# Prescribed Burning Guidelines in the Northern Great Plains

Kenneth F. Higgins

Arnold D. Kruse

James L. Piehl

EC 760



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U.S. Fish and Wildlife Service
and Cooperative Extension Service
South Dakota State University
U.S. Department of Agriculture

*"Successful and objective burning depends on the skillful and safe application and containment of fire on a specific area for a reasonable purpose and during desirable environmental conditions."*

—Kenneth F. Higgins

Some pictures show fire workers dressed in inappropriate clothing; these photos were taken when burning techniques were less well defined. Such photos are used only to illustrate another point; we strongly recommend proper attire as described in this publication. Use of tradenames is for reader convenience only and does not indicate endorsement of products or discrimination against products not mentioned.

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**Kenneth F. Higgins**
U.S. Fish and Wildlife Service
South Dakota Cooperative Fish and Wildlife Research Unit
South Dakota State University, Box 2206
Brookings, South Dakota 57007

and

**Arnold D. Kruse**
U.S. Fish and Wildlife Service
Northern Prairie Wildlife Research Center
Box 2096
Jamestown, North Dakota 58402

and

**James L. Piehl**
U.S. Fish and Wildlife Service
R.R. 1, Box 76
Fergus Falls, Minnesota 56537

## Abstract

The use of fire to manage grasslands for wildlife is a relatively new management option for resource managers in the Northern Great Plains (NGP). Nearly all of the burning during the past 20-25 years has been conducted without the aid of specific guidelines for the region. This state-of-the-art set of recommendations was compiled because of this void.

Records of 902 grassland fires (primarily on U.S. Fish and Wildlife lands), personal experiences, and synopses of other published fire research were used in developing the guidelines in this manual.

Fifty-two percent of the 902 fires were in native prairie grasslands with lesser amounts in tame and native grass plantings, wetlands, and woodlands.

Prescription grassland fires averaged 31 ha (77 acres) per burn. The personnel needed to safely conduct a grassland fire depended on the size of the burn, the kind of firebreaks, available equipment, and weather conditions. Costs and hours of effort to conduct fires were inversely related to burn area size. Cost ratios are extremely high for fires of less than 4 ha (10 acres). They are essentially the same for burns of 16 to 113 ha (40 to 280 acres).

The two primary reasons for burning grasslands are wildlife habitat improvement and native prairie restoration. Fire use steadily increased between 1965 and 1984, but the greatest increase occurred following workshop instruction in 1978.

These guidelines present a set of reasons, criteria, techniques, and examples of simple prescriptions which aid in the planning and execution of a safe and effective prescribed burning program for wildlife enhancement in grassland areas of the NGP.

## Preface

This manual contains state-of-the-art guidelines for conducting prescribed burning in the Northern Great Plains. It has been prepared especially for resource managers and "fire bosses" and will be useful for researchers and other interested persons.

It presents the latest "how-to-do-burning" strategies and is supplemented with summaries of data collected from over 900 grassland fires.

The manual results from the cooperative effort and support of the South Dakota State Cooperative Fish and Wildlife Research Unit (SDCFWRU), South Dakota State University, Brookings, South Dakota; the Northern Prairie Wildlife Research Center (NPWRC), Jamestown, North Dakota; and the U.S. Fish and Wildlife Service (USFWS), Fergus Falls, Minnesota. Manuscript typing and library services were shared between SDCFWRU and NPWRC. Data tabulations and figure drafting were provided by staff at NPWRC. A special thanks is extended to Drs. F.R. Gartner and W.D. Svedarsky for manuscript review and to Mary Brashier, editor, and Duane Hanson, graphic designer, Department of Ag Communications, SDSU.

We also extend thanks to the U.S. Forest Service's southeastern region for permission to use figures on patterns of spreading fire as presented in Mobley et al (1977).

K.F.H.

## Contents

# Prescribed Burning Guidelines in the Northern Great Plains

Fire, whether set or caused by lightning, has been a part of the prairie for thousands of years. Fire provides one or more benefits to a prairie. It can remove dead vegetation that hinders new growth. It can release nutrients to enrich the soil. It can reduce invader plants and encourage native species. It can create habitats attractive to wildlife.

