also followed a cold front and heavy dew formation. Conditions the morning of January 8, 1980 appeared impossible; relative humidity at 9:30 a.m. was 62 percent; grass was wet with a heavy dew; winds 0-3 miles per hour from the north-north east. However, by 10:45 a.m. winds were 5-7 miles per hour; fuels were dry, and relative humidity was 47 percent. Fires set after 10:00 a.m. burned hot with a rapid rate of spread. Fuel consisted of Kleberg bluestem on a heavy clay floodplain site. Soil temperature at 2:30 p.m. was 60 degrees F before the burn and 89 degrees F 15 minutes later after the fire passed. The areas were burned successfully

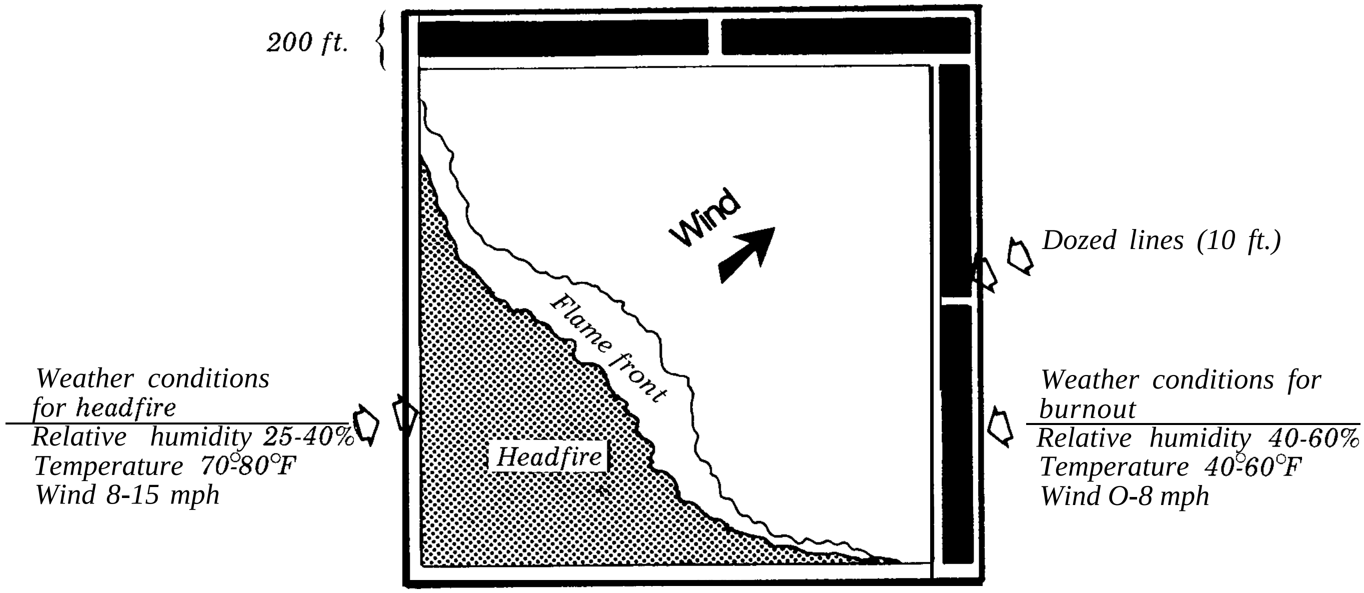

Figure 9. **Using a fixed wind direction prescription, South Texas mixed brush can be successfully burned. Burn out the firelines in January and February. In February or March, light the main headfire. (Wright 1980)**

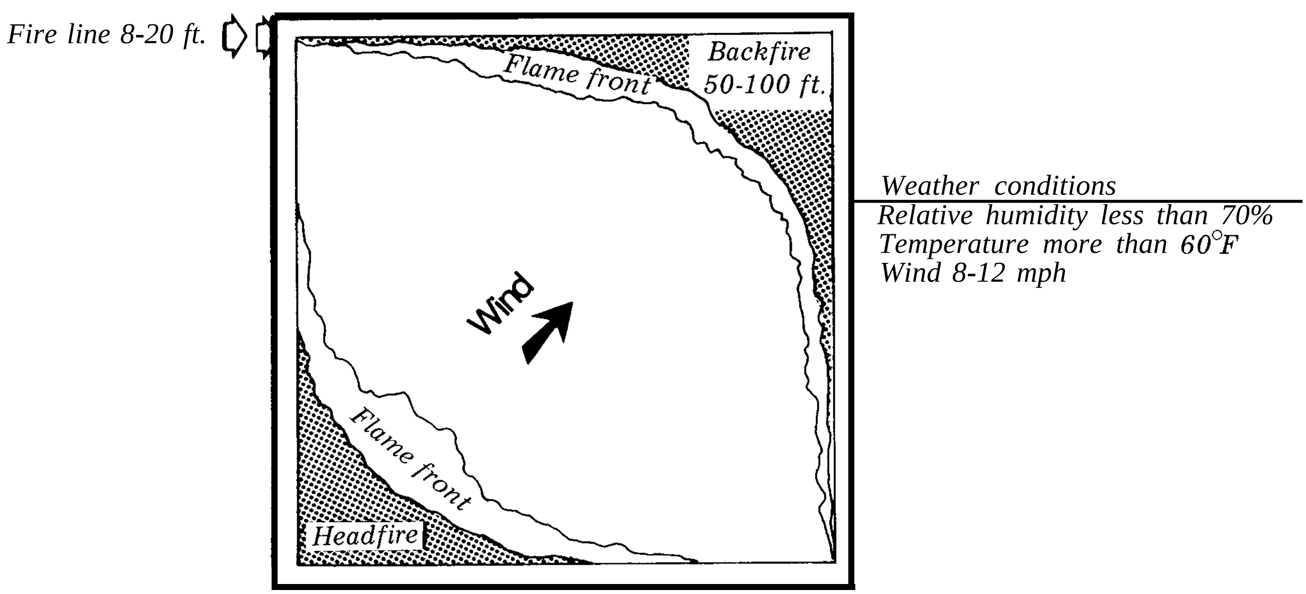

Figure 10. **Installation of burns on coastal prairie with simultaneous head-firing and backfiring system. (Gordon and Scifres 1977)**

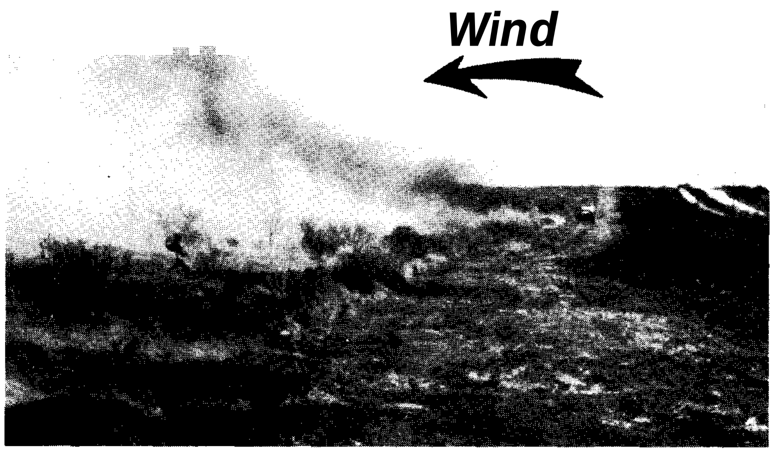

Figure 11. Headfires can be set from a one-foot wide game trail (top) or a dozed and burned fireline (bottom). Setting a headfire quickly by truck or other means allows a uniform fire front to develop. This prevents one area of the fire from getting ahead and overly influencing the local wind patterns (see Figure 5).

demonstrating different firing procedures. Wind currents over the surrounding brush areas created roll eddies and some erratic but predicted fire behavior.

The San Pedro Ranch burn (February 26, 1980) in Dimmit County utilized two dozed lines 100 feet apart around the 750-acre pasture. The grass strip was then burned out using back and strip firing as well as flank fires when moving into the wind to keep the smoke and embers confined to the burned out firelines (Figure 12). Due to slight wind shifts, torch men had to alter lead so that the flank fires met in the center of the strip. Once the entire perimeter was burned out, a head fire was set on the east side from the back of a pickup truck (Figure 11). The headfire moved as a uniform flame front and burned the 750 acres in 19 minutes and 34 seconds (Figure 5). The fire was intense enough that flank winds maintained an upright convection column on the north and south sides. The rapid rise of heat caused the local wind in front of the flame front for a distance of approximately 300 to 500 feet to be pulled against the prevailing wind into the fire. A whirlwind also developed on the northwest corner of the burn as a result of the eddy wind currents. Buffelgrass and native grasses were the dominant fuels. Fuel quantity averaged 2558 pounds per acre. Burning was conducted following passage of a dry cold front. Firelines were burned out the mornings of February 25 and 26, 1980. Highly unstable wind conditions with dust devils common by noon resulted in cancellation of afternoon burning on the 25th. Weather conditions were as follows during the burn:

February 25 -	9:30 a.m.	- Relative humidity 68%, air temperature 53°F, wind speed 4-6 mph from the northwest
	10:30 a.m.	- Relative humidity 39%, air temperature 63°F, wind speed 2-6 mph from the northwest
	1:30 p.m.	- Relative humidity 20%, air temperature 75°F, wind speed 6-8 mph from the northeast
February 26	8:00 a.m.	- Relative humidity 50%, air temperature 51°F, wind speed 5-8 mph from the northeast
	10:10 a.m.	- Relative humidity 35%, air temperature 57°F, wind speed 8-12 mph from the east, northeast
	11:00 a.m.	- Relative humidity 29%, air temperature 62°F, wind speed 8-12 mph from the east, northeast

The headfire was set at 11:00 a.m. on February 26, 1980. The fire burned the area efficiently and went out almost immediately after burning to the west fireline. No spot fires or escapes resulted. Heavy fuels were consumed and burned for several days. Smoldering logs near the boundaries were extinguished.

Prescribed burns can be effectively conducted over standing water or wet soils in marshes following killing frosts and drying winds. The grass fuels must be close enough together to allow fire to spread between grass crowns.

Figure 12. A flankfire procedure (into the wind) was used to burn out the fireline between dozed lines on the San Pedro Ranch burn (top). Note the two flame fronts met in the center of the fireline, and the convection column rose vertically over the burned out area behind (bottom). A road grader, cattle sprayer, extra water, and two drip torches were used.

Such burns usually leave a stubble of approximately three inches above the water or litter-soil surface. Fires of this nature produce little if any heat near the soil surface but can be used to crown kill shrubs and to open grass stands.

Freshwater marsh burns (by the author) in Florida were used to stimulate grass regrowth, reduce forb dominance, and promote use of the areas by marsh wildlife, especially birds. Burns were conducted during the winter following cold fronts. A backfire/headfire prescription recommended for tallgrass prairie (Figure 13) was adapted to local conditions. Wind direction and fire spread was selected to take advantage of open water. Firelines were effectively installed by crushing the herbage into standing water or moist soil immediately followed by setting the backfires. A single disced line was used where necessary. Heavy grazing around the perimeter of some burns prompted green regrowth and little standing dead fine fuels further serving as a fire barrier. Such fuels dry quickly following rain if conditions are correct and will burn rapidly,

FIRE CONTAINMENT PRACTICES

As already mentioned, prescribed fires require preparations to contain the fire to the specified area. Usually firelines are constructed using mechanical equipment to expose the mineral soil and rob the fire of fuel thereby stopping its spread. Gaylor (1974) concludes that "as far as man's ability to control fire is concerned, lessening or elimination of fuel is his most important tool." Certainly prescribed fires have an advantage because the time of the burn can be selected and "barriers" created to contain the fire.

Invariably ranchers ask how wide a fireline should be. The question seems simple, but the firing techniques, weather conditions, and fuel characteristics plus topographic features will alter the recommendations. Firelines can vary from the one-foot wide line used to headfire the Cotulla Airport burn to a 500-foot fireline in high volatile fuels. A 100-foot fireline (two dozed lines plus the burned out strip) was more than sufficient for the San Pedro burn (Figure 12).

Generally, the procedure of firing must be adapted to the kind of firelines and natural barriers available. A one or two-foot fire retardant chemical line can be used if care is taken to backfire precisely along the chemical line and not promote flame height within proximity of unburned or untreated fuels (Figure 14). Thus fire is used under carefully controlled conditions to widen and create a sufficient fireline. The amount of retardant and width of fuel treated requires experience.

The torch man igniting the fire must be careful never to allow a heat buildup that can escape. Flame heights become dangerous when they are reaching more than half the width of the treated line (Figure 15). Using fire to draw fire from the line can allow more intense fires (Figure 11). Wetline techniques and equipment are available for using water and backfiring (Martin et al. 1977). Advantages of the colored chemical fire retardants over water

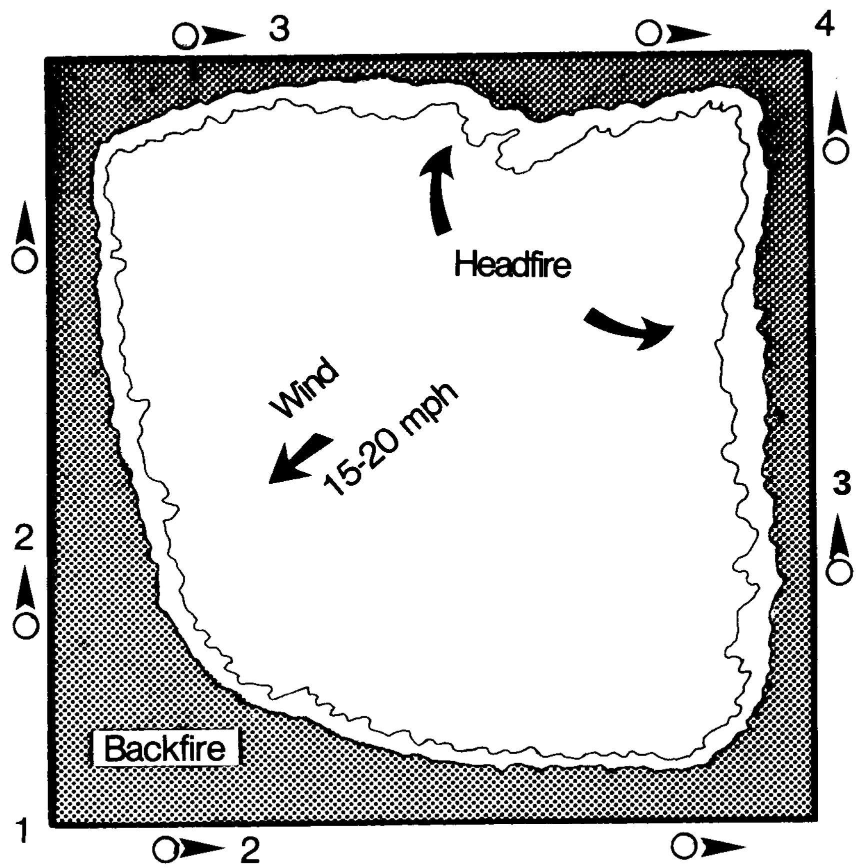

Figure 13. In Tallgrasses natural firebreaks, including roads, trails and fenceline cowpaths, are used to the extent possible. In some cases a wetline may be put down with a sprayer where there is no natural break. A backfire is started (1) and lit simultaneously in each direction (2). After the backfire has burned 50 to 100 feet on the lee sides, then the remainder of the area is lit (3), and burned with a headfire (4). Relative humidity is usually above 40 percent.

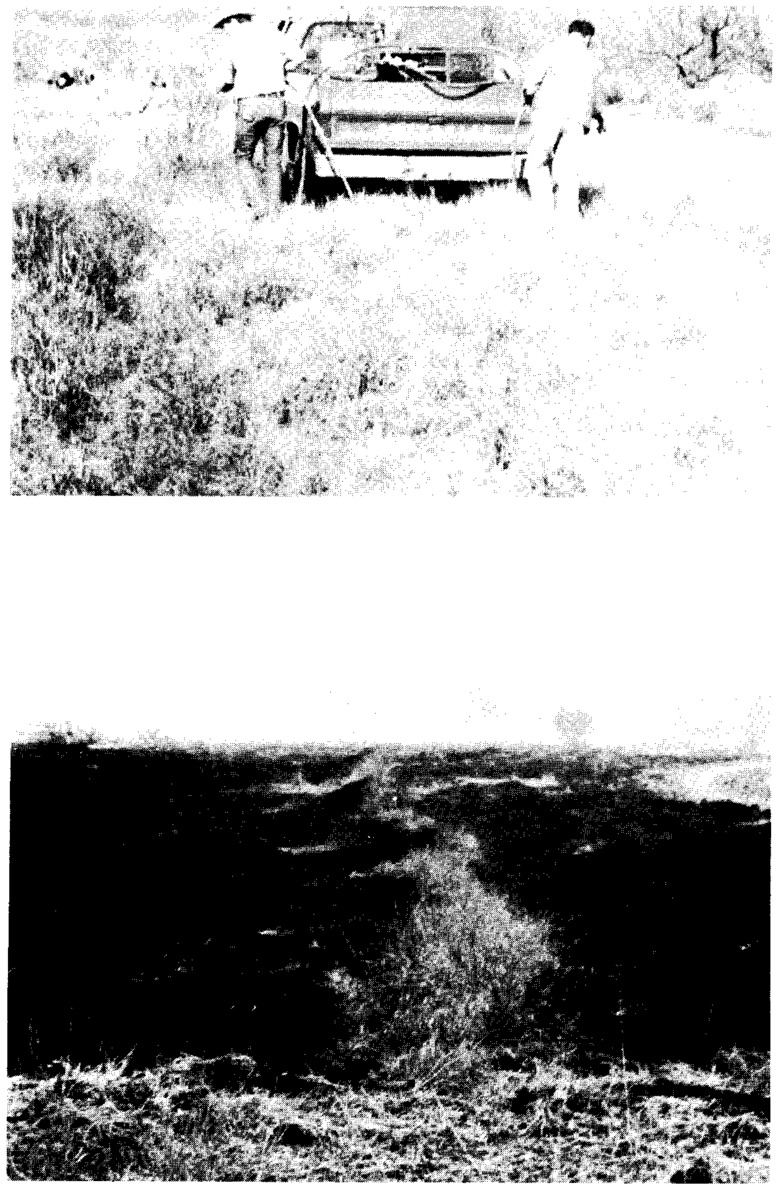

Figure 14. Chemical fire retardants sprayed on fuels can be used to create narrow lines to fire from or burn out between (top). Note the unburned fuel sprayed with Phoscheck chemical retardant did not burn from the strip fire to the right or when the headfire from the left burned to the treated fuel.

may warrant their costs. The colored retardant can be sprayed on the vegetation several hours or even days before the fireline is burned. With the wetline technique equipment failure can result in the backfire getting out of control since burning occurs in conjunction with spraying.

Fireline widths may vary at different locations around a proposed burn area because of concentrations of fuel, topcgraphy effects on wind patterns, adjacent fuel concentrations and neighbor concerns, etc. Because of firebrand problems and potential hot spots, control crews should be strategically placed. The boundary of the fire should be patrolled to quickly locate any spot fires that develop.

Two-way communication between the fire boss, weather monitor, ignition crews, and control crews must be maintained. Accurate and rapid communication allows proper decisions to be made and provides information to confirm what is happening.

Generally, fire is one of the best control tools used to contain a fire; however, the ability to quickly set fire must be available. Drip torches are considered a must to set uniform fires without considerable resetting. Erratically set fires result in stringers of fire proceeding at different rates and may draw each other creating erratic fire behavior.

Figure 15. Flame heights from back or strip fires should not exceed one-half the width of the fireline. The above situation shows a strip fire running into a backfire before a sufficient area had been burned out. A wider fired strip would probably have resulted in an escape to the fence line. It is obvious the dozed line would not contain a headfire without further widening of the firelines (San Pedro Ranch burn).

Wright (1980) concludes that "with the proper weather, a crew of 6 to 10 people, 2 pickups, 1 pumper, 1 dozer (or extra pumper), 2 weather kits, 5 drip torches, an adequate quantity of diesel-gas fuel (4 to 1 mixture), and 4 FM radios, burns in most fuel types can be conducted safely."

PRESCRIBED BURNING TECHNIQUES

Prescribed burning can be accomplished by using a box of matches and simply setting a fire to run with the wind. This most resembles a natural wildfire; however, due to management goals, physical improvements and facilities, landownership boundaries, etc., fire must be initiated and conducted in a predetermined manner. "Based on behavior and spread, fires either move in the same direction as wind (headfire), in opposite direction to wind (backfire), or at a right angle to the wind (flankfire)" (Mobley et al. 1978).

The headfire is the most intense because of its faster rate of spread, wider burning zone, and greater flame heights (Figures 5, 16). The flankfire is of intermediate intensity. Four firing techniques are more commonly recommended for rangelands (Figure 17). Combinations of these fires when properly coordinated can be used to prescribe burn under variable wind directions (Figure 18).

Backfires require higher fuel quantities and a more continuous fuel distribution than headfires. Since backfires trove slower and have a less intense flame front, they are easier to control (Figure 5). Also, in heavy fuels a backfire may consume more fuel keeping heat closer to the soil surface providing greater heat penetration to bud zones than fast moving headfires.

Headfires are very effective at crown killing shrubs and trees with intense heat several feet above the soil surface (Figures 16, 17). Preheating of fuel by headfires helps speed the combustion process. Headfires will burn under a wider range of weather and fuel conditions than backfires but are more dangerous. Headfires may be required to burn large acreages in a reasonable amount of time especially since burning regulations require burning to be conducted between 9 a.m. and 5 p.m. However, a series of plowed lines or fire retardant lines across a pasture can be used to set a number of backfires in a relatively short time period. Costs of fireline construction would be considerably higher.

A modification of the head and back firing technique is the strip headfire (Figures 5, 17). This is simply a line of fire set within the pasture at right angles to the wind direction. The result is a headfire across the strip and a backing fire into the wind. This technique can be used to speed up the widening of firelines. The width of the strip must be regulated by the ignition crew so that the flame front does not leap the fire barrier. Changes in fuel quantity and continuity require corresponding changes in width of the strip fired area. Using strips of increasing widths will confirm the safety of the fireline against the major headfire. Once a headfire moves 50 to 100 feet, its major flame front characteristics are developed (exception being

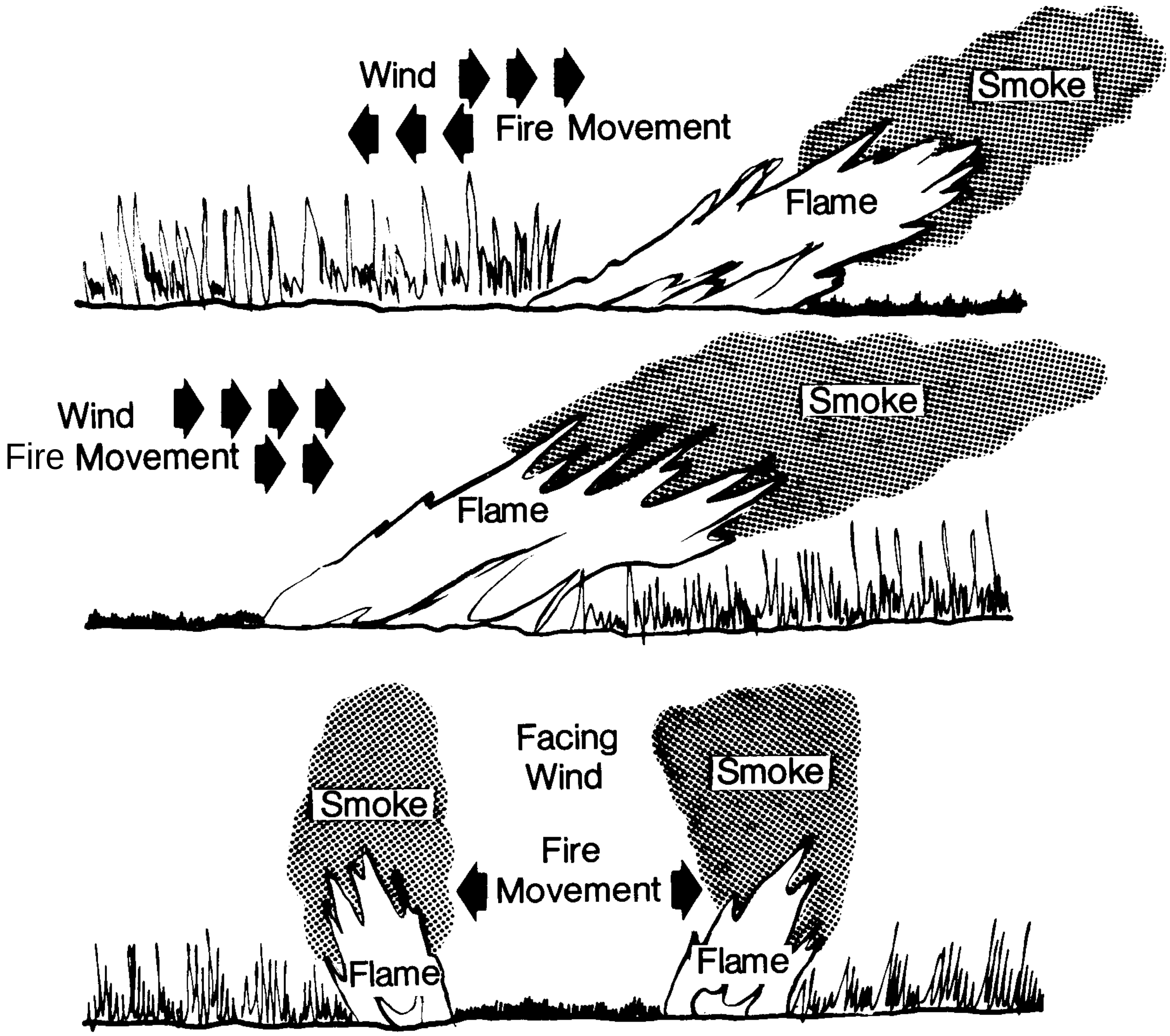

Figure 16. Backfires move into the wind with little preheating of unburned fuels (top). These move slowly and require heavier fuel quantities and more uniform continuity than headfires (middle). Headfires move with the wind with a high rate of spread. Flank fires result in fires moving at a diagonal to the wind (bottom).

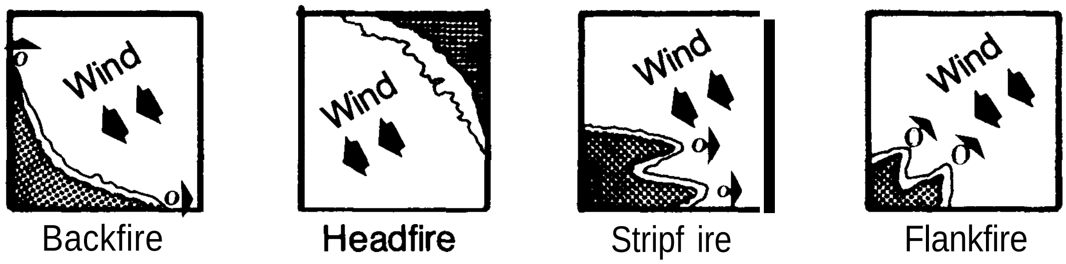

Figure 17. Firing techniques used for prescribed burning.

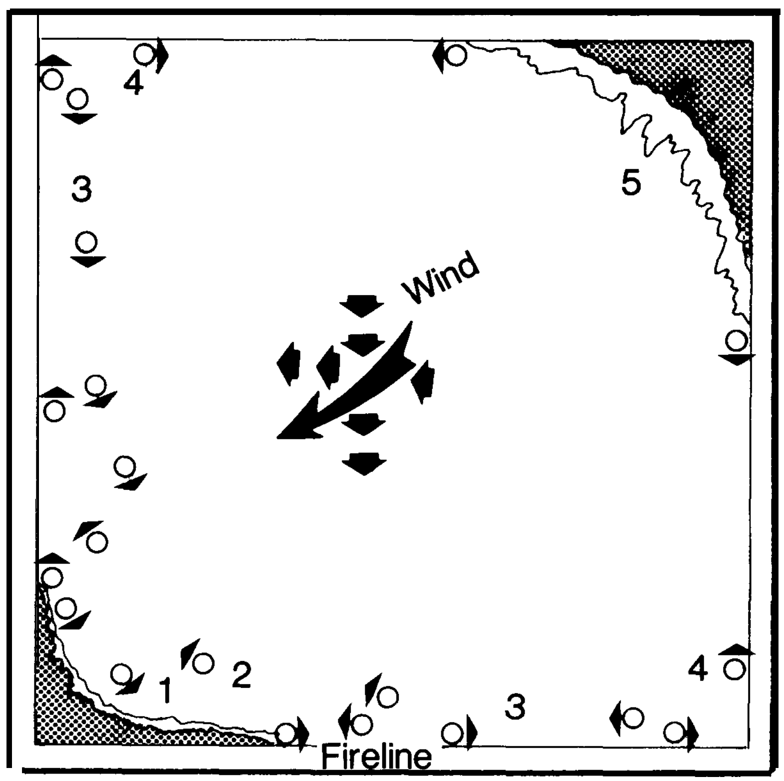

Figure 18. Using combinations of firing techniques to widen the firelines and contain a headfire under variable wind directions. The backfire plus narrow strip fires (1) are used to widen the burnout of downwind sides. Increasingly wider strip fires are used to increase fireline width within the burned out backfired lines (2 and 3). A flank-headfire is used to slowly widen burnout of corners (4). The headfire is set using two torches to the burned out corners (5).

convection column and uplift of firebrands). The ignition crew should not run a strip fire into another strip fire until true backfire characteristics have been established and the flame front from the previous headfire calmed. Do not set more fire than can be safely handled.

SUMMARY

Prescribed burning is a viable range improvement practice on many ranches throughout southwest Texas and the Coastal Bend. However, "many ranchers will not be able to use fire as a viable tool until they achieve better range conditions" (White 1980). Wright (1980) considers that ranges "need to be in high fair, good, or excellent condition for a prescribed fire to be an effective management tool." This may not be true in the more moist and humid range sites where high herbage production can result even though range condition may be low.

When a rancher decides to utilize prescribed burning; planning, training, experience, patience and assistance are a necessity. A series of small simple burns should be used to develop experience by the rancher and burning crews. The rancher must become a weather watcher and forecaster extrapolating weather reports to actual ranch conditions. Most ranchers already watch the weather to anticipate rain, but wind patterns, etc., must be added to the list. Each burn will add knowledge and skill; the success of a burn program will be the rancher's interest and ability to combine the local experience with known principles, etc., and adapt techniques and application to best meet his objectives.

This paper has presented basic vegetation and fire behavior principles essential to understanding fire effects and application. Also, general prescriptions and firing techniques used to achieve different intensity of burns have been discussed. Safety is emphasized but hinges on the conditions and manner in which fire is applied. Avoid over-optimism; this is dangerous in setting fire as well as expecting too much. Use fire where benefits can realistically be achieved and integrated with the ranch operation. Ranchers unwilling to adequately prepare themselves and their personnel should abstain from using fire and rely on other range improvement techniques.

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INTEGRATION OF PRESCRIBED BURNING WITH OTHER PRACTICES IN BRUSH MANAGEMENT SYSTEMS

C.J. Scifres

INTRODUCTION

Renewed interest of Texas range livestock producers in the use of fire as a range improvement practice is primarily the result of increasing costs of herbicides, heavy equipment, and energy associated with brush management. Although the expectation of many producers is to use burning instead of the more costly methods, there are few situations in which fire can be directly substituted for other approaches and with the same results. Fire is usually most effective when used "in addition to" rather than "instead of" other conventional methods, and this effectiveness depends largely on the degree of attention given to planning and implementing the burns. Success from prescribed burning requires development of a workable fire plan and its implementation under logical, carefully prescribed conditions. There are several requirements for the most effective use of prescribed fire, one of the most important being an adequate load of continuous fine fuel.

In general, an evenly-distributed, fine fuel load of 2,500 to 3,000 lb/acre is considered adequate for an effective burn (Scifres 1980b). Rangeland supporting moderate to heavy brush cover is characterized by seriously reduced and patchy herbaceous cover, a fine fuel load that is inadequate for implementing an effective uniform fire except under harsh and hazardous weather conditions for burning. Burns applied under such conditions (high winds to push the fire through brush crowns; high temperatures to facilitate ignition and combustion) are referred to as "reclamation burns" (Scifres 1980).

Even with conditions that allow installation of a reclamation burn, coverage of the first fire is generally patchy at best. The initial burn opens the brush canopy and releases herbaceous species which improves the fine fuel load and continuity. Assuming appropriate grazing management to retain enough of the fuel released by the first fire, the second burn is usually more uniform than the first. The third prescribed burn may then uniformly and completely cover the management unit. If the burns are installed at 2 to 3 year intervals, from 4 to 6 years will usually lapse between the first and third burns.

Because of the dependence on an adequate load of evenly distributed fine fuel, range burning may be applied most effectively as a treatment subsequent to an initial method which uniformly reduces the brush canopy and releases the fine fuel. This approach reduces the time required for range improvement using only burning. Moreover, prescribed burning often increases the effective life of initial treatments and compensates for characteristic weaknesses of several of the methods. Because of this utility, recent research has enphasized fire-based Integrated Brush Management Systems (IBMS) to take maximum advantage of several methods, including fire, over a relatively long time period.

THE IBMS CONCEPT

Development of IBMS requires considerably more thought and planning at the firm level than simply selecting a sequence of brush control treatments. It spans a series of managerial activities including the setting of land-use objectives for the management unit, establishing grazing management strategies, and economic projections with due consideration for livestock production, wildlife habitat and other uses of the rangeland. IBMS is the use of a coordinated body of methods in a plan of procedure to optimize yield of range products on a sustained basis and within an economically sound framework (Scifres 1980b). Since a detailed discussion of IBMS is out of the realm of this paper, the potential of fire integrated with other methods, as an important component of IBMS, will be emphasized.

HERBICIDE/FIRE SYSTEMS

Integration of herbicide application with prescribed burning appears to hold considerable potential for inclusion into IBMS strategies for several brush problems. Prescribed burning has been evaluated following applications of herbicide sprays and of pellets as broadcast or individual plant treatments.

Aerial broadcast application of herbicide sprays reduces the brush canopies quickly (within 30 days in most cases) and, in years of adequate precipitation and with proper grazing management, releases fine fuel for prescribed burning. This method allows substitution of the herbicide application for as many as two reclamation burns, thins the stands by killing some of the woody plants, and allows the burns to be installed under relative safe environmental conditions. Most research has emphasized the use of prescribed burning 18 to 24 months after the herbicide application and in the dormant season (Scifres 1975). Late winter and early spring burns are advantageous in that the soil of the target area is not bare of vegetative cover for a prolonged period. In fact, burned areas generally develop a green cover of herbaceous vegetation earlier in the spring than do adjacent unburned areas. Moreover, the prescribed burns are effective for restoring the forb populations, especially legumes, that may be seriously reduced by the herbicide applications. Some examples'of this approach will be presented with the intention of demonstrating principles and strategies that may be applied to other management problems rather than belaboring specific research results.

Macartney rose (Rosa bracteata)-infested rangeland has been effectively improved by applying aerial sprays of 2,4,5-T ([2,4,5-trichlorophenoxy]acetic acid) + picloram (4-amino-3,5,6-trichloropicolinic acid) as a 1:1 mixture in the fall or the spring (Scifres 1975a, 1975b). Scifres (1975a) reported good topgrowth control of Macartney rose with applications of the 2,4,5-T + picloram mixture at 1 lb/acre. Applications of 2,4-D ([2,4-dichlorophenoxy]acetic acid) at 2 lb/acre followed the next year by application of 1 lb/acre has also given good control (Hoffman et al. 1964). However, one of the objectives of IBMS is to eliminate repeated herbicide application and to minimize herbicide application rate. Although it has not been researched, a single application of 2,4-D may be adequate to prepare the vegetation for prescribed burning.

The herbicide application defoliates the Macartney rose, dries the canes, kills some of the plants (thinning the stand), and releases fine fuel for prescribed burning. Prescribed burning applied in late winter or early spring just prior to the second or third growing season following herbicide application removes the dead standing canes, suppresses Macartney rose regrowth, promotes warm-season grasses such as little bluestem (Schizachyrium scoparium), and helps restore the forb component on the rangeland. There is no advantage to applying the prescribed burns the winter following herbicide application in the spring or fall. Although the fine fuel may develop the season of spraying, regrowth of the Macartney rose on plants surviving the spray should be allowed to develop into the fuel for maximum detriment of the fire to the woody plant. Regrowth of Macartney rose has usually developed adequately by the end of the second growing season for maximum exposure to the fire front but not to the extent such as would limit fine fuel production.

Prescribed burning may be reapplied periodically, perhaps at 2 to 3 year intervals, depending on rainfall conditions, to maintain range improvement. In some cases, especially when individual plant herbicide treatments may be applied to thin the Macartney rose stand back to the desired cover. Whereas two or three, successive, annual broadcast herbicide applications have been required to improve Flacartney rose infested rangeland, use of prescribed burning has allowed use of a single broadcast herbicide application and occasional individual plant maintenance treatments to accomplish the same result on a long-term basis.

Prescribed burning can be applied, in some cases effectively, without pretreatment with other methods (Gordon and Scifres 1977). However, fire kills few of the plants so that repeated burnings at regular intervals may be required to suppress influence of the woody plant. Also, localized areas of heavy cover of reinfestations may create problems in maintaining the burning program whether used alone or in a system. It would be undesirable to let these areas develop such a cover as to be highly susceptible to herbicide sprays, especially broadcast applications. Thus, a technique was needed for incorporation into the system to maintain burning effectiveness.

Subsequent research indicated that broadcast or individual plant applications of'picloram pellets applied immediately following burning will effectively control the Macartney rose (R.A. Gordon, C.J. Scifres and J.L. Mutz, unpublished data). Effective control of Macartney rose was achieved with broadcast applications of picloram pellets at 1 to 2 lb/acre (active ingredient) of the 5 or 10% formulations. Since the pellets can be broadcast applied with spreader attachments which fit conventional farm equipment, this approach offers a method for reducing the influence of localized reinfestations of the pastures at the convenience of the land manager.

The prescribed burn/picloram pellet system also appears promising for control of common goldenweed (Isocoma coronopifolia) (Mayeux and Hamilton 1979). As with Macartney rose, the picloram pellets are applied directly into the ash immediately following the fires. This allows movement of the herbicide into the soil with first rainfall following the fire. As the actively growing new sprouts utilize water from the soil, the herbicide is available for root absorption. Based on preliminary research results, it appears that equivalent common goldenweed control can be obtained with about half the herbicide rate required for control of the weed on unburned rangeland.

Whitebrush (Aloysia lycioides) is a difficult-to-control woody plant that infests some of the most potentially productive rangeland in South Texas. It is not effectively controlled with broadcast applications of conventional herbicides. However, whitebrush can be effectively controlled with aerial applications of 1 to 2 lb/acre of the recently released herbicide, tebuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N,N'-dimethylurea) (Scifres et al. 1979).

A tebuthiuton/prescribed burning system for whitebrush has been described in detail by Scifres (1980b) so only a general discussion will be given here. The tebuthiuron applications kill a high percentage of the whitebrush and release range forages. By the second or third growing season, regrowth of whitebrush from those plants which are not killed by the tebuthiuron can be suppressed by a cool-season burn. The fire also removes much of the debris left standing after herbicide application, and further improves botanical composition of the native forage stand.

The tebuthiuron pellets may be applied in strips alternated with untreated strips to leave ample brush cover and browse for wildlife (Scifres 1979). At the rate applied for whitebrush control, tebuthiuron does not control honey mesquite (Prosopis glandulosa var. glandulosa). Burning the strips during the dormant season did not destroy brush in the untreated brush strips, and did minimal damage to large scattered honey mesquites which serve as shade for livestock. Based on research on the South Texas Plains where the tebuthiuron was applied in the fall of 1975 and burned during the late winter of 1978, it now appears that periodic use of prescribed burning and sound grazing management may preclude further use of herbicides for 10 to 15 years.