Misused, it can do the opposite. The best planned and best managed fire, prepared and executed according to the standards in this manual, may be destructive if its probable results on all biological systems on the site have not been examined and weighed first.

When fire is in your management plan, use this manual.

These state-of-the-art guidelines are developed specifically for land resource managers in the north-central United States and south-central Canada. They present the key elements of planning, using, containing, and evaluating prescription burns in the Northern Great Plains (NGP).

## Area covered by guidelines

The grassland areas for which these guidelines are intended lie within the general boundaries of the NGP, specifically the glaciated prairie pothole region of the north-central U.S. and south-central Canada (Fig 1). The delineation of the natural grassland vegetation of this area follows Wright and Bailey (1980) as modified from Kuchler (1964) and Rowe (1972).

Although Iowa and Nebraska are not part of the NGP, the guidelines should have application to some grassland areas of northwest Iowa and the northern edge of Nebraska.

Major grassland habitats of this area include mixed-grass prairie, tallgrass prairie, fescue prairie, and several types of forage crop plantings varying from mixtures of exotic grasses and legumes to mixtures of native grass cultivars.

These guidelines do not include the aspen parklands, the shortgrass prairie, or any extensive woodland areas. However, they will pertain to prairies and plains that also support scattered trees, shrub thickets, and shrub communities such as silverberry (*Elaeagnus commutata*), western snowberry (buckbrush) (*Symphoricarpos occidentalis*), and sagebrush (*Artemisia* spp).

## Fire in historical perspective

Fire is one of the natural forces maintaining northern grasslands. Lightning-set fires are still common in the U.S. and Canada (Higgins 1984; Raby 1966; Nelson and England 1971). However, fires set by native peoples were mentioned most in historical journals, diaries, and other accounts (Nelson and England 1971; Moore 1972; Higgins 1986).

The presence of historical fire in the NGP can not be contested; it was there and the native people used it.

Most of the more recent lightning-set fires in the NGP occurred during summer and early fall (Rowe 1969; Higgins 1984). Although fires were reported from April through September, the majority were in July and August.

Higgins (1984) estimated a frequency of six lightning fires/yr/10,000 sq km in grasslands in eastern North Dakota, 25/yr/10,000 sq km in western North Dakota, and 92/yr/10,000 sq km in pine-savanna lands in northwestern South Dakota and southeastern Montana.

The periodicity of lightning-set fires undoubtedly plays an important role in the composition and ecology of grasslands of the NGP.

Deliberate firing of the prairie by native peoples was much more frequent in historical literature than were lightning-set fires. Native Americans set fires both unintentionally and deliberately for a variety of reasons (Moore 1972; Nelson and England 1971; Higgins

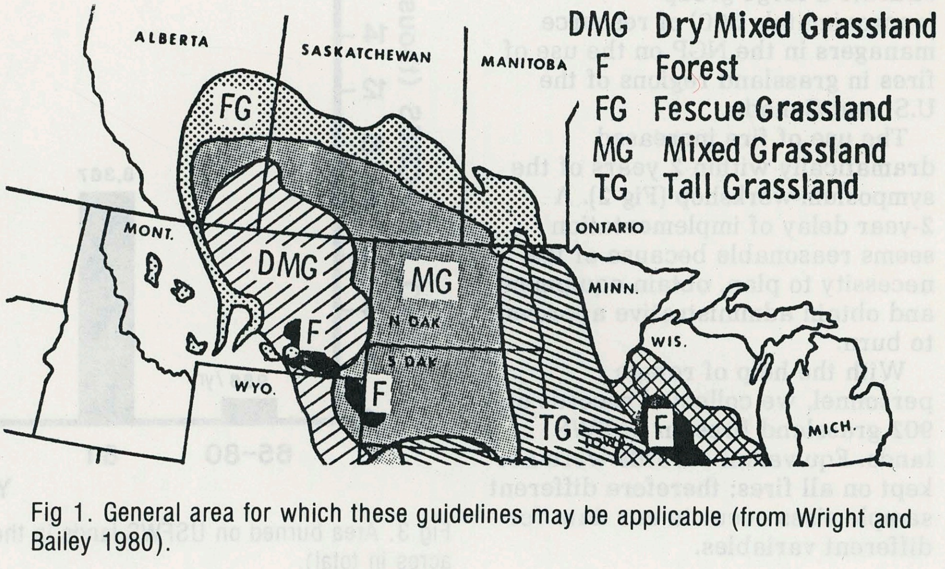


Fig 1. General area for which these guidelines may be applicable (from Wright and Bailey 1980).