The tebuthiuron/fire system also appears to hold promise for improvement of areas infested with post oak, blackjack oak and associated species (C.J. Scifres, unpublished data). Although many species are effectively controlled by the herbicide application, shrubs such as American beautyberry (Callicarpa americana) and vines such as saw greenbrier (Smilax bona-nox) and peppervine (Ampelopsis arborea) are left to increase. Prescribed burning may be applied to hold these species to desired densities for wildlife habitat and improve their browse value.

Running mesquite (Prosopis reptans) is another troublesome species which has required multiple applications of conventional herbicides for effective control. Preliminary research results on the South Texas Plains indicate that a single application of 2,4,5-T + picloram followed by prescribed burning may effectively improve rangeland infested with running mesquite.

Although these examples relate to use of specific herbicides, research is being conducted continually to develop additional compounds for integration into brush management systems.

MECHANICAL METHOD/FIRE SYSTEMS

Prescribed burning may be effectively used in conjunction with various mechanical methods, for brush management, depending on brush size, stand composition, cost of the method, and objectives of management. Simple top removal methods such as shredding and roller chopping are highly effective as preparation treatments for prescribed burning (Scifres 1980b). The mechanical method removes the aerial brush growth and allows release of herbaceous species. Depending on conditions following application of the method, a second treatment may be required before prescribed fires are most effective. Although roller chopping and shredding temporarily reduce the stature of the brush, stem densities may be increased by prolific sprouting (Dodd and Holtz 1972). Moreover, the new sprouts grow rapidly, especially in years of favorable moisture conditions. For instance, honey mesquite, twisted acacia (Acacia tortuosa), whitebrush and other species replaced their original height (4 to 5 feet) the growing season after shredding near Campbellton (Hamilton et al. 1981). Thus, prescribed burns must be scheduled by the second or third growing season after mechanical top removal to adequately suppress the brush growth to allow range improvement,

Roller chopping or crushing of species such as Macartney rose compacts the woody material and facilitates its uniform and complete combustion. However, in contrast to use of herbicides, regrowth is rapid following the fires and the land manager must maintain a relatively rigid burning schedule to prevent reestablishment of the problem.

SUMMARY

Prescribed burning has considerable potential for integration into brush management systems for South Texas. Treatments such as herbicide application may be used to reduce the brush canopies and release fine fuel for

prescribed burning. Prescribed burning can then be used to suppress surviving woody plants, remove rough forage plants, promote legumes and other desirable forbs usually damaged by the sprays, promote uniform distribution of livestock grazing, expedite secondary succession and improve botanical composition of grass stands, and preclude repeated herbicide use.

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RANGE BURNING AND WILDLIFE HABITAT

Bill Kiel

INTRODUCTION

When the invitation came to participate in this symposium, I was reluctant to accept because I do not have first-hand experience in measuring effects of rangeland burning on wildlife habitat. Some encouragement by colleagues persuaded me it might be worthwhile to pose some questions regarding the goals or objectives of prescribed burning in this region. These concerns apply as well to herbicide treatment of rangeland and to various methods of mechanical brush control.

What is the goal of prescribed burning of rangeland? The answer will clarify whether results are likely to be beneficial or detrimental to wildlife habitat. If the goal is to eliminate woody plants and cacti and turn this region into vast expanses of dense grassland, the result will be poorer habitat for deer*, javelina, turkey, quail, and many other species of wildlife for which the region is renown. On the other hand, fire might be a beneficial tool in managing habitat for wildlife if used to open up large acreages of dense stands of brush or tall grass, to create interspersion of plant cover types, to promote growth of wildlife food plants such as forbs and legumes, and overall to preserve woody cover in a pattern that enhances maximum production of wildlife.

Without the use of prescribed burning, this region is renown for its game populations. The economic value of hunting leases equals or exceeds the net income from livestock production on many ranches that have preserved high quality wildlife habitat. Hundreds of thousands of acres, however, have been taken out of optimum wildlife production by large-scale brush removal by mechanical and/or herbicide treatments. These land management practices are particularly detrimental to wildlife production when land clearing is followed by the establishment, on a large scale, of introduced grasses that provide inadequate food and/or cover for the principal game species of birds and mammals (Kiel 1976).

The decisions on land management are the landowner's, My point is that rangeland managed to produce wildlife crops, as well as livestock, can net the landowner $4 to $6 per acre or more annually by the leasing of hunting opportunity in addition to income from livestock. Unless the brush-cleared land produces additional net income above this level--and on a long-term sustained basis--the brush elimination treatments may be a money-losing proposition.

Rangeland in this region has not been static since historical times. The brush invasion of grassland described by many authors may more precisely be called an increase in brush density (Inglis 1964). Most likely the woody plants are the true climax vegetation of this region, and grasslands were dependent on fire to maintain their dominance over woodland or chaparral (Johnston 1955, Box et al. 1967). Those wildlife species for which this region is renown today--white-tailed deer, turkey, javelina, and quail--no doubt benefitted from the brush interspersion with grassland. Brushland may reach a point of maturity and density, however, that is not conducive to optimum production of wildlife

* Scientific names in Appendix.

crops of economic value (Komarek 1963). For example, dense stands of brush with a closed canopy limit growth of food-producing forbs, and browse availability for deer is lessened when some taller woody plants reach maturity. Desirable mast production, however, may be at high levels. Prescribed burning might be a tool valuable in maintaining openings in otherwise closed stands of brush and in suppressing woody regrowth in openings created by previous brush control treatments that considered rangeland management for both wildlife and livestock. Steuter (1980) reviewed wildlife responses to prescribed burning in the Rio Grande Plain at a similar symposium in Carrizo Springs. He concluded that habitat changes induced by fire could be beneficial or detrimental to wildlife depending on how fire is used.

SOME OBSERVATIONS ON WILDLIFE HABITAT AND PROSPECTIVE USES OF BURNING

In the South Texas region where the amount and pattern of rainfall is of critical importance to wildlife production, I have observed that mast and/or browse provided by woody plants, prickly pear cactus, amd vines such as old man's beard are some food resources that permit the survival of higher densities of deer, javelina, turkeys and quail than would be possible without these foods. Bobwhite quail may be abundant (densities of 2 birds per acre) in rather open grasslands composed of many species of native grasses and forbs in the early fall following favorable breeding seasons with adequate rainfall. Often, though, in commonly dry late fall and winter months, they retreat to more brushy habitat. During drouthy times, deer leave dried out open areas and concentrate where there is cactus and browse, the only green food remaining. Turkeys and deer feed heavily on the leaves of old man's beard in severe drouths. Continuing studies at the Texas Agricultural Research and Extension Center at Uvalde are documenting the high nutritional value of forbs and browse, including prickly pear cactus, in the diet of deer (Blankenship et al. 1979).

The long-term ability of rangeland to support good populations of game is dependent on the food and cover resources available during critical times--in this region, drouthy periods. Too often the only brushland preserved for wildlife under brush control treatments is that on less fertile sites. Forbs and plants producing browse and mast respond favorable to soil fertility, and some good range sites need to be preserved for wildlife habitat.

Prescribed burning may be a beneficial tool in managing rangelands for game production. In addition to the usual precautions necessary in planning burns, discussed by others at this symposium, I anticipate there may be problems with the rainfall pattern in attaining desired results. In the Kingsville area, average annual rainfall is about 25 inches. The late fall and winter months, however, are typically the drier period of the year. October-December rainfall averages less than two inches per month and January-March rainfall is only slightly over one inch per month on the average. Timing of the burn to take advantage of soil moisture conditions undoubtedly will be of primary importance.

On rangeland that has received brush control treatments and strips or mottes of brush have been left for wildlife habitat, it probably will be necessary to disc fireguards to protect the brushy areas. I have observed burning of scrub live oak in pastures with some mottes of larger trees. Each succeeding burn kills a few trees on the outer edges of the mottes. If burns are frequent enough and fuel loads are adequate, the desirable mottes of large trees will be removed by fire unless fireguards are used.

Ground-nesting game birds such as turkeys and bobwhite quail could have nests destroyed by spring burning. Young of both turkeys and bobwhites begin hatching the last week in April in the Kingsville area. Allowance for incubation and egg laying periods would indicate burning later than March 15 could destroy active nests. Earlier burns should be planned to leave residual nesting cover in patches or strips if quail and turkey management is a part of the range management plan. Hurst (1972) emphasized the importance of insects in the diet of young quail up to 20 days of age. Burning in Georgia enhanced the abundance and availability of small insects for young quail, but Hurst advised "When using fire the manager should finish all burning before insect emergence and hatching of the over-wintering eggs takes place. Woody-brushy areas, which serve as brood-holding areas, should be saved from burning. Burning in strips or patches is recommended, to leave preferred nest habitat adjacent to brood habitat." Insects also are of critical importance in the diet of turkey poults.

Burning has not been necessary to maintain high populations of bobwhite quail on a 16,000-acre study area near Kingsville. Average fall populations of 1 to 2 or more birds per acre are produced on rangeland grazed by cattle and rootplowed to control brush (Kiel 1976). Brush mottes have been preserved for wildlife benefits, and dense stands of introduced grasses have not been established in these pastures.

Certainly prescribed burning should be evaluated as a tool for range management in this region. Preservation or improvement of wildlife habitat needs to receive equal priority with improvement of forage for livestock grazing. I believe a variety of grass species, forbs and browse may be better in the long run even for cattle production than a monoculture of a single grass species. Rippling waves of stirrup-high grass may sound good in historical accounts, but how long can it persist under the frequent drouths and other adverse factors? Kleberg and Dias (1957) described the decimation in a two-year period of Rhodesgrass, a native of South Africa, that flourished as a forage grass in south Texas in the 1915-42 period. It was killed by a grass scale native to China and previously unknown in North or South America.

The interior of the Rio Grande Plain has "boom or bust" characteristics as grazing land. Lehmann (1969) documented that legions of sheep--over 2 million at their peak in the early 1880's--once grazed here. By 1900 they were gone. He also cites historical records to show the region produced relatively little grass on a sustained basis.

Maintaining diversity in vegetation--grasses, forbs, legumes, brush and cacti--should be the goal of rangeland management for wildlife habitat. Such diversity may well be the best management in the long run for cattle as well. Wildlife is surely a crop of the land that can be produced on a sustained yield basis for profit and recreation. Prescribed burning deserves to be tried and evaluated in this region as a method of managing rangeland for sustained crops of livestock and wildlife.

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APPENDIX

Scientific Names of Plants and Animals Mentioned in the Text

Plants

Live Oak - Quercus virginiana

Old man's beard - Clematis drummondii

Prickly pear cactus - Opuntia lindheimeri

Rhodesgrass - Chloris gayana

Animals

Bobwhite quail - Colinus virginianus

Javelina - Pecari tajacu

Scaled quail - Callipepla squamata

Turkey - Meleagris gallopavo

White-tailed deer - Odocoileus virginianus

Grass scale - Antonina graminis

ENVIRONNENTAL CONSIDERATIONS AND REGULATIONS ASSOCIATED WITH RANGE BURNING

Gary I. Wallin

In 1975 the Texas Air Control Board's regulations were changed allowing outdoor burning for specified purposes when certain conditions are met. Prior to this time the regulations did not contain any rules allowing outdoor burning for crop or range management purposes. Prior to changing the regulation the Board held several meetings, a public hearing, received many written comments concerning outdoor burning and studied other state's regulations.

As you know, the burning of vegetable matter does produce air contaminants.Through research, emission rate factors have been developed for different types of burning operations. The copy of this paper in your symposium proceedings includes a table of emission factors for open burning of agricultural materials developed by the Environmental Protection Agency. This table gives emission factors for different types of crops and for grasses. The factors given for grasses is probably representative of range burning emissions. The major contaminants are particulate matter, carbon monoxide and hydrocarbons. The general public's primary concern with outdoor burning is visible degradation.

Even though emissions from outdoor burning of vegetable matter for forest, range and crop management purposes can put large amounts of contaminants into the atmosphere, the Board decided to allow this outdoor burning when there is no practical alternative to burning and when the burning will not cause or contribute to a violation of any Federal primary or secondary ambient air standard.

The portion of Regulation I pertaining to this type of outdoor burning reads:

> Outdoor burning is authorized in each of the following instances:
>
> Outdoor burning in a rural area of trees, brush, grass and other dry vegetable matter at the site where it occurs and only when no practical alternative to burning exists for right-of-way maintenance, land-clearing operations, and for those forest, crop, and range management purposes not specifically governed by orders issued pursuant to Rule 131. 03.01.002(a) of this Regulation if all the following conditions are met:
>
> > (1) Any burning conducted for salt marsh grass management purposes in the following counties may be conducted only after verbal or written notification to the Texas Air Control Board Regional Office having

jurisdiction: Orange, Jefferson, Chambers, Galveston, Harris, Brazoria, Matagorda, Jackson, Calhoun, Aransas, Refugio, San Patricio, Nueces and Kleberg. Burning of salt marsh grass in these counties shall not be conducted during periods of actual or predicted persistent (12 hours or more) low-level atmospheric temperature inversions (non-surface based) or in areas covered by a current National Weather Service (NWS) Air Stagnation Advisory. This meteorological data will be available from the Texas Air Control Board Regional Office having jurisdiction.

(2) Prior to prescribed or controlled burning for forest management purposes, the Texas Forest Service shall be notified.

(3) The burning must be outside the corporate limits of a city or town except when it is necessary to eliminate a naturally occurring fire hazard.

(4) Burning shall be commenced only when the wind direction is such as to carry smoke and other pollutants away from any city, town, residential, recreational, commercial or industrial area, navigable water, public road or landing strip which may be affected by the smoke. Burning shall not be conducted when a significant shift in wind direction is predicted which could produce adverse affects to persons, animals, or property during the burning period. If at any time the burning causes or may tend to cause smoke to blow onto or across a road or highway, it is the responsibility of the person initiating the burning to post flagpersons on affected roads in accordance with the requirements of the Department of Public Safety.

(5) The burning must be at least three hundred feet (ninety meters) from any residential, recreational, commercial or industrial area except those located on the property where the burning is to take place, except when it is necessary to eliminate a naturally occurring fire hazard.

(6) Heavy oils, asphaltic materials, items containing natural or synthetic rubber or any material other than dry plant growth which may produce unreasonable amounts of smoke must not be burned.

(7) The hours for burning shall comply with the following:

(A) The initiation of burning for land-clearing and right-of-way maintenance purposes shall commence after 9:00 a.m. Material which will not be completely consumed before 5:00 p.m. shall not be added to the fire.

(B) The initiation of burning for crop and range management purposes shall commence after 9:00 a.m. The acreage to be burned should be adjusted to provide that the burning is completed by 5:00 p.m. on the same day or as soon as is reasonable practical.

(8) Burning shall not be commenced when surface wind speed is predicted to be less than 6 mph (5 knots) or greater than 23 mph (20 knots) during the burn period.

As you can see, the burning of salt marsh grass in specified coastal counties gets special treatment in the regulation. The reasons for this rule are due to the past problems we have encountered with this type of burning. Numerous accidents have been caused by smoke blowing across highways and severe visible degredation created when burns were conducted during atmospheric inversions. The worst problems have occurred in the more populated counties. Please contact our nearest regional office prior to burning any salt marsh grass. A list of our regional offices with addresses and phone numbers is included with this paper. Our regional office will be able to advise you about any air stagnation advisories.

With any burning always watch the weather. The wind direction, wind speed, time of day, and humidity play a big part in minimizing the affects of your emissions. Always think of your neighbors and try to burn under the conditions that will least likely bother them. For those with close neighbors, you may want to notify them prior to burning.

There are numerous burning procedures that tend to improve the affectiveness of your burns as well as keep your emissions to a minimum. Burning when your combustible material is dry, when the wind speed is not too high or too low and burning against the wind are such conditions. The table of emission factors for open burning of agricultural materials which I referred to earlier contains factors for headfire burning and for backfire burning of several crops. These factors indicate backfiring will substantially reduce the quantity of particulate matter produced but will slightly increase emissions of carbon monoxide and organics. An effective burn and low emissions compliment each other.

So in summary, the Board has recognized the need for outdoor burning for range, crop and forest management purposes. tlowever, we do require that certain precautions are taken to minimize the effects of these burns. If everyone does their best to comply, the right to practice outdoor burning will continue to be allowed by the Board.

Emission factors and fuel loading factors for open burning of agricultural materials

Emission Factor Rating: B

Refuse category	Emission factors: Particulate lb/ton	Particulate kg/MT	Carbon monoxide lb/ton	Carbon monoxide kg/MT	Organics (as C_6H_{14}) lb/ton	Organics (as C_6H_{14}) kg/MT	Fuel loading factors (waste production) ton/acre	Fuel loading factors (waste production) MT/hectare
Field crops								
Unspecified	21	11	117	58	23	12	2.0	4.5
Grasses	16	8	101	50	19	10		
Headfire burning								
Alfalfa	45	23	106	53	36	18	0.8	1.8
Bean (red)	43	22	186	93	46	23	2.5	5.6
Hay (wild)	32	16	139	70	22	11	1.0	2.2
oats	44	22	137	68	33	16	1.6	3.6
Pea	31	16	147	74	38	19	2.5	5.6
Wheat	22	11	128	64	17	9	1.9	4.3
Backfire burning								
Alfalfa	29	14	119	60	37	18	0.8	1.8
Bean (red), pea	14	7	148	72	25	12	2.5	5.6
Hay (wild)	17	8	150	75	17	8	1.0	2.2
oats	21	11	136	68	18	9	1.6	3.6
Wheat	13	6	108	54	11	6	1.9	4.3
Vine crops	5	3	51	26	7	4	2.5	5.6
Weeds								
Unspecified	15	8	85	42	12	6	3.2	7.2
Russian thistle (tumbleweed)	22	11	309	154	2	1	0.1	0.2
Tules (wild reeds)	5	3	34	17	27	14		

(Adapted from Lahre, T. and P. Canova. 1978)

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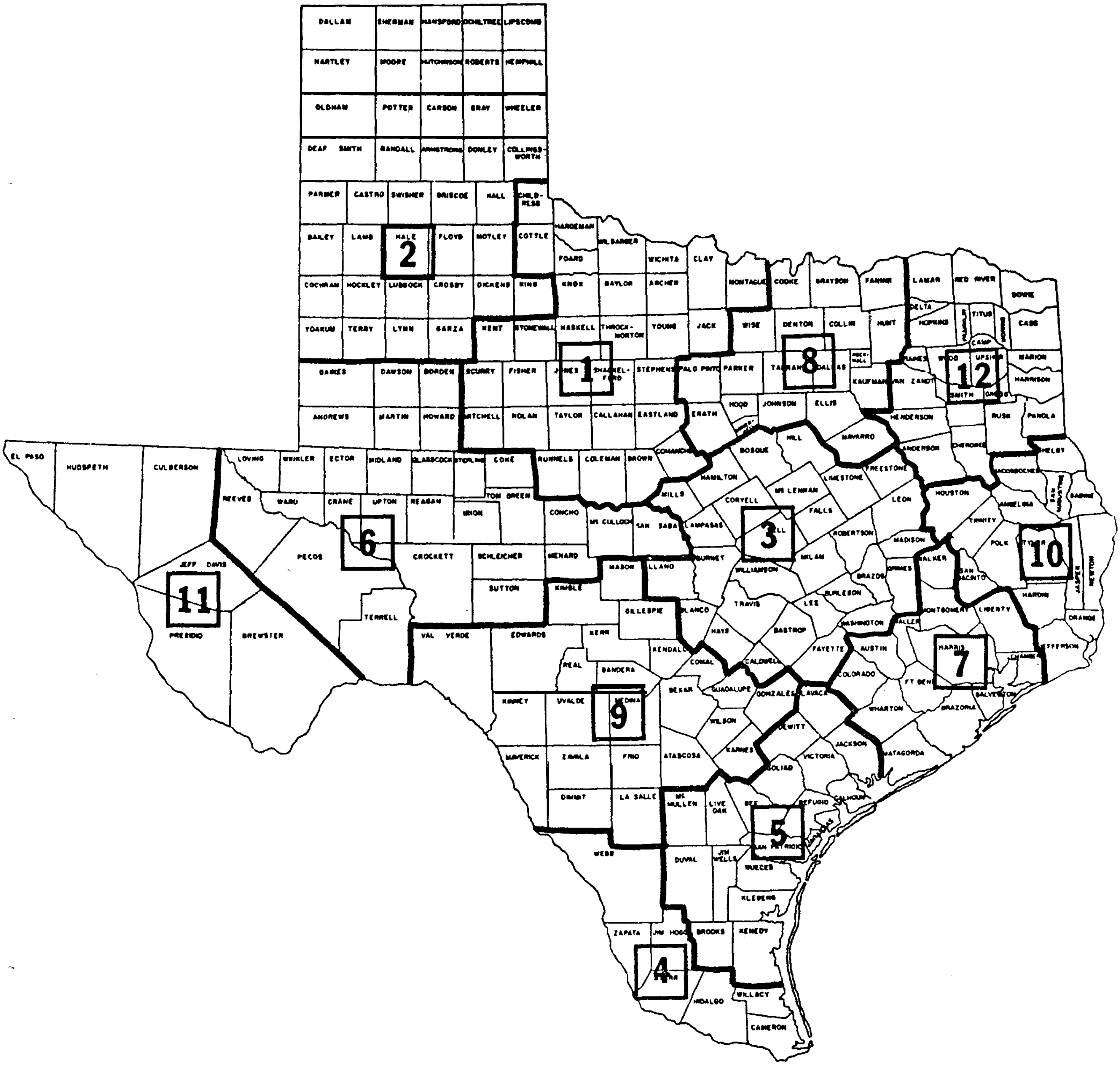

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GULF CORDGRASS: DISTRIBUTION, ECOLOGY AND RESPONSES TO PRESCRIBED BURNING

C.J. Scifres and D.L. Drawe

INTRODUCTION

Ranchers on the Coastal Prairie have historically burned gulf cordgrass (Spartina spartinae) (referred to as "sacahuista"). Apparently, some producers fired gulf cordgrass ranges routinely whereas others used the stands as a source of reserve feed during stress periods, especially during recurring droughts which characterize the vegetation region. The original thrust of our research 1/ was directed toward the use of prescribed fire to create a source of cool-season grazing from gulf cordgrass to help alleviate winter forage shortages. Thus, vegetative growth and development and nutritional status of the herbage was studied in response to season of burning. Interpretation and proper use of data from these experiments required that certain aspects of gulf cordgrass ecology be investigated. The objective of this paper is to collate results of our experiments and other investigators into a state-of-the-art review of gulf cordgrass ecology, and its response to fire on the Coastal Prairie.

DESCRIPTION AND DISTRIBUTION OF GULF CORDGRASS

Gulf cordgrass is a native perennial which forms large, dense tufts of stout culms (Gould 1975). Although generally referred to as occurring as discrete bunches, weakly rhizomatous plants have been collected on the Coastal Prairie (McAtee 1979). The narrow, stiff leaf blades taper to sharp, spine-like tips. The plant may grow to more than 4 feet tall on the more favorable sites.

Four other species of Spartina, smooth cordgrass (S. alternifolia), marshhay cordgrass (S. patens), big cordgrass (S. cynosuroides), and prairie cordgrass (S. pectinata) also occur in Texas, but gulf cordgrass is decidedly the most important species based on the amount of area it occupies. On the Coastal Prairie and marshes, almost pure stands of gulf cordgrass may comprise entire large pastures. It also occurs inland, at least as far west as Gonzales County (Correll and Johnston 1970) in sizable stands, but is restricted to lowlands and waterways. Gulf cordgrass also occurs in South

1/ This paper is based largely on research efforts of the authors, Dr. J.W. McAtee, R.D. Oefinger, and J.L. Mutz. The research was conducted in cooperation with the Rob and Bessie Welder Wildlife Foundation on the refuge near Sinton, the Aransas National Wildlife Refuge near Austwell, and with the Armstrong Ranch.

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America and on sites similar to those that it inhabits in the United States. Extensive stands of gulf cordgrass, referred to locally as "espartillo," occurs in northern Argentina,2/ and it apparently extends northward into Paraguay (Correll and Johnston 1970). Since it is highly adapted to sites that support few other species, is highly productive, and occurs in extensive stands on the Coastal Prairie, gulf cordgrass has become recognized as an important forage resource to be managed for livestock production rather to serve only as reserve feed.

SITE ADAPTATIONS

Gulf cordgrass occurs at elevations and on sites between the lowland Gulf marshes and the upland prairie plant communities (Gould 1975, Oefinger and Scifres 1977, Shiftlet 1963, Scifres et al. 1980). In contrast with upland communities, the species composition of which shift with season, and with the marshes where botanical composition responds to extent and duration of inundation, gulf cordgrass forms relatively stable stands with undisputable, year-round dominance of the species (Scifres et al. 1980).

Whereas soil saturation inhibits root growth and development of most grasses, species of *Spartina* are well adapted to excessive wetness for relatively long periods. Gulf cordgrass is most adapted to sites which are alternately inundated and dried (Scifres et al. 1980), and grows readily in water standing several inches deep. Gould (1975) also stated that gulf cordgrass requires periods of soil saturation for maximum stand development. However, Scifres et al. (1980) inferred that perpetual inundation or prolonged inundation in excess of a tolerable water depth could cause replacement of gulf ccrdgrass stands with wetland communities composed of sedges (*Carex* spp.), burhead (*Echindorus rostratus*), spikesedges (*Eleocharis* spp.), common arrowhead (*Sagittaria latifolia*) and other hydric species. Well developed gulf cordgrass stands often occur immediately adjacent to such marshes.

Because gulf cordgrass generally occupies lowland areas periodically inundated and near sea level in coastal zones, it is often associated with saline sites and is occasionally referred to as "saltgrass." Although gulf cordgrass may occur on saline soils (Gould and Box 1975), salinity is not a requisite for stand development (Oefinger and Scifres 1977) as evidenced by well developed stands in the presence of fresh water (Scifres et al. 1980). Intensive disturbance of saline sites supporting gulf cordgrass may result in its replacement by seashore saltgrass (*Distichlis spicata*) and other salt-tolerant but less productive species, especially on the drier sites. Our studies on the species have been conducted on sites with soils ranging from non-saline to saline and from loamy sands (Oefinger and Scifres 1977) to clays (Scifres et al. 1980). Development of gulf cordgrass stands has usually reflected potential of the sites to support vegetation growth; i.e. maximum stand development on fertile clay loams and clays.

2/ Observed by senior author during trip to Argentina in 1980.

PRODUCTION POTENTIAL OF GULF CORDGRASS

Gulf cordgrass produces relatively high amounts of topgrowth and retains some green tissues year-round on the Coastal Prairie. In 1976, total standing crop of gulf cordgrass averaged roughly 6,600, 8,500 and 8,400 lb/acre in the spring (April), summer (July), and wirter (December), respectively, on the Welder Refuge (McAgee et al. 1979a). Of this standing crop, roughly 39, 19, and 22% was green tissues, respectively. Thus, in the cool season when other warm season forages were dormant, green standing crop of gulf cordgrass exceeded 1,800 lb/acre. On the Aransas Refuge in 1976, summer(June) standing crop was about 6,500 lb/acre, and fall (September) standing crop was 6,80C lb/acre, of which 61 and 44%, respectively, was green tissue. Soils on the Welder Refuge were Aransas-Victoria clays, accounting for somewhat greater standing crops in corresponding seasons, compared to that on the Aransas Refuge site which was Galveston fine sand with inclusions of Veston silt loam. Winter (February) standing crops of gulf cordgrass on loamy sands and alkali sandy loam sites near Armstrong in 1974 ranged from about 875 to 1,200 lb/acre of green tissues.

These data illustrate that gulf cordgrass stands have relatively high production potential depending on site, and develop on a wide array of soil textures. Moreover, the stands maintained a substantial amount of green tissue year-round. Consequently, range management directives should consider procedures which promote use of this species by livestock. Cf primary interest to researchers has been development of prescribed burning techniques for improved management of gulf cordgrass ranges.

GULF CORDGRASS HERBAGE PRODUCTION AND GRAZING USE FOLLOWING BURNING

Although gulf cordgrass maintains green tissue all year, mature plants are not grazed to an appreciable extent by livestock if other forages are available, regardless of season. However, the tender shoots emerging after burning are relished by livestock.

Shortly after burning, amount of gulf cordgrass herbage utilized 3/ was a function of availability of new regrowth where livestock were allowed to graze burned areas in a larger pasture on a free-choice basis (Oefinger and Scifres 1977). Thus, site influenced utilization as it regulated forage availability. In one study, average utilization during the 120 days of peak grazing use immediately following burning varied from slightly less than 3 lb/acre/day on the least productive site to about 41 lb/acre/day on the most productive site (Oefinger and Scifres 1977). Amount of gulf cordgrass herbage varied in proportion to site capability under a grazing pressure that removed about 80% of the topgrowth. This degree of use is not necessarily suggested as a guideline since it reflects a concentration of animals on the

3/ Utilization was considered an estimate of grazing use but also included losses to insects, trampling, etc.

burned area. However, it did no apparent damage to the gulf cordgrass stand.

Prescribed burning is not detrimental to the herbage production potential of gulf cordgrass. Rather, it appears to revitalize the stands by removing excessive mulch and standing dead tissues. On one of the more productive sites which was protected from livestock grazing, 90% of the pretreatment weights of standing live gulf cordgrass was replaced by 3 morths after burning in April (McAtee et al. 1979a). Amounts of green herbage on burned areas at 6 months after treatment were essentially the same as prior to burning.

Amount of gulf cordgrass herbage produced following burnirg will depend largely on soil water availability. Earlier soil warming in the spring accelerates green-up on burned compared to unburned areas. These environmental responses emphasize the need to schedule prescribed burns in years when favorable rainfall conditions have ensured adequate soil-water storage to accommodate the regrowth of gulf cordgrass stimulated by burning.

Specific livestock carrying capacities following burning will vary with site and year of burning as it regulates rainfall. Consequently, specific management decisions will be necessary fcr each situation. For example, Oefinger and Scifres (1977) reported that burned gulf cordgrass range composed mostly of sandy-sandy loam sites could support 1 animal unit/10 acres for at least 6 months. In contrast, McAtee et al. (1979a) reported that burned gulf cordgrass range on clay sites was capable of supporting 1 animal unit/5 acres for at least 6 months.

With a specific site potential and set of weather conditions, postburn grazing management should be designed to enforce maximum use of the gulf cordgrass regrowth without damaging the stands. If no other vegetation is available in the management unit, then grazing pressure can be used to maintain the gulf cordgrass in an active growth stage and prolong nutritional value. However, if other green forages are available (including certain forbs), the livestock will preferentially graze gulf cordgrass only for a short period after burning. Oefinger and Scifres (1977) found that cattle relished gulf cordgrass regrowth on burned areas during the cool season when other forages were dormant but moved to adjacent upland sites at first spring green-up. The gulf cordgrass then matured, and was not grazed to any appreciable extent by the end of the first growing season following the fires.

Gulf cordgrass is often burned and the livestock turned in immediately giving little or no deferment following the fires. This practice may not prove detrimental in wet years and with light stocking. However, grazing deferments following burning of gulf cordgrass should be considered based on regrowth potential of the gulf cordgrass in any given year. McAtee et al. (1978) reported that following top removal of gulf cordgrass in late spring-early summer and with ample soil water, the new shoots elongated more than 1 inch during the first 24 hours. Since the new shoots are at their most nutritional stage of development, and improved nutritional status of the herbage usually persists for no more than 30 days following burning, grazing should be initiated as soon after burning as possible to take advantage of the lush new growth. However, stocking rate should be adjusted to the production potential of gulf cordgrass. Sizable areas of gulf cordgrass have been grazed out where spot fires from railroads occurred during stress periods. A good rule of thumb might be to initiate grazing when the regrowth is 4 to 8 inches tall, and maintain the grazing pressure such that regrowth does not exceed 10 to 15 inches tall at the end of the first growing season. Using this approach, deferments will be no longer than a week to 10 days following late spring burns during wet years.

In wetter areas of South America, gulf cordgrass stands have been burned annually for several years without apparent damage to stands. Although annual burnings are probably not advisable, gulf cordgrass ranges apparently may be burned every second to third year, rainfall not limiting and under proper grazing management, without damaging the stands.

NUTRITIONAL STATUS OF GULF CORDGRASS FOLLOWING BURNING

Crude protein content of gulf cordgrass foliage depends largely on the time of sampling in relation to burning, being highest shortly after burning and diminishing as the foliage matures. Within 30 days after burning in December or July, crude protein contents of foliage from burned areas were 11.4 to 11.8% (McAtee et al. 197913). Crude protein contents of tissues from unburned areas varied little, 4.4 to 4.7%, during the entire growing season after burning. At 90 days after burning in April, July or December, crude protein contents of gulf cordgrass tissues without grazing were 7.4 to 8.9%. By the end of the first growing season following the burns, there was no difference in crude protein contents (generally less than 5%) of gulf cordgrass green herbage from burned and unburned areas.

Range site, presumably inherent fertility, also apparently has a bearing on crude protein content of gulf cordgrass herbage following burning. Oefinger and Scifres (1977) compared crude protein contents of gulf cordgrass among several burned sites which were grazed to repeatedly enforce new growth. In early spring following burning in late fall, crude protein contents of gulf cordgrass from loamy sand sites averaged slightly over 11 %, compared to about 5% in tissues from unburned areas. Foliage from burned alkali sandy loam sites contained about 7.5% crude protein, compared to 5.5% in foliage of plants from similar sites which were unburned. Foliage from burned alkali loamy sand sites contained 9.5% crude protein with slightly more than 4% occurring in tissues from similar unburned sites.

Phosphorous deficiency of many southeast Texas soils commonly causes range livestock production problems. Trends in phosphorus contents of gulf cordgrass herbage generally followed those described for crude protein contents following burning with greatest amounts shortly after burning. However, phosphorus contents of herbage following burning are usually subject to considerable more variation than crude protein contents. Variations in phosphorus contents reported by Oefinger and Scifres (1977) were attributed to variation in grazing use and periodicity of rainfall which interacted to stimulate new growth. As new shoots developed in response to intensified grazing use during the growing season following burning, phosphorus contents of herbage from burned and unburned areas also varied with range site. Phosphorus content of regrowth in September on a loamy sand site which was burned the previous winter was 0.161%, compared to 0.102% on a similar unburned site. At the same time, herbage from burned alkali sandy loam sites contained an average of 0.188% phosphorus, compared to about 0.14% in gulf cordgrass foliage from unburned areas. Although phosphorus content varied considerably within a treatment and site, foliage of plants from burned sites generally contained more phosphorus than that of herbage from unburned sites for the first growing season following the fires.

Digestible energy content of forages is a critical limitation to effectively wintering cattle on the Coastal Prairie. Digestible energy contents of gulf cordgrass herbage from unburned areas vary seasonally, tending to decrease in late fall and increase during the spring as new growth emerges. Digestible energy content of green gulf cordgrass leaves also varied between years in the study of McAtee et al. (1979b). However, digestible energy contents of herbage from unburned areas generally ranged from 1,910 to about 1,925 kcal/kg by late spring-early summer, decreased to about 1,850 kcal/kg in the early fall, and were reduced to 1,650 in some cases by late fall-winter. In contrast, digestible energy contents of gulf cordgrass herbage ranged from 2,414 to 2, 891 kcal/kg within 30 days after burning in spring, summer or winter. Digestible energy contents of tissues from burned areas were generally higher than those of foliage from unburned areas into the fall after the fires, and occasionally tended to be higher into the second growing season after burning (McAtee et al. 1979b; Oefinger and Scifres 1977).

Thus, in the absence of grazing, crude protein, phosphorus, and digestible energy contents of gulf cordgrass tissues may be increased for about 30 days after burning. Therefore, grazing should probably not be deferred for more than 30 days to take advantage of the increase in these nutrients. Moreover, a grazing pressure should be maintained which will enforce new growth and prolong grazing value of the burned stands without detriment to the stands.

INFLUENCE OF BURNING ON GROWTH HABIT AND SEED PRODUCTION IN GULF CORDGRASS

Although plants which bear rhizomes have been noted, gulf cordgrass usually develops into a discrete bunch which apparently initiates new growth as tillers arising from the outside of the bunch. After several years and without disturbance, most of the bunches become hollow in the center forming a ring-like structure with new shoot growth most actively occurring from the outermost part of the circle (McAtee et al. 1978). The inner hollow area provides sanctuary for a number of species of insects, reptiles, rodents and for some lagomorphs. It also serves as a reservoir of interlaced standing dead fine fuel with adequate oxygen supply for complete combustion during prescribed burning. The result following burning, then, is for a single, large bunch to reappear as several smaller individual plants. The net result is usually an increase in plant density and foliar cover by the second growing season after burning, compared to unburned areas.

Numbers of infloresences per gulf cordgrass plant is generally increased the growing season following burning compared to unburned stands. According to McAtee et al. (1979a), only 1 to 3% of the plants in an unburned mature stand produced infloresences during a 3-year study. Following burning, from 19 to 56% of the plants produced infloresences with the stimulation of flowering being most obvious the growing season after the fires. There appeared to be no influence of season of burning on fecundity.

Other unpublished observations by the authors and their colleagues relative to gulf cordgrass growth include a deeper green color and stiff, erect leaves of regrowth on burned areas. These responses have been reported for various other grass species (Daubenmire 1968).

FIRE BEHAVIOR IN GULF CORCGRASS STANDS

Regardless of season, gulf cordgrass generally burns readily and completely if environmental conditions, primarily wind speed and relative humidity, and fine fuel water contents are not so extreme as to prohibit ignition. As would be expected, the hottest, sweeping fires have been achieved in the summer rather than during the spring or winter. Fine fuel loads of gulf cordgrass stands undisturbed for several years often exceed 10,000 lb/acre (McAtee et al. 1979a). During summer burns on the Welder Refuge, surface temperatures between gulf cordgrass bunches reached 572°F whereas temperatures within the canopies reached 1213°F and, at 6 inches above the canopy, temperatures of 1670°F were recorded.

During preheating, live gulf cordgrass leaves generally become oily-appearing on the surface. Upon ignition, the first smoke is blackish followed by gray-white smoke as the tissues are consumed. This behavior indicates that the species may contain a volatile substance that facilitates its burning.

FIRE PLAN FOR BURNING GULF CORDGRASS

Our research has employed the relatively simple fire plan described by Gordon and Scifres (1977) and Scifres (1980). It entails encircling the area to be burned with a fire guard brought to surface soil. These fire guards usually should be at least 15 feet wide. Since gulf cordgrass forms a thick, heavy mat over the soil surface, heavy equipment is required to plow or scrape the fire guards. Fire guard preparation is facilitated by first shredding the topgrowth, removing the plant material by raking, and then discing the stubble under. However, great care must be exercised to cover or remove all existing stubble. Small amounts of debris, if only partially exposed, may serve as fuel bridges to allow the fire to escape, especially at corners.

The areas to be burned are usually best handled as squares or rectangles. On a bright day, preferably with relative humidity of 70% or less, air temperature of at least 60°F, and wind speeds of 10 to 12 MPH, a backfire can be set on the lee side of the area to be burned. When the backfire has burned in for 50 to 100 feet and the adjacent area is secure, the headfire may be ignited. This firing procedure has resulted in effective uniform burns in our studies.

SUMMARY

Gulf cordgrass forms almost pure stands at elevations intermediate between the lowland marshes and upland Coastal Prairie, and requires inundation alternating with dry periods for maximum stand development. Presence of gulf cordgrass has not been related to any specific chemical or physical soil property including texture, saturation percentage, base saturation, exchangeable hydrogen or salinity. However, it is a salt-tolerant species which may occupy sites too saline for establishment of upland species.