1986). Their most frequent use of fire was probably to aid a hunter-gatherer lifestyle, to drive game and to procure food, shelter, and clothing (Authur 1975).

These fires, like lightning-set fires, undoubtedly played an important role in the evolutionary process and development of the grassland biomass of the NGP. The use of fire is equally important today as prairies are managed for the future.

## Present-day burning

The trend toward prescribed burning of grasslands is illustrated by the U.S. Fish and Wildlife Service's (USFWS) increasing use of fire on fee title lands in the prairie pothole region. The first management fire on USFWS lands in this region was conducted in North Dakota by A.D. Kruse on Arrowwood National Wildlife Refuge in 1965. An average of 16 burns/yr was set on USFWS lands between 1965 and 1980; the number increased to an average 162/yr between 1981 and 1984 (Fig 2).

Field personnel conducting prescription fires during the late 1960s and early 1970s soon realized that more knowledge and training were necessary for successful burning programs. A Prairie Prescribed Burning Symposium and Workshop was held in Jamestown, ND, on 25-28 April 1978. This was the initial effort to educate a large group (approximately 300) of resource managers in the NGP on the use of fires in grassland regions of the U.S. and Canada.

The use of fire increased dramatically within 2 years of the symposium-workshop (Fig 2). A 2-year delay of implementation seems reasonable because of the necessity to plan, obtain equipment, and obtain administrative approval to burn.

With the help of refuge personnel, we collected records on 902 grassland fires on USFWS lands. Equivalent records were not kept on all fires; therefore different sample sizes occur in our data for different variables.

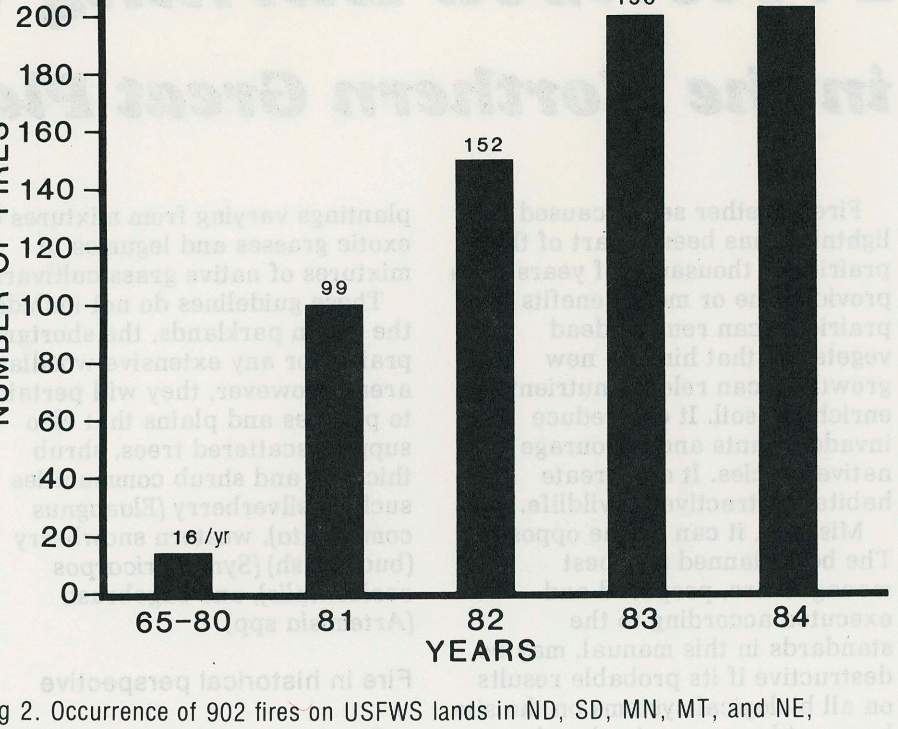


Fig 2. Occurrence of 902 fires on USFWS lands in ND, SD, MN, MT, and NE, 1965-1984.

In all, 28,141 ha (69,484 acres) were burned in 902 fires by the USFWS (Fig 3). Most (77%) burns occurred during 1981-1984. These fires averaged 31 ha (77 acres) in size, varying from less than 0.4 ha (1 acre) to 1,013 ha (2,500 acres) (Fig 4). Almost 96% of the fires were conducted in two states, 63.2% in North Dakota and 32.4%

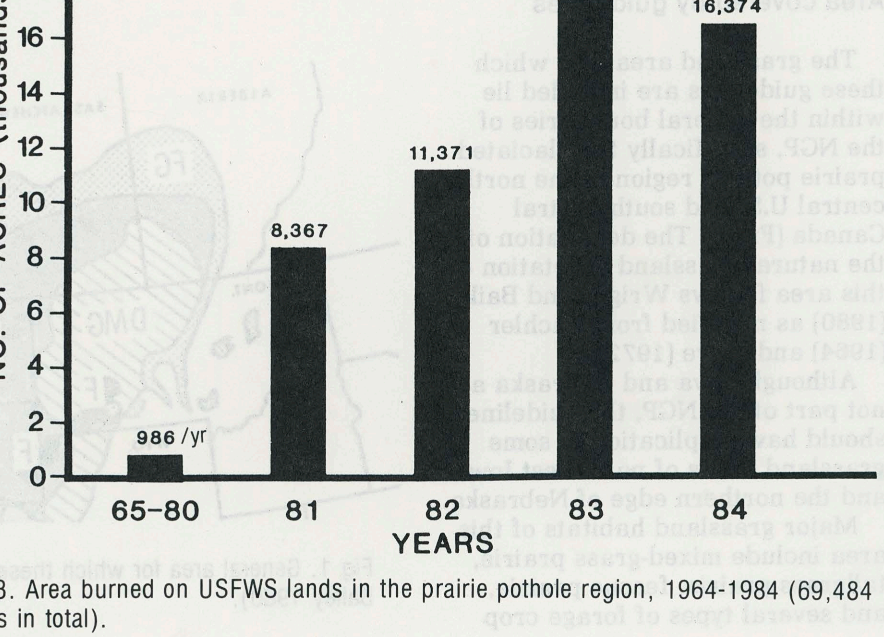


Fig 3. Area burned on USFWS lands in the prairie pothole region, 1964-1984 (69,484 acres in total).

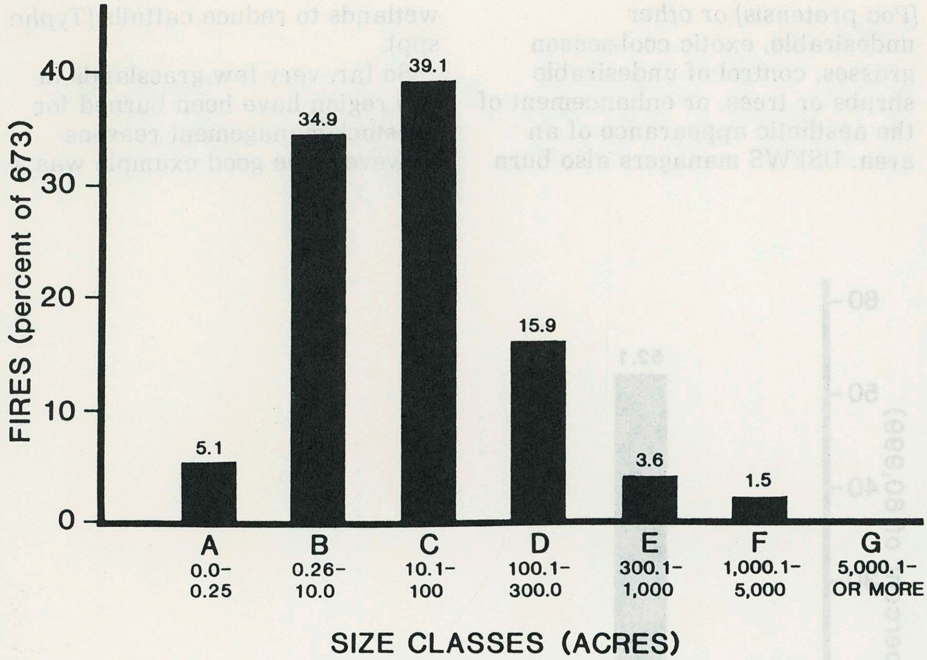


Fig 4. Percent of 673 burns by size class on USFWS lands, 1965-1984.