Gulf cordgrass appears to be well adapted to fire. Periodic prescribed burning 'removes excessive mulch and rejuvenates the stands. Veqetative growth and development is augmented following-burning via the replacement of large, decadent, gulf cordgrass bunches with several small er but vigorous plant units. Production of infloresences is increased following burning, especially the first growing season after the fire.

Gulf cordgrass is a highly productive species with considerable potential for improved grazing use of the Coastal Prairie. In the mature state, it is unpalatable and not normally grazed to any appreciable extent by domestic livestock. Burning at essentially any time of the year, given adequate stored soil water to support the regrowth, will stimulate grazing use by cattle. Morover, the new growth is higher in crude protein, phosphorus, and digestible energy content than mature herbage. Gulf cordgrass has considerable potential for filling the_cool-season forage gap on the Coastal Prairie.

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FIRE EFFECTS ON DEEP SAND RANGE SITES IN SOUTH TEXAS

J.L. Mutz

HIGHLIGHT

Fire has occurred on the sandy range sites in south Texas for years. Accounts by travelers in the area during the 1800's indicate that vegetation varied from sparse to luxurient, probably reflecting the amount of rainfall prior to each traveler's account. As man settled this region the age-old cycle of fire was broken. The cessation of fire has caused vegetation changes not totally beneficial to the livestock and wildlife. As knowledge of fire as a vegetation management tool is gained, resource managers will have an additional alternative to aid in maintaining rangeland in a productive state. Planned fires have produced benefits such as promoting earlier spring green-up, increased utilization of unpalatable grasses, and decreasing weed and parasite populations.

INTRODUCTION

Location

The deep sand range sites in south Texas occur primarily in the southern parts of Kleberg, Jim Wells, Duval, and Webb counties and throughout Kenedy, Brooks, and Jim Hogg counties. The northern portions of Starr, Hidalgo, and Willacy counties also contain considerable acreage of deep sand range sites (Figure 1). Average annual precipitation in this area ranges from 23 to 28 inches. Average monthly rainfall is lowest during January and February and highest in May or June. After a mid-summer depression, another peak is reached in September, usually as a result of tropical storms and hurricanes. Summer temperatures are usually extremely high. Winters are usually mild with frost-free periods of 335-340 days being common. The soils that form the deep range sites include primarily Nueces and Sarita soils with less significant amounts of Delmita and Falfurrias series. These soils are deep, nearly level to gently sloping and gently undulating. They are moderately well drained and have a low water-holding capacity.

Throughout recorded history this area of Texas has been known under various names including the Sands, Dune Country, and Nueces Strip. However, the most common name associated with this region is the "Wild Horse Desert". This name came from the numerous wild mustangs which descended from horses around abandoned Spanish missions. Periodic droughts and low water holding capacity typical of sandy soils often caused this region to be characterized as a desert by explorers and travelers during the 1800's.

This natural barrier of fine, glistening sea of sand dunes that shifted with the wind and periodic lengthy drought Periods prevented vegetation and wildlife found in the Rio Grande Valley from becoming established in the Wild Horse Desert until recent times. Some dunes were not vegetated until the late 1800's; therefore, the potential for fire to occur over widespread areas did not exist until recent times. However, during recorded time fire occurred in the Wild Horse Desert and undoubtedly has been a factor in determining present vegetation.

Past History

In 1837, Muir described the territory between the Nueces and Rio Grande, a distance of about 150 miles, as "sandy, barren, and timberless...the desert of North America (Lehmann 1969). During the early 1840's Kennedy described the "Wild Horse Desert" south of Kingsville as "so utterly arid and sterile that it is unfrequented even by reptiles and insects and the traveler rarely encounters a living thing in traversing its desolate surface" (Lehmann 1969).

In 1846 McClintock traveled through Brooks County and described it as "clothed in tall grass excepting a motte or small chaparral at long intervals." He saw no running water but observed horses, antelope, and deer and stated that cattle had been present in the area at one time. John Russel Bartlett, Project Leader with the United States and Mexico Boundary Commission gave a vivid account of his travels through Brooks County in 1853 (Inglis, 1969). He stated that the road was "heavy" (sand?) and that the county was an "open rolling prairie dotted with clusters of mesquite and oak covered with luxurient grass".

Kirby-Smith traveled through the "sand" in 1846 in the vicinity of present Sarita and described the county to the south as a "barren sandy region." Around Armstrong the route was described as a "sandy desert", while about halfway to the Willacy County line the area was described as a perfect desert, scanty herbaceous having been burnt by the enemy (the Mexicans) (Inglis, 1964). Furber (1847) while traveling through the sands of Jim Hogg and Kenedy Counties, observed that "the vast prairie had recently been run over by fire and the young grass had not well sprung up".

In 1855, Havard described the northern tip of Jim Hogg County as an open grassy plain with no shrubs. The most common grasses present were Elionurus ciliatus (Pan American balsamscale), Aristida purpurea (purple threeawn), and Sporololus cryptandrus (sand dropseed) (Inglis, 1964).

In contrast to Bartlett's and other travelers' reports, Fremantle in 1863, crossed the "sands" and saw it as a dreary region, 60 miles wide. The trip was described as a struggle through the deep sandy wilderness. He felt the vegetation of the prairie and chaparral to the south was more luxurious than that of the "sands" (Inglis, 1964).

The varying amounts of vegetation present during these expeditions was undoubtedly a result of amount of rainfall prior to the account. Based on my experiences on this sandy country, rather rapid changes in vegetative cover can occur following rainfall.

Recent Burns

Since scientific data on prescribed burning in the Wild Horse Desert is limited only to a few experiments, I would like to make some generalized

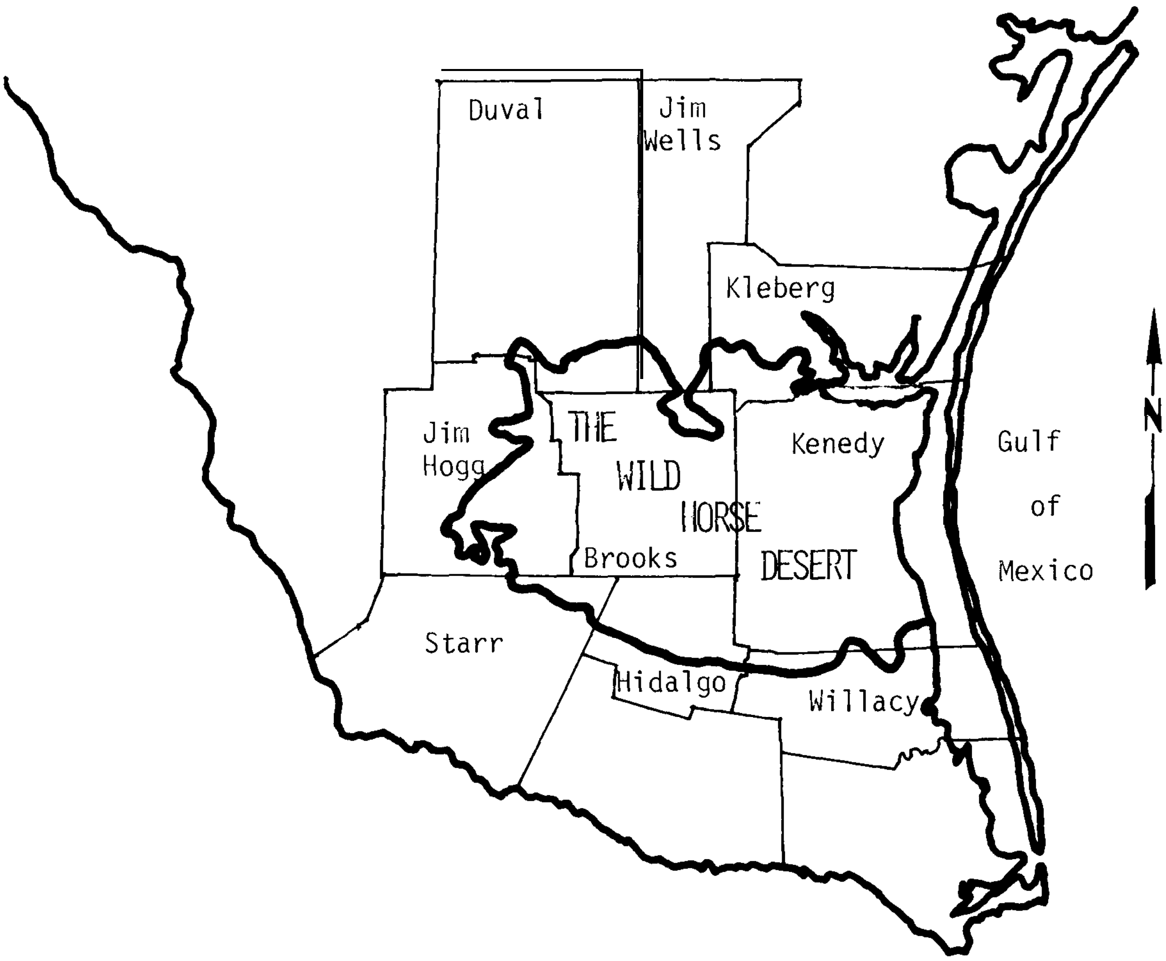

Figure 1. Map of south Texas and location of sandy range sites known as the Wild Horse Desert.

statements based on my observations of large scale planned burns that have been carried out by Frank Graham, manager of the Jones Alta Vista Ranch south of Hebbronville. Frank gained his first experience with burning when a hunter accidentally burned off a large pasture several years ago on the Alta Vista. Fortunately this accidental burn occurred during late winter when the environmental and soil conditions were such that this wildfire was extremely favorable. Vegetation changes following the wildfire caused Frank to experiment with fire as a tool for restoring and maintaining the productivity that was being diminished by brush and weed invasion. He was so impressed with the results of these burns that he currently burns approximately 30,000 acres annually if conditions are favorable. All of the burns to date have been cool season burns that were installed in late January or early February. Although I have not seen a summer burn in this area, it is my opinion that a hot summer burn probably would be too harsh on this extremely fragile ecosystem.

The single most important factor in determining whether to burn or not to burn in a particular year on sandy sites is the presence of an adequate supply of soil moisture to insure post burn plant growth. Since sandy soils can only hold a small amount of water as compared to heavier soils, fall and early winter rainfall are a prerequisite. Insufficient soil moisture prior to the burn will retard vegetative growth, thus allowing the soil surface to be exposed which increases the possibility of soil erosion. Rainfall during the fall and winter of 1979-80 was inadequate thus no planned burning was done on the Alta Vista.

A secondary factor that determines the success of a planned burn on this sandy area is an adequate evenly distributed fuel load. Areas that have a discontinuity of fuel or a fuel load of less than 1500 - 2000 pounds per acre will generally not carry a fire unless relative humidity is low (25%) and wind speed is relatively high (15-20 mph).

Benefits that occur after a prescribed fire include earlier green-up on the burn area. Earlier green-up is attributed to the darkened soil surface absorbing more of the incoming sun's energy. In 1979 on the Alta Vista Ranch, spring green-up was about 2 weeks earlier on the burned areas as compared to an adjacent unburned area.

On the Alta Vista Ranch, as in much of the Wild Horse Desert, wildlife, including deer and quail, has become economically important. Wildlife habitat therefore is receiving more consideration. Large tree-type honey mesquites (Prosopis juliflora var. glandulosa (Torr.) Cockerell) 15 to 20 feet tall are scattered throughout the sandy range sites in clumps or "mottes". These honey mesquite mottes provide shade-and cover for domestic livestock and wildlife. We have found that in most cases the fuel load in the mesquite mottes is insufficient to carry a fire that generates enough heat and intensity to inflict damage to large trees. The outer edges may receive enough heat to be defoliated, but the mottes usually regain their original canopy cover within 1 year following a burn.

Brush encroachment is becoming a problem in the open grassland between the mottes. We have found that mesquite seedlings 1 to 2 feet tall are generally severely damaged and often killed by a fire. However, mesquite and other woody species 3 feet tall or taller between mottes are usually top-killed, but almost always resprout from crown buds immediately post burn. The resultant brush regrowth has a higher nutritional value and is more utilized by wildlife and probably by domestic livestock than unburned plants.

Another factor being studied is the response of tick populations to burning. In 1977 cayenne ticks (Amblyomma cajennensis) were collected monthly from April to July utilizing CO_2 traps in pastures that had the following burn history: 1) burned in 1977, 2) burned in 1979 3) burned in 1977 and 1979, and 4) no burn. Fewer ticks were collected from rangeland burned in 1979 than from unburned rangeland (Table 1). Tick numbers were higher on the Z-year old burn than areas burned in 1979, but tended to be lower than unburned areas (Tom Oldham, personnel communications).

Table 1. Average number of ticks collected with CO_2 traps from burned and unburned rangelands near Hebbronville, Texas from April through July 1979.

Unburned	Year burned (winter)		
	1977	1979	1977 and 1979
50.6	12.0	0.7*	4.3*

* Significantly different from unburned rangeland based on t-test (< P 0.1).

An emerging problem on south Texas sand sites is camphorweed (Heterotheca subaxillaris), an annual, aromatic, herbaceous member of the Compositae. Camphorweed occurs primarily on sandy sites, and is most common within 30-40 miles of the coast. However, landowners and rangeland resource managers have observed that camphorweed has increased its range westward during the past 10-15 years. Well-developed stands now occur on sandy sites up to 110 miles inland. As its range extended westward, camphorweed was first observed in turnrows of cultivated fields, but it is now a dominant invader of many range sites. Heavy infestations of camphorweed have established on range sites ranging from poor to good conditions. Once dense stands of camphorweed are established on an area, production of desirable vegetation diminishes.

Research in other states has shown that camphorweed can be controlled with several row-crop herbicides, and that it can be killed by mechanical damage such as trampling when it is in a rosette stage of growth. When in the rosette stage, camphorweed apparently does not resprout if the above ground potion of the plant is damaged. With this information on camphorweed we decided to experiment with fire for controlling this weed.

On February 23, 1978 a 24-acre sandy site on the Eshleman-Vogt Ranch supporting approximately 1000 camphorweed plants per acre was burned with a headfire. Fine fuel load prior to burning was estimated to be approximately 2080 lb/acre, marginal for a good burn. However, a uniform burn was obtained because of low relative humidity (25%) and wind speeds of 12 to 20 mph during the burn. Temperatures of 300 F were recorded at 0.5 inches above the soil surface. Clinical details observed following the fire included response of the camphorweed and associated vegetation, cumulative production, and utilization of the desirable vegetation.

Camphorweed plants subjected to fire were killed. At the time of burn the camphorweed plants were in a rosette form, a stage of growth which is apparently highly susceptible to damage by fire. From this experiment and observation of camphorweed response to burning on the Alta Vista Ranch, it was concluded that light to moderate stands of camphorweed can be controlled by burning. It is doubtful that heavy infestations of camphorweed will produce enough fine fuel to carry a fire hot enough to inflict damage to camphorweed (Mutz et al 1980).

In another study dense stands of camphorweed were successfully controlled with various herbicides including 2,4-D ester or amine at 1.0 lb per acre applied during late winter or early spring. Range resource managers desiring to develop vegetation management systems might consider selecting an appropriate herbicide as an initial treatment to be applied in late winter or early spring. Herbicide application and sound grazing management should reduce the camphorweed population and release grass for increased grazing and as fine fuel for prescribed burning. Following herbicide application, periodic cool-season burns may effectively suppress invading camphorweeds.

After burning, the study area on the Eshleman-Vogt Ranch did not receive significant rainfall until late May. Consequently, forage response was minimal during that period, and herbage production and utilization were not measurable. On August 10, 1978, standing crop produced since February 23, 1978 was 2099 pounds/acre on the burned area and 2289 pounds/acre on the adjacent unburned area.

Six months following burning, utilization was significantly greater on the burned area (Table 2). More than 90 percent of the herbaceous standing crop was utilized on the burned area, while 74 percent was utilized on the unburned area. On the burned area, about 95 percent of the grass standing crop was utilized, while only 52 percent of the broadleaves were utilized. On the unburned site, about 90 percent of the broadleaves were utilized, and 66 percent of the grass standing crop was utilized.

On August 2, 1979, 18 months following burning, the total standing crop in the exclosures protected from grazing was 2292 pounds/acre, while on the unburned area the standing crop was 2342 pounds/acre. Forage utilization 18 months after burning was relatively low, reflecting a reduction in stocking rate on the study area, and was only slightly higher on the burned site than on the unburned site (Table 2). Although camphorweed was evident in the burned plot at 18 months following treatment, the density was estimated at 40 percent less than on the unburned plot.

Table 2. Total standing crop (lb/a) and percentage utilized from February 23, 1978 to August 10, and from August 10, 1978 to August 2, 1979 on burned and unburned sites near Hebbronville, Texas.

Treatment	Grazing period	Total standing crop Produced lb/A	Utilized (%)
Burned	23 February 1978 to 10 August 1978	2099	92
	10 August 1978 to 2 August 1979	2292	33
Not burned	23 February 1978 to 10 August 1978	2289	74
	10 August 1978 to 2 August 1979	2342	21

Pan American balsamscale (Elyonurus tripsacoides Hump. and Bonpl.) is a grass that contributes in excess of 50% of total vegetative cover on many sandy sites in South Texas. Without burning, utilization of Pan American balsamscale by livestock is usually limited only to a short period of time during early spring growth. Observations indicate that Pan American balsamscale is heavily utilized by cattle for a longer period on burned areas than on unburned areas. Although data are limited, indications are that crude protein and digestible energy may be significantly increased following a burn. Crude protein of Pan American balsamscale following burning was 19% or greater 10 weeks following a burn on the Alta Vista Ranch.

SUMMARY

Although the research on burning on the deep sand range sites in south Texas is in its infancy, initial data and observations indicate that cool season burning has possibilities as a range management tool. Indications are that prescribed burning can be used to promote earlier spring green-up, increase the utilization of Pan American balsamscale, decrease camphorweed densities and reduce the tick population. Following burning botanical composition usually favors an increase in forbs, especially legumes such as snout beans.

ACKNOWLEDGEMENTS

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THE ROLE OF FIRE IN THE COASTAL PRAIRIE

D. Lynn Drawe

HIGHLIGHT

Fire played an important role in the development of Coastal Prairie vegetation, but recently has been eliminated by man's activities. This has resulted in an encroachment of woody species into the native vegetation. Prescribed burning can be used as a tool for manipulating Coastal Prairie vegetation. Fire effectively suppressed most woody species while encouraging grass and forb growth. Timing of burning, conditions during the burn, and grazing management prior to and following the burn are the primary management considerations. By proper timing of the burn, the appropriate set of conditions during the burn, and regulation of grazing prior to and following the burn, the manager can regulate composition of the post-burn plant community. Prescribed burns conducted during the dormant season have little direct impact on wildlife populations. Long-term beneficial effects of improved plant productivity and increased edge and diversity created by a properly conducted burn designed for wildlife habitat improvement far outweigh short-term detrimental effects of the fire.

INTRODUCTION

Fire has played a role in the development of vegetation over much of the earth, especially in the development and maintenance of grasslands such as the Texas Gulf Coastal Prairie.

The Texas Coastal Prairie is an important ranching area which historically has supported vast herds of domestic animals and wildlife (Oberste 1953). There is good evidence that present native vegetation is different from that encountered by the first Spanish explorers nearly 450 years ago (Box et al. 1979). There appears to have been a change from prairie-like vegetation to dense shrublands and woodlands. Cessation of fires has been suggested as a major cause of this change (Lehmann 1965). Heavy grazing by livestock, wet and dry cycles in climate, mechanical brush control, and intensive agriculture also have contributed to this change. Reasons for consideration of fire as a vegetation management tool in this region, therefore, include the reduction of woody plant cover and heavy accumulations of herbaceous mulch.

HISTORY OF FIRE AND GRAZING IN THE COASTAL PRAIRIE

Lehmann (1965) presented an excellent history of fires in the Coastal Prairie from 1528 to 1940. He reported the early use of fire by Indians to control mosquitoes, to aid in hunting, and to discourage settlers from invading their hunting grounds. Later, in the early 1800's during colonization encouraged by Mexico, settlers annually burned prairies to provide green feed for livestock. Lehmann (1965) concluded that "In a real sense, therefore, the upper coastal prairies were the tinderbox of Texas: the region where fire, purposeful and otherwise, burned most often, and for the longest time...