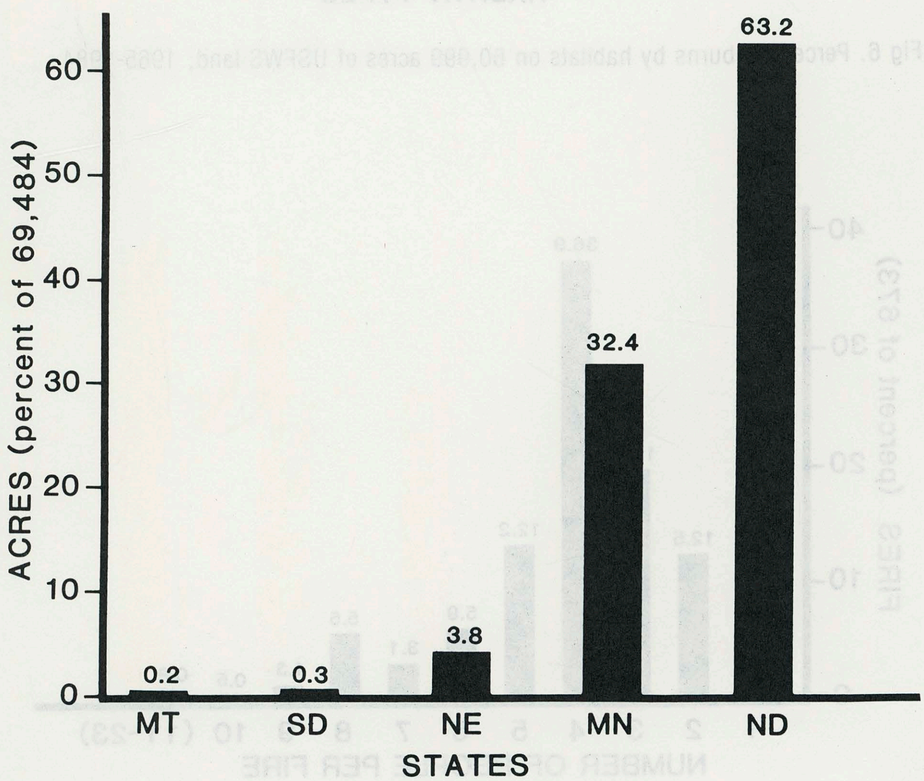


Fig 5. Distribution of 69,484 acres of burns on USFWS lands by state, 1965-1984.

in Minnesota, with fewer in Nebraska, South Dakota, and Montana (Fig 5). Fifty-two percent of the burns were in native grasslands with fewer in tame and native grass plantings, marshes, and woodlands (Fig 6). The percentage of burns by habitats is in close proportion to that which occurs on USFWS lands in this region.

The number of people assigned to a fire ranged from 1 to 23 on USFWS lands; only two to five people (most commonly, four) conducted 81% of the fires (Fig 7). The number of people necessary to safely conduct a fire depends on the size of the burn, the kind of firebreaks and equipment available, and weather conditions.

The cost of each grassland burn is related to the number of people present and the size of the burn area (Figs 8 and 9). Costs and work hours per unit of effort are extremely high for small fires of less than 4 ha (10 acres), but were essentially the same for larger burns of 16 to 113 ha (40 to 280 acres) (Figs 8 and 9).

### Is fire a choice?

NGP grasslands can be managed in different ways; fire is but one possible choice. Other grassland management options include grazing, mowing, haying, fertilization, herbicides, soil scarification, interseeding, and total renovation and reseeding.

A land manager's first decision is to determine whether fire is a viable option. Fire should **not** be a grassland management choice for a specific area if:

1. Federal or state regulations prohibit burning.
2. Local ordinances or zoning prohibit burning.
3. Containment and safety factors are extremely risky.
4. Endangered species or natural communities are subject to harm or their status is in doubt.
5. Fire behavior or fire effects will not meet the objectives for the area.
6. Local residences would be in jeopardy.

If fire can not be used for any of the above six reasons, accept the decision as final. Establish a file record of the specific area that may not be burned and list the reasons that limit or prohibit the use of prescribed fire. List the most probable alternative grassland management methods for the specific area and the reasons for these choices.

The following guidelines were developed with the assumption that fire can be used as a grassland management tool for a specific area.

## Reasons for grassland burning

Grasslands are burned primarily to manipulate vegetation and enhance the biological productivity and diversity of specific organisms or to accomplish specific objectives.

Specific objectives may be broad (prairie restoration and maintenance) or narrow (management for endangered or rare species or reduction of woody plants).

Most of the recent prescribed fires in the NGP have been used either for native prairie restoration or for wildlife habitat management. Very little burning has been done for livestock management purposes in this region.

From interviews with a sample of USFWS refuge and wetlands managers, we found that, where native prairie was not a major part of the management area, nearly all prescription fires were used to reduce vegetative litter, to control noxious weeds, or to improve the height and density of planted cover (dense nesting cover for wildlife).

Where native prairie was a major part of a management area, the primary reasons for burning were approximately 60% for wildlife habitat improvement and 40% for prairie restoration, improvement, or enhancement.

Occasionally, a manager burns for very specific reasons such as reduction of Kentucky bluegrass *(Poa pratensis)* or other undesirable, exotic cool-season grasses, control of undesirable shrubs or trees, or enhancement of the aesthetic appearance of an area. USFWS managers also burn wetlands to reduce cattails *(Typha* spp).

So far, very few grasslands in this region have been burned for livestock management reasons. However, one good example was a

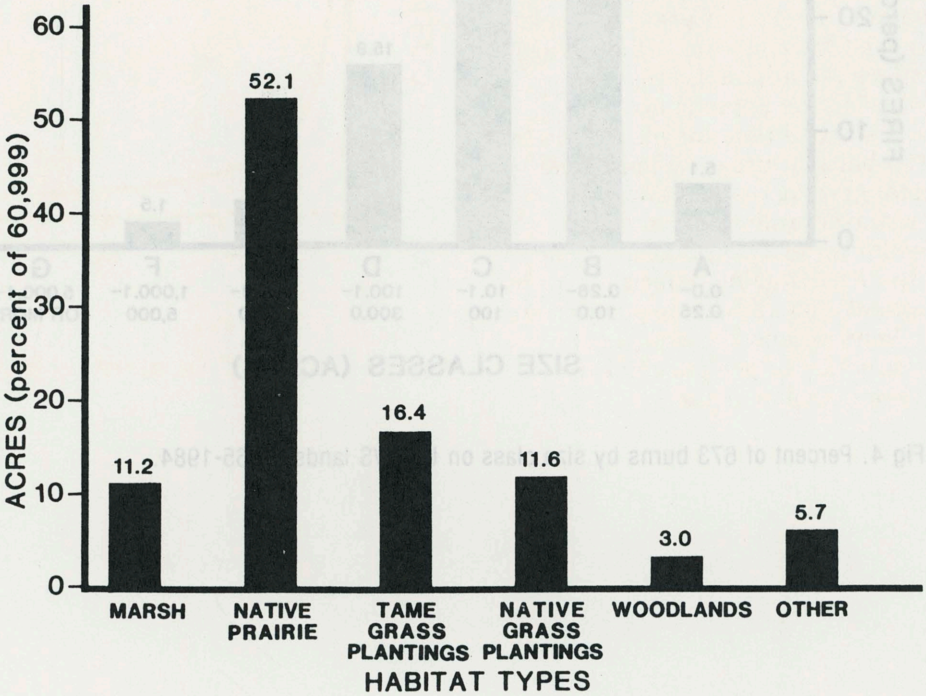


Fig 6. Percent of burns by habitats on 60,999 acres of USFWS land, 1965-1984.