Nowhere else in Texas, perhaps nowhere else in the whole Plains Region, however, were such large stores of combustible material produced...And, because of Nature's unique protective system of fire guards, and feed reservoirs in low spots and stream 'bottoms', nowhere else could stockment burn with less danger of being without feed until the next growing season".

The Coastal Prairie has a long history of grazing use. As early as 1768, de Solis reported that the general area around the early missions supported large herds of wild cattle and native wildlife. Settlers brought large herds of cattle and horses to the area in the early 1800's. Numbers of domestic animals increased, and by 1841 herds of 1,500 to 2,000 wild horses were reported on the prairies of San Patricio County (Kennedy 1925). Livestock numbers continued to increase until after the Civil War and the advent of trail drives to rail heads farther north. There remained, however, more livestock in south Texas than the markets could handle. Evidence of extreme stocking rates is available in photographs taken by Coffey (1909) in San Patricio County showing severely denuded pastures on Victoria clay soils. Although few records exist of exact grazing pressures, it can be surmised safely that by recent times overgrazing had reduced fuel loads to such an extent that fires would no longer burn across many native pastures unless areas were deferred to build up fuel for a fire.

THF COASTAL PRAIRIE ENVIRONMENT

The Texas Coastal Prairie occurs on a low, flat plain dissected by streams originating farther inland. Saltwater marshes occur near the coast and freshwater marshes and intermittent lakes occur farther inland.

The plants of the Coastal Prairie are mostly of tropical or subtropical origin. The flora is complex; more than 1400 species of flowering plants occur in a 50-mile radius of Corpus Christi(Jones 1975, Gould and Box 1965).

Present vegetation includes cordgrasses (*Spartina* spp.), sedges (Cyperaceae), and rushes (Juncaceae) in saltwater marshes, and aquatic grasses and forbs in freshwater marshes. Streams are lined with deciduous hardwood trees and chaparral (mixed-species stands of thorny shrubs). Grassland or chaparral vegetation occurs on well-drained upland areas. Most authorities agree that the original natural vegetation of these upland areas was a tallgrass prairie (Kuchler 1964, Weaver and Clements 1938).

Most soils of the area have formed from the Beaumont and Lissie formations of Pleistocene age. These formations have been reworked by recent streams and winds, and may be overlain by alluvium and aeolian sands. Thus, the major soil types vary from fine sands to heavy clays.

The climate of the Coastal Prairie is humid and subtropical with long, hot summers and short, mild winters. Freezing temperatures occur intermittently only for brief periods, thus plant growth can occur any month of the year. The frost-free period is 300 days or more. Rainfall fluctuates between years and in cycles of wet and dry periods which may extend over several years. Average annual rainfall is about 35 inches, with minimums of about 14 inches and maximums of about 41 inches. Rainfall may occur in any month, but peaks of rainfall occur in spring and during the fall hurricane season. Daily rainfall totals of over 16 inches have been recorded. Prevailing southeasterly winds blow from the Gulf of Mexico throughout the year. Cold fronts bring northerly winds during winter. Relative humidity is high yearlong, heavy dews may occur nightly, and fog is common in winter and early spring.

MANAGEMENT CONSIDERATIONS FOR PRESCRIBED BURNING IN THE COASTAL PRAIRIE

Prescribed burning is a promising tool for use on Coastal Prairie rangelands. In times of rising energy costs, burning is attractive as an economical method of manipulating vegetation, whether used alone or in combination with other methods.

Burning should not be attempted unless a rigid set of management conditions can be met. Often in the past, the manager -or landowner has had a bad experience with fire because all criteria for a successful burn were not met. We are just now learning many of the details of successful burning in the Coastal Prairie.

The most important part of any burning program is the grazing management plan. Burning cannot be successful unless the grazing use of the area is coordinated with the burning program. The two most important considerations in designing a burning-grazing program are scheduling of burning and grazing periods and proper timing of the burn. The management program must allow sufficient time for plants to regain vigor after burning before livestock are allowed to graze. Much of the adverse sentiment about fire has resulted when wildfires burned rangeland and the manager could not or did not remove livestock to allow the range to recover. If the manager cannot arrange a graze-rest schedule that will allow the burned pasture to rest until plants have regained vigor, then the range should not be burned.

Timing is critical in a prescribed burning program. This is an area about which we know little and must learn considerably more. A manager probably can create varying types of post-burn plant communities by manipulating the date of the prescribed burn.

Historically, fires burned in the summer and early winter in the Coastal Prairie. Lehmann (1965) quotes two authorities on this: (1) Parker writing in 1836 and (2) Ilkin writing in 1841. He quoted Parker as saying that prairies near the coast were ". ..all burnt over twice a year---in mid-summer and about the first of winter. Immediately after the burning, the grass springs up again; so that there is abundant supply all the year round." Although most of our recent experience has been with winter burning, summer burning may have potential for management of the more productive areas (Drawe and Kattner 1978).

Burning may be done when vegetation is dormant and dry enough to carry a fire. In the Coastal Prairie this may occur in July and August, during the normal "summer drought", or during winter, after the second or third frost. Frost may occur any time after mid-November.

Grazing management must be scheduled to consider not only plant responses after the fire, but also creation of adequate fine fuel loads to carry a fire.

A minimum of 2500 pounds per acre of fine, evenly distributed fuel is generally considered necessary to carry an effective but manageable fire. Many Coastal Prairie ranges do not accumulate this much fuel because yearlong, continuous grazing is used. On the other hand, fuel accumulations of up to 16,000 pounds per acre may occur under moderate stocking and periodic deferments.

Burning in the Coastal Prairie is unlike burning in any other region where fire is used as a management tool. During a wet cycle such as that from 1963-80, there are very few days when a burn can be carried out. The summer drought has been non-existent during the recent wet cycle, thus limiting burning to the winter. Heavy dews, fogs, and high humidities are common during winter. Burning, therefore, is limited to those days when dry northerly winds blow after the passage of cold fronts. Since it is the tendency of early and late cold fronts to be weak, many lasting for only a day or two, this further restricts the burning period. In my experience, the best time for burning in the Coastal Prairie in terms of climatic conditions is from about December 15 to March 1, i.e., the "dead" of winter for this area.

Preparation for the fire must be accomplished well in advance in the Coastal Prairie, particularly during wet cycles. Because of high precipitation, fire lanes should be in place before the fall rainfall peak occurs. This means that in areas with heavy vegetative cover which will require mowing and double-disking, fire lane preparation should begin immediately after spring rainfall ends.

EFFECTS OF FIRE ON COASTAL PRAIRIE VEGETATION

The effects of fire on Coastal Prairie vegetation have not been studied until recent times. In a thorough review of the literature, the earliest study mentioned by Vogl (1974) was that of Box et al. (1967).

Most research to date (Box et al. 1967, Box and White 1969, Dodd and Holtz 1972, and Gordon and Scifres 1977) indicates that fire has reduced brush cover on Coastal Prairie ranges, and two burns have been more effective in reducing brush than a single fire (Box and White 1969). Gordon and Scifres (1977) found prescribed burning, particularly when combined with chemical or mechanical methods, was effective in restoring range heavily infested with Macartney rose (Rosa bracteata).

Studies on the Welder Wildlife Refuge since 1974 have concentrated on the influence of repeated fires on both woody and herbaceous vegetation. Detailed data have been collected on research plots, whereas much valuable information has been obtained by subjective analysis of larger management burns. Fire research on the Welder Wildlife Refuge has been designed to determine (1) the influence on the ecosystem of the removal of accumulations of mulch and (2) the possibility of the suppression of undesirable brush species.

The current fire research program on the Welder Refuge was initiated in early 1974. These were some of the first fires on the Refuge since the cessation of burning in the early 1900's. In 1974 the Coastal Bend was in the midst of a wet cycle. Average annual rainfall had increased from 30 inches in 1965 to 35 inches in 1974 at the Welder Refuge. In some years rainfall was as high as 40 inches. In addition, since 1954 refuge managers had followed a conservative grazing program in which each individual range unit was periodically deferred. This combination of extremely wet years and conservative deferred grazing management had allowed accumulation of excessive amounts of mulch. There had been essentially no livestock on the refuge for almost a year prior to the initial burning of 4,000 acres of the area. This also contributed to the build-up of mulch. Prior to burning each area, data were collected on brush cover, herbaceous cover and composition, and herbaceous production. Many of these initial management burns have been repeatedly burned during the past 6 years.

A series of three 50-acre blocks were selected in the Chaparral-Mixed Grass community on Victoria clay soils in 1975 to more accurately assess the effects of repeated fires on Coastal Prairie vegetation. Each of these three blocks was assigned a treatment: (1) burn as often as possible, (2) burn every 3 years, or (3) burn every 5 years. All three areas had been burned in 1974, therefore initial preburn vegetation data were available.

Over the past 6 years other burns have been conducted to study specific objectives. We examined the effects of two successive mid-March burns, in 1974 and 1975, on the composition and cover of vegetation. Currently, we are studying the influence of fire on vegetation in the Mesquite-Mixed Grass community on Victoria clay soils. The latter study is designed to determine the effects on vegetation of fire in combination with oiling and low energy grubbing of huisache (Acacia farnesiana). Huisache was removed initially by oiling or grubbing. Fire was then superimposed over the oiling and grubbing treatments resulting in a combination of treatments including burning only, burning and oiling, burning and grubbing, oiling only, and grubbing only. Particular interest is being assigned to the effects of fire and other treatments on forb and grass cover and herbaceous stand composition.

One research objective is to determine the effect of fire on woody species and its suppressive effect on particular woody species. The combination of oiling and/or grubbing and burning is particularly effective in suppression of huisache. Oiling is a promising practice when combined with burning. The use of the low energy front-end grubber on a crawler type tractor may be desirable on sandy soils (Bontrager et al. 1979); however, on heavy clay soils the cost is higher than oiling. Also, grubbing leaves such a rough terrain on clay soils that this may be a detrimental factor. Roughness was not a problem, and grubbing may be as economical as oiling on sandy soils. Both oiling and grubbing were effective and economical in stands of trees up to 150 trees per acre. However, when the number of trees exceeded 150 per acre, costs were prohibitive. In stands of huisache with greater than 150 trees per acre burning was not an effective tool. There was not enough fine fuel on the ground to carry the fire through a dense stand. In dense stands therefore, it may be desirable to roller chop or chain and defer grazing to allow herbaceous fuel to build up so a fire will carry through the area.

Repeated burning has effectively suppressed woody vegetation. The 50-acre plot burned as often as possible has been burned four times since 1974.

It has been possible to burn this plot every year or every other year, depending on the amount of fine fuel buildup. In drier years burning may not be possible annually. It may take more than two years to build up sufficient fuel for a fire if the area is not deferred from grazing. (Our plots receive moderate grazing pressure.) Fuel loads on the areas burned every 3 years or every 5 years have been adequate.

The three repeat-burn study plots are in Chaparral-Mixed Grass communities with a 40 to 45% woody cover. After one fire there was almost a total elimination of woody cover. One extremely hot reclamation fire burned through most smaller chaparral mottes. On the windward side of a motte the fire destroyed 100% of the cover. On the leeward side of a motte, depending upon wind speed during the fire, there have been protected areas where some woody plants avoid topkill. In larger mottes, i.e., those greater than 20 feet in diameter, woody plants survived in the center and leeward side of the motte. Fine fuel has been nonexistent within mottes. Only crown fires have burned completely across a large motte. The whole motte has survived in cooler maintenance burns, even in the case of some of the smaller mottes less than 20 feet in diameter. During maintenance or reclamation burns, individual plants between the clumps have been top-killed.

Essentially all chaparral species resprout. These species may regain their original size in 18 to 22 months (Hamilton and Scifres in press). On the area burned as often as possible, burning every 2 years reduced 40% cover to zero. Prior to the second burn the cover was essentially 40% again.

On the area burned every 3 years, fine fuel accumulations have been adequate and canopy cover reduction of chaparral has been as great as the area burned as often as possible. After the third burn on both areas it appears that there has been a loss of many individual woody plants, and vigor of individual chaparral plants appears lower. Therefore, our recommendation may be to burn every 3 years.

Burning every 5 years may be a good recommendation for the rancher/land manager interested in preserving most of his brush for wildlife cover. If the primary interest is in suppressing brush it will be necessary to burn more often. On the area burned every 5 years, reductions in brush cover comparable to the burn-as-often-as-possible treatment and the burn-every-3-year treatment have been obtained. However, the long period between burns has allowed the chaparral to regrow to its former height and density and possibly increase in density. These are only preliminary results from a long-term study, and conclusions may be changed as additional data are gathered.

Individual plant response of the chaparral species has been monitored to some extent. Following the first fire on the burn-every-third-year plot, 100 plants of each species of chaparral were examined 3 months after the fire and again 1 year after the fire. It appears that the most susceptible plant to fire was agarito (Berberis trifoliolata). Agarito burns "explosively" and usually burns completely down to ground level in a hot fire, thus possibly sustaining more physiological damage than other species. Three months after the fire essentially 100% of the agarito appeared to be dead. About 20% of the Mexican persimmon (Diospiros texana) appeared to be killed. Regrowth was not suppressed on the other 10 or 12 chaparral species. One year after the burn, all species including agarito and Mexican persimmon were regrowing vigorously. Following the third burn on the burn-every-third-year plot, there appeared to be a reduction in the amount of cover of all chaparral species. Data on individual species response after three fires have not been analyzed; however, it appears that agarito is the most susceptible species with an apparent death of many agarito plants. Some mottes have been almost totally top-killed after three fires. Many decadent stumps of all chaparral species are apparent. Weedy herbaceous vegetation is growing in the mottes that have been totally removed.

Results of these studies indicate also that fire is an effective tool in removing excess mulch accumulations that occur during wet cycles under conservative grazing. One of the problems to the range resource manager in the Coastal Prairie is that during wet years extreme accumulations of mulch can occur. On the Welder Refuge during the burns in 1974, fine fuel loads from 4,500 pounds per acre to 16,000 pounds per acre were burned (average 5500 pounds per acre). Greater amounts of fine fuel form a mat that may not be penetrated by light and actually acts to suppress plant growth. We found an increase in herbage production in the year following the initial burn.

INTEGRATION OF FIRE WITH GRAZING MANAGEMENT SYSTEMS

Another aspect of the Welder Refuge range research program is the study of integration of fire and grazing management. In a separate but associated study (Drawe and Cox 1979), the effects of continuous grazing, Merrill four-pasture, deferred-rotation grazing, and short duration grazing on Coastal Prairie vegetation are being studied. Burning is integrated with this grazing system research. Each pasture is burned to remove heavy mulch accumulations or to remove heavy cover of woody plants. The refuge is divided into 13 pasture units. One of these units is continuously grazed, four are utilized in the deferred-rotation system, and seven are utilized in the short duration system. Grazing pressure has varied between one animal unit to 12.5 acres to 1 animal unit to 14.5 acres, but grazing pressures are maintained at a constant rate across systems.

The flexibility provided in the short duration system has made it possible to burn any unit on that system in any given year. It is possible on the short duration system to defer a pasture to build up fuel for a fire then burn the entire unit. If necessary we can skip that unit during the next grazing period to allow plants to recover. Over the past 6 years we have burned each of the seven pastures on the short duration system at least once. One pasture has been burned three times. In the short duration system, a pasture may be grazed for 2.5 to 6 weeks. Each pasture is thus grazed twice each year and is rested about 5.5 months between grazing periods. This lengthy rest period allows accumulation of fine fuel for a fire. It also allows plants to mature, presenting grazing animals with less palatable vegetation. Therefore fire is of great benefit to both plants and animals. We have found that crude protein content in grasses on Victoria clay on the Welder Refuge increased after a fire.

Fire has been beneficial on the four-pasture, three-herd deferred-rotation system. The pastures on the four-pasture, deferred-rotation system are about 1000 acres in size. Cattle remain on the same pasture for 1 year, then the pasture is deferred for 4 months. Cattle graze some portions of these large pastures while leaving other portions ungrazed. Plants become "wolfish" and less palatible on ungrazed areas. Burning ungrazed areas will improve palatibility of the plants, their nutritional status, and distribution of grazing animals. Burning normally is not recommended unless whole range units can be burned. However, under good management where pastures receive periodic deferments and where range condition is high, grazing abuse does not occur.

On the Welder Refuge burns are scheduled so that the area can be rested after each burn. However, when we have burned 100-200 acres of a 1000-acre pasture, cattle have concentrated on the burned area for 2-3 months following deferment. Plants on the burned area have been heavily utilized during that period. However, during most years plants recovered within 3-6 months even under grazing. With adequate rainfall in the Coastal Prairie, vegetation grows faster than grazing animals can utilize it. Also, plants in other portions of the pasture eventually become more palatable and desirable than those on the burn, therefore the burned area is not overgrazed for an extended period. We have burned portions of each of the units on the four-pasture, deferred-rotation system over the past 6 years, and it has not been necessary to alter the graze-defer pattern to build up fuel for a fire.

The interaction of fire, soils, and grazing pressure can alter the burning program just described. Large areas of Nueces fine sand soils occur in two pastures on the deferred-rotation system on the Welder Refuge. Vegetation on these less fertile soils is not as stable as that on Victoria clay soils. Two prescribed burns 2 years apart with the combination of moderate grazing pressure caused a reduction in the amount of preferred grasses. The reduction was even more apparent in areas traditionally more heavily used by livestock.

Burning has not been possible on the continuously grazed pasture without fencing out a portion of that pasture, because fuel accumulations have not been sufficient. We fenced out a 90-acre research plot on the continuously grazed pasture, allowed it one growing season to accumulate fine fuel, and burned it during winter 1978. The area was deferred from grazing for one growing season following the burn. Burning and continuous grazing probably are not compatible.

EFFECT OF FIRE ON WILDLIFE POPULATIONS

Fire has a varied impact on animal populations depending on fire characteristics, size and shape of the area burned, and cover available to animals during the fire. <u>The primary impact of fire on wild animal populations is the effect on the habitat.</u> If the fire-altered habitat is enhanced for a particular species then that species can be expected to increase after the fire, and vice versa. Therefore, changes in animal species diversity and population density can be expected following fire. Better knowledge of these changes would allow the manager to attain predetermined objectives.

Public sentiment against fire has occurred because of thoughts about cute, fuzzy little animals screaming death cries of agony in fires. The Smokey-the-Bear syndrome which occurred in the United States from the time of the conservation movement until sometime in the 60's was, in part, based on this public sentiment. These feelings were based mostly on information from wildfires in national forests and grasslands. A prescribed burn has completely the opposite effect on wild animal populations.

Prescribed burning can easily be designed to have the least initial or direct impact on wildlife populations and create the greatest benefit for those populations following the fire. If done during the dormant season, i.e., winter in the Coastal Bend, fire will have little direct impact on animal populations. Those few detriments will be outweighed by the benefits derived from the increased post-burn productivity of the ecosystem. Although animal species composition may change for a short time, the area will return to normal pre-burn species composition and density within 2-3 years following the fire. A cool fire which allows some unburned areas within the major burn will create more edge and further enhance animal populations. A patchwork of relatively small burned and unburned areas also can be used to create more edge.

Fire has been used to maintain open grass areas beneath the coniferous forest while suppressing the secondary successional growth of woody hardwood species (Lay 1956, Stoddard 1963). Thus, burning has benefited ground nesting birds such as bobwhite quail (Colinus virginianus) and the eastern turkey (Meleagris gallopavo silvestris). Fire is an important component of the habitat of the Attwater's Prairie Chicken (Tympanuchus cupido), an endangered species of grouse in the Texas Coastal Prairie (Chamrau and Dodd 1972, Kessler 1979).

Studies of the effects of fire on wildlife populations at the Welder Refuge are in the initial stages; however, some general impressions about the effect of fire on animals can be made: Burning during winter lessens mortality since most animals are less active at this time. Rarely do we see any animals, other than an occasional snake, directly killed by the fire, especially if we burn on a cold day. During only one fire have I noticed any significant direct kill of wild animals, and this occurred during a fire in late winter of 1979-80 when we burned on a very warm day. Before the fire we noticed quite a few active animals, especially rodents and rabbits running ahead of, into, and away from the fire. Some actually caught afire because they did not escape fast enough. Conversely, on a cold day any animal that is out often is more curious about than afraid of the fire. On many occasions I have seen white-tailed deer (Odocoileus virginianus texanus) traveling back and forth through the flames of a cool fire and in the smoke immediately in the flame front. Once I approached to within 15 feet of a young buck who seemed more interested in the fire and smoke than he was in a human being. We normally see increased numbers of raptors circling above the smoke of the fire, probably in search of small mammals that they detect moving around on the ground. As an example of the number of dead animals that we might find following a typical 40-50 acre burn, a thorough search of the area usually results in less than 6 snakes, 6 rodents, 1 armadillo (Dasypurs novemінctus), and possibly a cottontail rabbit (Sylvilagus floridanus) or two. In summary, the direct impact of fire on animals during the dormant season is minimal.

Fire can benefit wildlife by increasing food supplies. Powell and Box (1966) reported increased deer and cattle use of brush resprouts after mechanical treatment. They attributed the increased use to greater palatibility and higher nutrition in the more succulent resprouts. In current research, we also are finding increased deer use of brush resprouts after a fire. Not only does top removal create resprouts which are more palatable, but also the new growth is more available. Top removal reduces the overall height of brush plants and removes the restriction to browsing caused by sharp thorns and stiff, old growth.

Wildlife, particularly game species such as turkey and quail, may be suppressed by excessive accumulations of mulch. Quail prefer open foraging areas. The wild turkey, although a woodland or woodland margin bird, ranges into open grassland areas, but will not venture into areas where heavy accumulations of mulch or extremely tall and rank herbaceous growth occurs. Both species of birds prefer some open ground. Therefore, removal of heavy mulch accumulations would be beneficial not only to vegetation but also to wildlife.

Roth (1979) studied mockingbird (Mimus polyglottos) feeding behavior in the Coastal Prairie. He found that a tall, dense forb-grass layer, such as that found on unburned areas at the Welder Refuge, caused more aerial feeding and feeding in shrubs than on an area at Seadrift, Texas where the shrub layer was similar but the herbaceous layer very short and sparse. This resulted in lower mockingbird densities and no nesting on the heavily vegetated area, and higher densities and good nesting success on the more open area. This suggests that in heavily vegetated areas, burning may be of benefit to this non-game species.

The white-tailed deer prefers mid-successional stages of vegetation. Over the 20 years since the Refuge was established, the successional stage of the vegetation changed from weed stage to mid-successional stages (Box et al. 1979). Also, Chamrad (1968) and Drawe (1968) found that deer in the Coastal Prairie prefer forbs. With advanced succession and heavy mulch accumulations, forb production appears to be suppressed. Scifres and Kelly (1979) found increased forb production with prescribed burning. We also hoped that fise would remove excessive mulch accumulations and promote forb growth. The answer to this question is not completely clear at this point, and probably lies more in timing of burning than in any other factor. For example, in the study of two consecutive late winter burns, we found that forbs, particularly perennial forbs such as bundleflower (Desmanthus virgatus), frogfruit (Phyla incisa and P. nodiflora) and wild petunia (Ruellia nudiflora), were suppressed. Conversely, in current studies of burning, oiling, and grubbing it appears that forb populations are promoted by fire. The fires of the latter study were burned at an earlier date. A fire in early winter or in the dead of winter when all plants are dormant would not suppress forb growth, but a fire which occurred after growth initiation on cool season plants would kill any growing herbaceous plant. In particular we have noticed varying responses from, but generally a reduction in, the amount of Texas wintergrass (Stipa leucotricha) after a late burn.

Wilson (1978) studied the effects of fire on bobwhite quail populations on the Welder Wildlife Refuge. She found that fire increased the numbers of bobwhite quail on study plots. The plots were 40 acres in size, rather small to attribute the increases in quail numbers to the fire. Quail were being drawn into burned areas to feed. No increase was detected in overall population numbers in the general area of the burn.

Currently, we are studying the effect of fire on tick (Amblyomma spp.) populations. A fire during a time when ticks are still active will destroy most of the tick population. Lehmann (1965) reports Drummond, an early naturalist traveling in the Coastal Prairie, as stating in 1834 that: "I am sorry to say that I have found no insects, as they are very scarce in these and all prairie countries, owing to the frequent burning...".

We are also studying the effects of fire on rodent populations on the Welder Wildlife Refuge. There is a general decrease in rodent numbers on burned areas. This is attributed mainly to the cover requirements of rodents. Without sufficient cover rodents will be present in extremely low numbers, since without cover they are more susceptible to predators. However, after herbaceous cover regrows, rodent numbers begin to increase on the burned area.

SUMMARY

Prescribed burning shows potential as an economical method of vegetation manipulation; however, much of the current information is preliminary, making it imperative that managers use caution in its application. Any management program involving burning and domestic animal grazing must allow plants time to regain vigor after burning before livestock are allowed to graze.

Repeated fires can be used to suppress growth of woody vegetation in the Coastal Prairie. Three repeat burns have killed many chaparral plants, and caused former chaparral communities to take on the aspect of a grassland community. Heavy woody cover can be manipulated through combinations of mechanical methods and fire.

Less well known are the effects of fire on herbaceous plant composition. A single fire can be used to remove excessive mulch accumulations, increase herbaceous production, and improve vigor of herbaceous plants. Burning in winter after the initiation of growth by cool-season plants appears to eliminate cool-season annuals and to suppress cool-season perennials.

Prescribed burning can be combined with a grazing management system to benefit both livestock and the habitat. Benefits include improved palatability and nutrient content of forage plants and improved grazing distribution.

Wildlife habitat can benefit from prescribed burning through careful planning of timing and conditions of the burn. Minimal direct impact occurs to existing wildlife populations if cool fires are used during winter. A patchwork of block burns can add edge and variety to the habitat. The latter, plus increased herbage production, can act to increase post-burn wildlife populations.

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PRESCRIBED BURNING OF IMPROVED PASTURES

Wayne T. Hamilton

Highlight

Mid-winter or late-winter burning of buffelgrass infested with woody plant regrowth did not change buffelgrass density, and cumulative forage production was increased for 2.5 growing seasons. These burns promoted a "flush" of forage production early in the growing season followed by noticeable moisture stress and slightly lower production than on unburned areas during mid-summer dry periods. Burning of Coastal bermudagrass just prior to spring growth may also significantly increase forage yields.

Utilization of buffelgrass following burning closely paralleled production. Use was 2.7 times greater on burned than unburned areas during the first four months after the fire when production and forage palatability were greatest.

Replacement of preburn canopy and height of all woody plants following burning of buffelgrass occurred in less than two full growing seasons, and there was no significant change in the number of live woody plants whether areas were burned once or twice. Burning for suppression of common goldenweed killed 43% of the weeds, and reduced weed canopy cover by 88 and 30% after one and two growing seasons respectively.

These data indicate that burn intervals of up to three years could be used to increase buffelgrass production over unburned areas by suppressing woody plant regrowth. Also, cool season burning is an effective method for suppression of common goldenweed infestations.

INTRODUCTION

A problem of major concern to South Texas livestock producers is deterioration of introduced pastures, such as Coastal bermudagrass (Cynodon dactylon) and common buffelgrass (Cenchrus ciliaris L.), caused by re-invasion of woody plants and perennial wee-and White 1963, Mayeux and Hamilton 1979, Hamilton and Scifres 1981). These infestations can eliminate the potential use of pastures for hay production, and if allowed to persist, can reduce density of grasses.

Common methods of controlling woody plant and weed infestations in pastures include shredding, grubbing and herbicide treatments. The increasing costs of machinery, labor and energy for mechanical methods, and the cost and limitations such as drift hazard or potential regulatory constraints placed on herbicides, have prompted consideration of prescribed burning as a pasture and rangeland management method (Scifres 1978). Burning in the latter part of the cool-season removes old standing crop and manure from the pastures and facilitates earlier green-up and cleaner hay cuttings. Dormant season burns, particularly when installed with adequate levels of stored soil water, present little risk for damage to pastures and minimize the sacrifice of forage quality consumed by the fires (Varner and Blankenship 1978). Properly fertilized and managed introduced pastures are capable of producing heavy, uniform fuel loads which are desirable for effective prescribed burns (Scifres 1980).

Burning Coastal Bermudagrass

Burning of Coastal bermudagrass in South Texas is not an uncommon practice, but there are no research data giving results of such burns on grass production or for brush and weed control. However, production data is available from Tifton, Georgia, the "home" of Coastal bermudagrass (Monson, et. al. 1974). While climatic conditions would differ from those in South Texas, this information appears applicable for the Coastal Prairies and perhaps the eastern Rio Grande Plain.

Old, well-established sod of Coastal bermudagrass was subjected to three burning treatments (Table 1). One set of plots were not burned but were mowed and raked on March 2 to remove dead stubble and weeds. Weed control treatments and fertilizer applications during the experiments were identical for all plots.

Burning Coastal bermudagrass at the right time increased hay yields by nearly one ton per acre (Table 1). In addition, burning at the proper time

Table 1. The effect of burning Coastal bermudagrass sod on hay yields at Tifton, Georgia.1/

	Burning Treatments	Tons of hay per acre in:			
		1966	1967	1968	3-yr. avg.
1.	Mowed and raked March 2	8.67ab*	5.20b	5.47b	6.44b
2.	Burned March 2	9.22a	6.65a	6.19a	7.35a
	Burned March 16	9.11a	5.86b	6.06a	7.01a
2:	Burned March 30	8.38b	5.66b	5.25b	6.3913

* Duncan's multiple range test-Yields carrying the same letter are not different at P=.05.

1/ Taken from llonson et. al. 1971. Affects of burning on soil temperature and yields of Coastal bermudagrass. Agronomy J. 66:212-214.

helped control winter weeds, plant diseases, spittlebugs and other insect pests. The average date of the last killing frost at Tifton is March 8. Researchers there recommend to "Burn about one week before the average date of the last killing frost in your county". Delaying burning until three weeks after the average date of the last killing frost reduced hay yields.

Based on burns of Coastal bermudagrass in the northern Rio Grande Plain near La Pryor, I can accept these recommendations. We usually burned in early February, about the normal date of the last frost for our area and just before new growth began. We found that burning later was hard on the grass and delayed the first hay cutting by as much as three weeks. An important consideration would be soil water content at the time of the burn. Burning Coastal bermudagrass in very dry conditions reduced herbage production near La Pryor. A good rain or irrigation water application immediately following the burn can partially overcome this problem, but to "burn dry and stay dry" appeared to reduce the sod density. We noticed more damage to stolons and an opening of the sod which allowed weed invasion. My recommendation is not to burn in years when preburn soil moisture is insufficient to promote rapid green-up and growth. A preirrigation to provide adequate soil moisture is the best alternative for dry years, if irrigation is available.

Our objective for burning Coastal bermudagrass was primarily to remove old stubble and manure to improve the quality of hay harvested during the first half of the growing season. Another benefit derived from the burns was brush sprout control. I am convinced that fire was a contributing factor in keeping these pastures brush free over a 15-year period. Areas along ditch banks, roadways, and corners which were never mowed in the haying process, but which were covered by the fires, were just as brush free as the center of the pasture.

I believe that Coastal bermudagrass could possibly be burned annually in high rainfall areas (30 to 40 inches) or where there is irrigation capability. A good fertilizer and management program to keep stands vigorous and productive complements the effectiveness of burning by producing uniform fuel loads and promoting quick recovery after the fires.

There is also some interesting work on burning of weeping lovegrass (Eragrostis curvula) from Oklahoma (Dalrymple Undated). While this area is also not representative of South Texas conditions, these data show the consistency of improved forage yields caused by correct burning programs (Table 2). The lovegrass was burned annually with damp to wet soil conditions just before the weeping lovegrass began growth (February 26 - March 10), thus corresponding very closely to the recommendations for Coastal bermudagrass discussed earlier.

Burning Buffelgrass

Stand Density and Foliar Cover

Like many other warm season grasses, buffelgrass appears to be tolerant of fire during the dormant season. Mid-winter or late-winter burns (before green-up) near Laredo did not reduce the density of live buffelgrass crowns (Mayeux and Hamilton 1979). A late-winter burn near Encinal resulted in a

Table 2. Spring Controlled Burning and Fertilization Influence on Weeping Lovegrass Yield (Pounds Per Acre, Oven-dry Basis). Nobel Foundation, Ardmore, Oklahoma. 1968 through 1970. a/

Treatment 1/	Pounds per Acre, Oven-dry Weight			
	1968	1969	1970	Ave.
No Burn - No Nitrogen	5,489	6,811	6,112	6,121
Burned - No Nitrogen	6,556	7,142	8,447	7,382
No Burn - Nitrogen Topdressed	10,431	9,651	10,778	10,287
Burned - Nitrogen Topdressed	10,186	9,693	11,614	10,498

1/ All areas received 40 pounds per acre of P_2O_5 and K_2O annually.

a/ Taken from Dalrymple, R. L. Undated. Weeping lovegrass management. Unnumbered pub. The Nobel Foundation, Ardmore, Oklahoma. 38 p.

slightly greater buffelgrass foliar cover after two years on the burned plots as compared to unburned plots. Foliar cover on this same area burned a second time 2 years after the first fire was no different than that on an area burned once (Hamilton and Scifres 1981).

The burns near Laredo were conducted with very low soil moisture at the time of ignition (less than 4% from the surface to 18 inches deep). Regrowth following the burns was restricted until significant rainfall occurred in May and June. The late-winter burn near Encinal was conducted when soil moisture was good (about 17% to 12 inches deep). This reserve moisture prompted rapid green-up of buffelgrass following the fire, and the remainder of the spring was relatively wet.

Following these burns, regardless of soil moisture at the time of burning, or rainfall immediately following the fires, buffelgrass density was unaffected and the burned buffelgrass yielded more herbage than the unburned areas by the end of the first growing season. These results lead us to be confident that mid-winter or late-winter burns can be applied to buffelgrass with minimum risk of damage to the stand or forage loss.

We are currently monitoring a summer burn applied near Catarina in August, 1979 under extremely dry soil conditions. Moisture conditions following this burn were also dry with less than 4 inches of rain occurring by the first postburn observation in June, 1980, a total of 10 months. New grass production on the area was negligible, but there was no apparent mortality of old, established buffelgrass plants even under these adverse conditions. However, final judgment must be reserved until significant rainfall occurs.

Buffelqrass Production

The area burned in early February, 1977 near Encinal had an accumulated forage production of 4710 kg/ha (4205 lbs/ac) by May 24, approximately 4 months after the burn, while the adjacent unburned area had produced only 2435 kg/ha (2174 lbs/ac) (Figure 1). This area had good soil moisture at the time of the fire and good rainfall during the postburn period through May. Over the next 2.5 months, however, only 4 cm (1.6 inches) of rain occurred (Figure 2) and the production trend reversed, with the unburned areas producing more buffelgrass than the burned. Between May and mid-July, the unburned area produced only 2035 kg/ha (1817 lbs/ac) (Hamilton and Scifres 1981).

The high production during the first 4 months following the burn apparently depleted available soil water more rapidly than on the unburned area, which remained slightly more productive until the fall of 1978, when soil moisture was restored to high levels. As moisture increased, the burned area again produced more buffelgrass than the unburned area in October and December 1978 (Figure 2).

Cumulative buffelgrass production remained higher on the burned area than on the unburned area for nearly 30 months following the fire. By December 1979, almost 3 years after the burn, cumulative production was about equal on the once burned and unburned areas (Figure 1), thus indicating about a three growing season life for benefits from the burn based on total buffelgrass yield.

A second burn on part of this same area was installed in February, 1979. Buffelgrass production followed the same general pattern as with the first burn. There was the flush of early growth following the fire that produced higher yields on the twice-burned area than on either the once-burned or unburned area. However, beginning in mid-summer, when dry conditions prevailed, less grass was produced on the burned area than on the unburned area as soil water was depleted for the remainder of the year. Still, cumulative buffelgrass production was greater on the twice-burned area for the entire period from date of the burn in February to December the same year.

The mid-winter and late-winter burns near Laredo also increased buffelgrass production for two growing seasons following the fire.

Buffelgrass Utilization

Studies were conducted on the burns near Encinal to determine the effect of a cool season fire on utilization 1/ of buffelgrass by livestock (Figure 3).

1/ Utilization implies the disappearance of forage and includes losses to Gathering, trampling, insects, rodents, etc. as well as grazing by livestock

Figure 1. Cumulative buffelgrass production (kg/ha) following a February, 1977 burn near Encinal, Texas. Data points with asterisks indicate production for the period was significantly different at the .05 level.

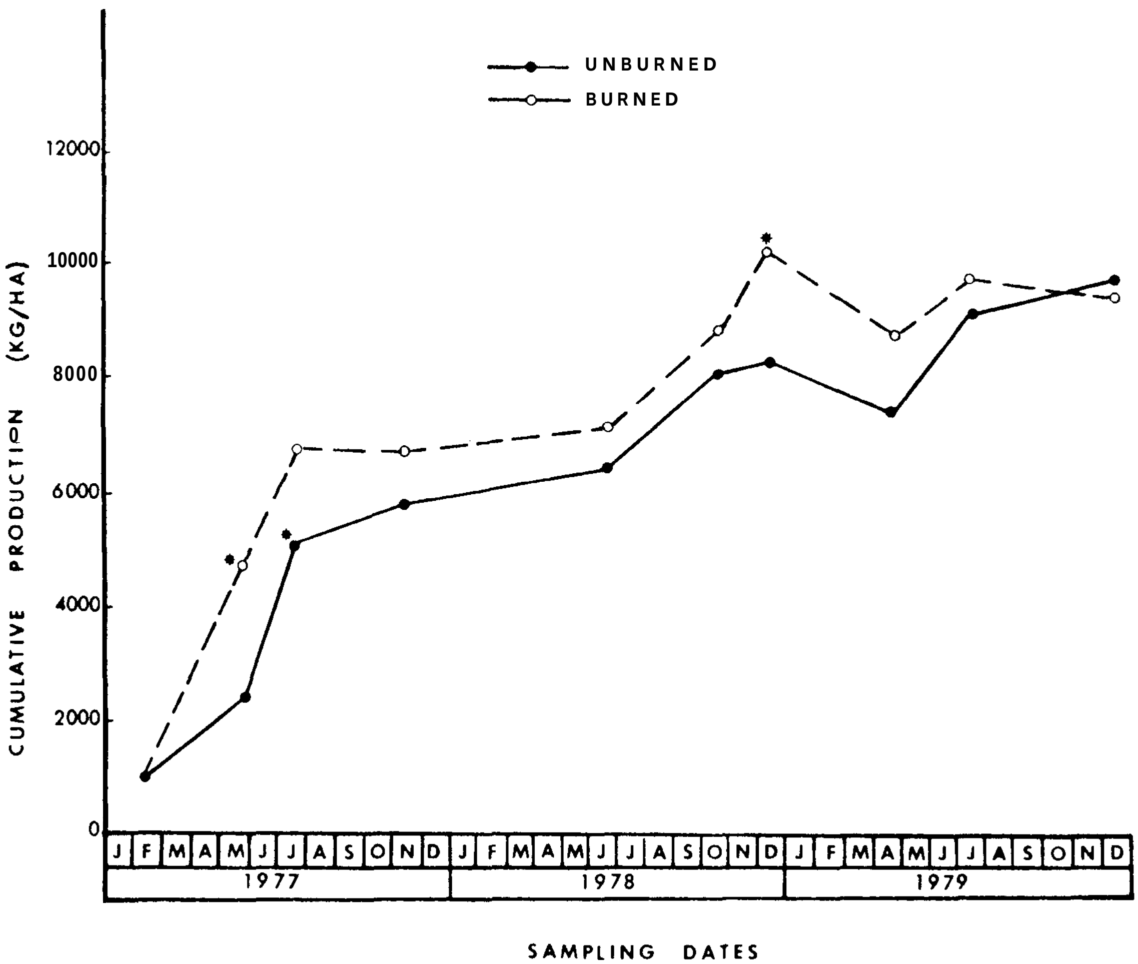


Figure 2. Accumulated precipitation (cm) by sampling dates following February 1977 and 1979 burns near Encinal, Texas.

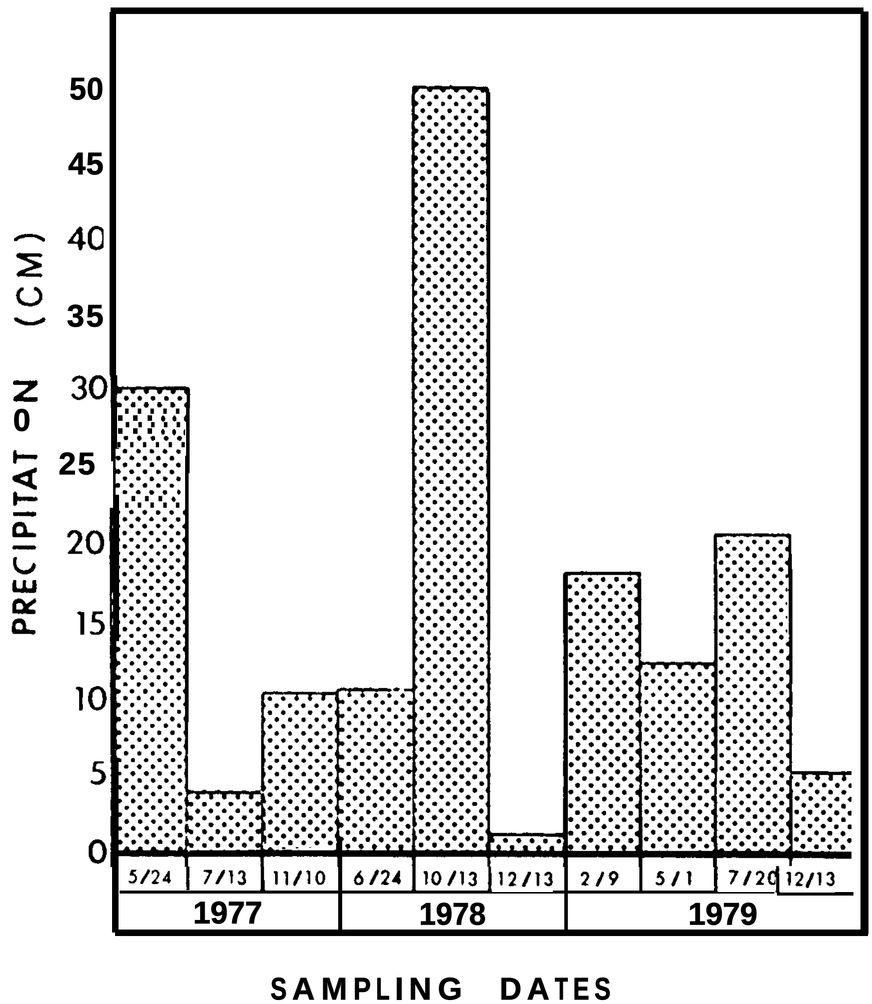
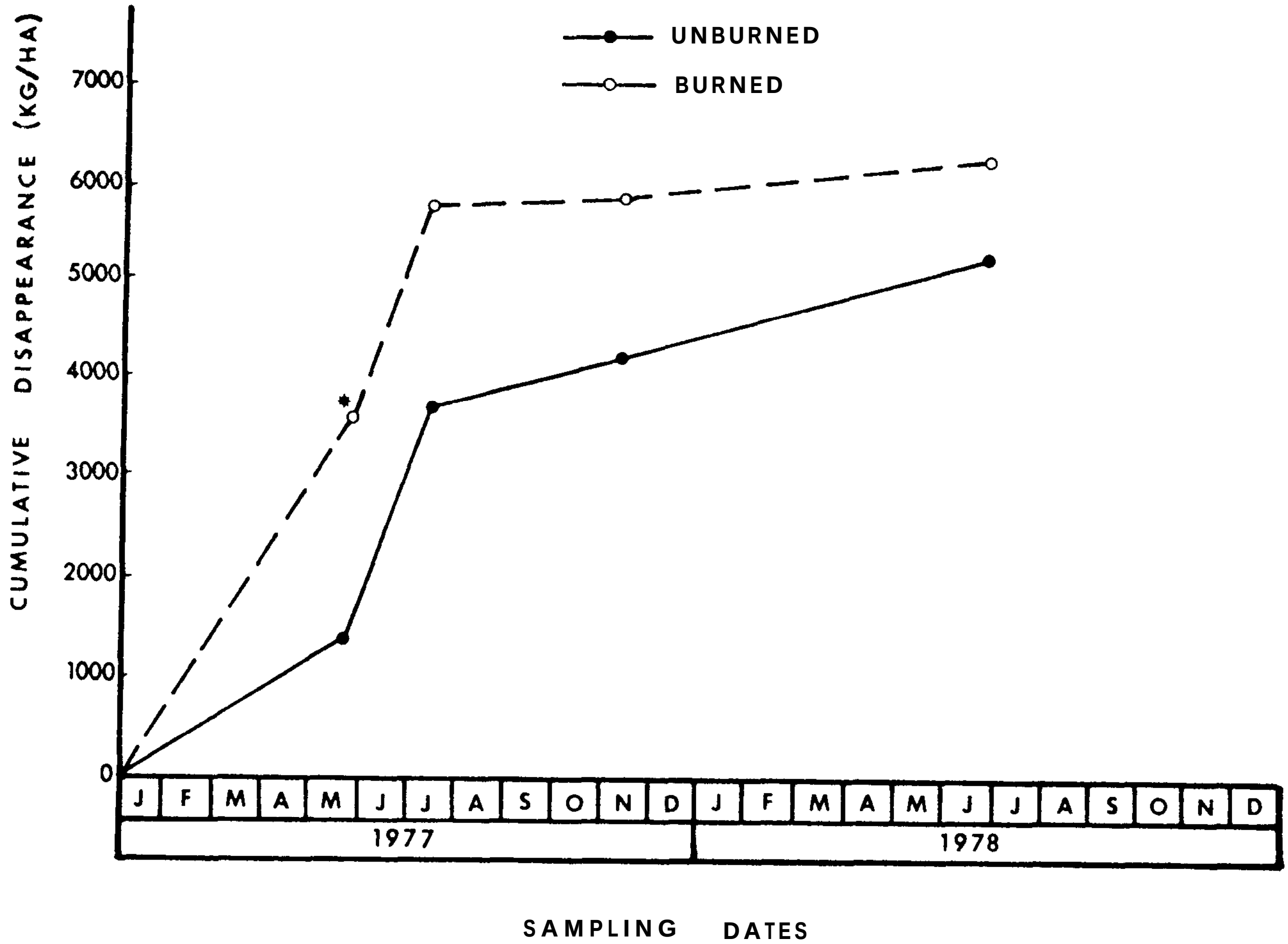


Figure 3. Cumulative buffelgrass disappearance (kg/ha) following a February, 1977 burn near Encinal, Texas. Data points with asterisks indicates disappearnace for the period was significantly different at the .05 level.



These studies confirmed other reports that grazing animals strongly favor forage produced on burned areas over that on adjacent unburned areas (Oefinger and Scifres 1977). Cumulative utilization on the burned area was 88% of cumulative production for the 17 month grazing period, while on the unburned area, it was 69% of the total amount of forage produced. A much greater difference in utilization occurred during the first 4 months following the burn on the fresh, succulent forage. During this period, the burned area was utilized 7.7 times more heavily than was the unburned. As production advantage switched to the unburned area during dry conditions, the difference in utilization became less distinct.

Woody Plant Suppression

A primary objective of the experiments near Encinal was to evaluate cool season burns for suppression of woody plant regrowth in buffelgrass. There were three woody species, honey mesquite (Prosopis glandulosa var. glandulosa), blackbrush acacia (Acacia rigidula), and twisted acacia (Acacia tortuosa), present in the experimental area in sufficient quantity to evaluate individually. These species accounted for 95% of the woody plant canopy on the study site. Other minor species present were grouped into a category called "all other woody plants"./

The number of live woody plants was not changed by burning, regardless of species or whether the areas were burned once or twice. This may be related in part to the marginal conditions at the time of the fires (Table 3), however, it does not appear that cool season burns will normally cause significant mortality of those South Texas species which are vigorous crown sprouters.

Canopy diameters of honey mesquite, twisted acacia and the group of species shown as all other woody plants were recovered to preburn levels by the end of the first growing season following the initial burn (Figure 4). Part of the reason for this rapid recovery to preburn levels is the nature of grassland burns which often leave some plants unaffected by the fire. This "mosaic" effect of burned and unburned spots is very desirable in many instances where wildlife habitat is important (Scifres 1980). However, it does permit recovery to levels of pretreatment canopy cover more quickly than with other top removal practices, such as shredding, which eliminates a higher percentage of the above ground plant tissue (Hamilton and Scifres 1980). Predictions of the time required for honey mesquite, twisted acacia and all other woody plants to replace preburn canopy diameter levels were approximately 6, 8 and 6 months respectively. These species could be regarded as having the potential to replace preburn canopies within the first growing season following cool season burns under conditions similar to those in this experiment. Blackbrush acacia was more

2/ All other woody plants include lotebush (Zizyphus obtusifolia), spiny hackberry (Celtis pallida), guayacan, (Porlieria angustifolia), leatherstem (Jathropa dioica), desert yaupon (Schaefferia cunfolia), whitebrush (Aloysia lycioides), wolfberry (Lycium berlandieri), guajillo (Acacia berlandieri), and tasajillo (Opuntia leptocaulis).

Figure 4. Canopy diameter expressed as the percent of preburn value following a February, 1977 burn near Encinal, Texas. Asterisks indicate canopy diameters are significantly different from preburn values at the .05 level.

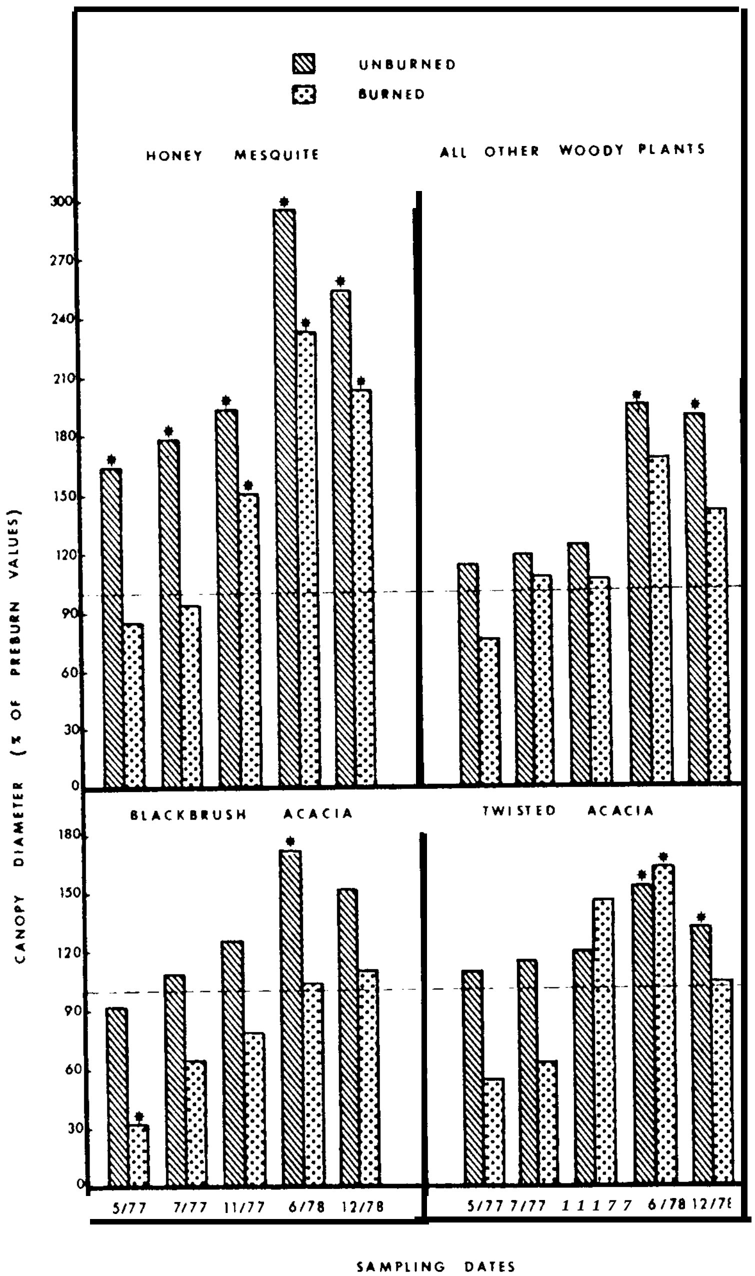


Table 3. Fuel and weather conditions at the time of ignition of burns for suppression of woody plants invading buffelgrass on the South Texas Plains, Encinal, Texas.

Variable	Burn date (February) 1977	1979
Fine fuel load (kg/ha)		
Standing crop	1120	2448
Mulch	20	882
Fine fuel water content (%)	23	14
Soil water content (%)		
0-15 cm	16	14
15-30 cm	19	14
30-45 cm	--	13
Maximum burn temperature (C)		
at 15 cm	225	223
Wind speed (km/hr)	8-13	0-8
Wind direction	SE	E/NE
Air temperature (C)	16	14
Soil temperature at 5 cm (C)	14	11
Relative humidity (%)	89	40

severely affected by the fire and went until early into the second growing season before reaching preburn canopy diameter (Table 4).

Table 4. Predicted time required (months) for replacement of preburn brush canopy cover following the single burn near Encinal.

Species	Prediction Equation	r^2	Months
Mesquite	Y = -56.32 + (92.54) (Log x)	.94	5.42
Twisted Acacia	Y = -43.13 + (70.58) (Log x)	.71	7.61
Blackbrush Acacia	Y = -46.32 + (57.02) (Log x)	.87	13.06
All other brush 1/	Y = 40.98 + (33.45) (Log x)	.67	5.87

1/ All other brush includes lote, granjeno, guayacan, leather stem, desert yaupon, whitebrush, wolfberry, guajillo and tasajillo.

Replacement of preburn height levels by all species was slower than canopy replacement. Predicted time required for honey mesquite to attain its preburn height was about 8 months, while twisted acacia required 11 months and blackbrush acacia required 19 months. A comparison of the rate of height increase on the burned and unburned areas for each species showed that burning did not change the height rate increase on honey mesquite and blackbrush acacia. The rate of height increase was significantly greater on the burned twisted acacia than on the unburned (Figure 5), however, this is attributed to the fact that twisted acacia height had stabilized prior to treatment. Scifres (1980) describes twisted acacia as a low growing shrub usually less than 1.8 meters tall. Twisted acacia plants on the study site averaged 1.6 meters in height at the time of the burn, indicating they had reached relatively stable levels.

Canopy of common goldenweed was reduced by an average of about 88% at the end of the first growing season following the mid-winter and late-winter burns. During the same time period, common goldenweed canopy cover increased by 32% on the unburned area. The mortality of common goldenweed caused by the burns averaged 43%, but the flames caused a reduction in vigor of the remaining live weeds by killing buds that would have provided canopy regrowth.

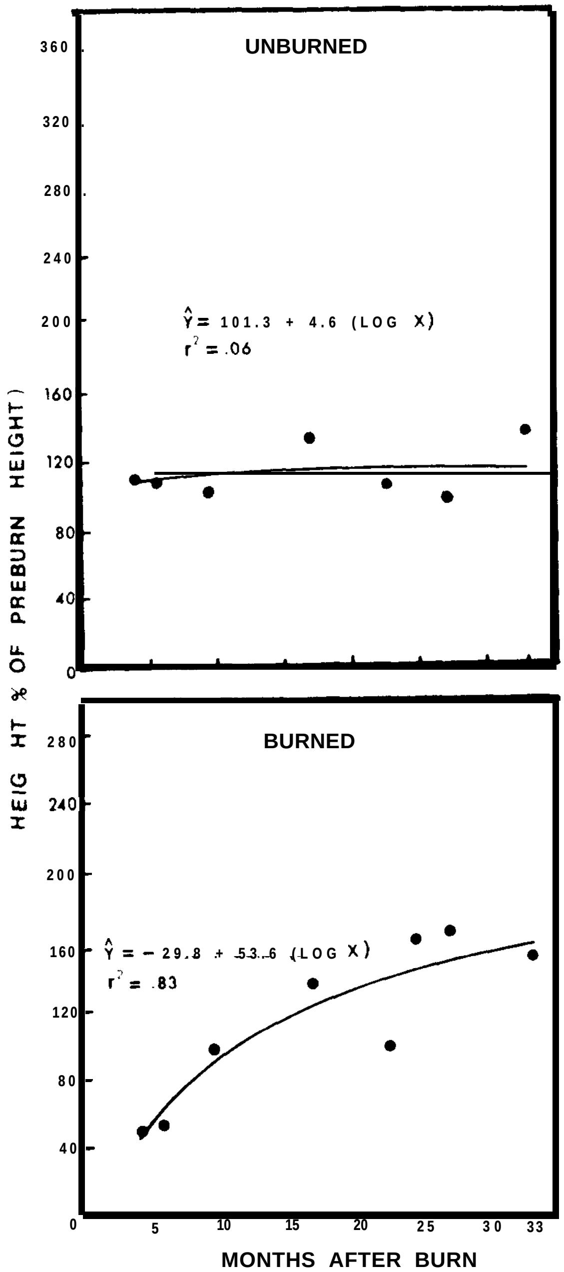
Conclusions and Management Implications

These data indicate that cool season burns are effective in temporarily suppressing woody plant regrowth and common goldenweed infestations in buffelgrass, and increasing cumulative forage production for up to three growing seasons. There appears to be little chance of significantly reducing the number of live woody plants with such burns. Based on the times required for woody plants to replace preburn canopy cover and heights, and with recognition of the longer duration of cumulative buffelgrass production which favored the burned areas, it appears that a 3-year burning interval would be the maximum to maintain acceptable brush density and forage production levels (Hamilton and Scifres 1980). It is quite possible, however, that beginning the burning program at an earlier date, perhaps only 5 years after land clearing, could increase the burn interval required. Burning more frequently than 3 to 4 years in the drier parts of South Texas would appear to be risky because of the chance of long term reduction in soil organic matter and nutrients, particularly under heavy grazing use (Sharrow and Wright 1977).

Although single cool season burns did not result in high levels of common goldenweed mortality, significant.reductions in weed vigor and concomitant increases in forage production suggest that burning is useful in the management of goldenweed infestations. These cool season burns also allowed reductions in the rate of pelleted herbicides (tebuthiuron and picloram) to half the amount required for high levels of goldenweed control without burning, thus indicating a synergistic effect in a burn/herbicide management system.

A common point to all data presented herein on the use of fire for pasture management is that cool season, maintenance-type burns, particularly when applied before spring growth and with good levels of soil moisture, present little risk in the reduction of stand density and are effective in increasing

Figure 5. Rate of twisted acacia height increase expressed as the percent of preburn height following a February, 1977 burn near Encinal, Texas.



herbage yields. While observations from a single hot summer burn indicate a high rate of buffelgrass survival for many months into extremely dry conditions, it is still logical to assume greater risk with reclamation-type burns (Scifres 1980). Producers may be faced with a "trade-off" of deciding whether to use reclamation burns for improved brush control or cool season burns for less risk of damage to the pasture and quicker recovery to green forage production.

Another point for management consideration in the use of prescribed fires on South Texas pastures is that cool season burns will promote a flush of growth which will draw heavily on soil moisture. As soil moisture declines in the summer months, burned areas may show moisture stress earlier than unburned areas. Grazing management should consider taking advantage of this added production from the treatment, but be careful to allow time after the burn for the grass to establish vigorous growth.

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