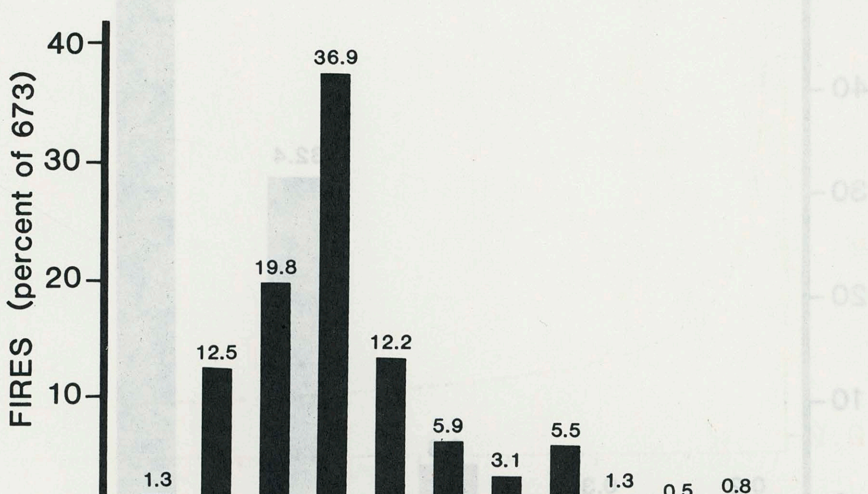


Fig 7. Number of people used on 673 burns on USFWS land, 1965-1984.

cooperative burning program implemented among members of the North Dakota State University Botany Department, the Sheyenne Grazing Association, and the U.S. Forest Service in the Sheyenne National Grasslands near Lisbon, ND (W.T. Barker, pers comm).

The agencies burned sedge (*Carex* spp) lowlands in the spring before the start of grazing. These burned lowlands were then grazed before the adjacent uplands, allowing the uplands an undisturbed time for plant growth. The burning program improved total grazing distribution and increased utilization on sedge lowlands which previously had little use. Grazing deferment on the upland also allowed nesting cover to improve and provide greater production of prairie chickens (*Tympanuchus cupido*).

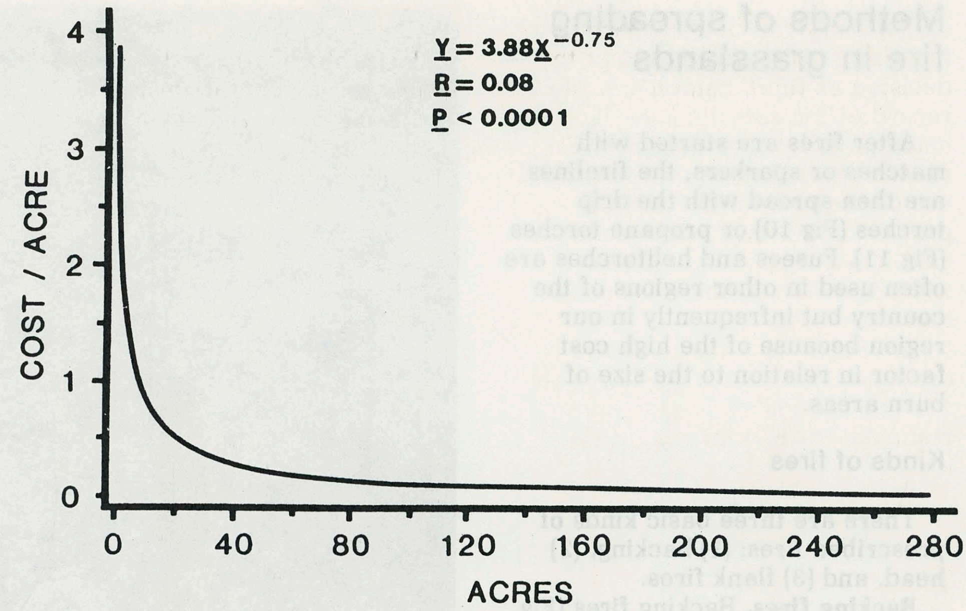


Fig 8. A regression of the relations of cost per acre on fire size.

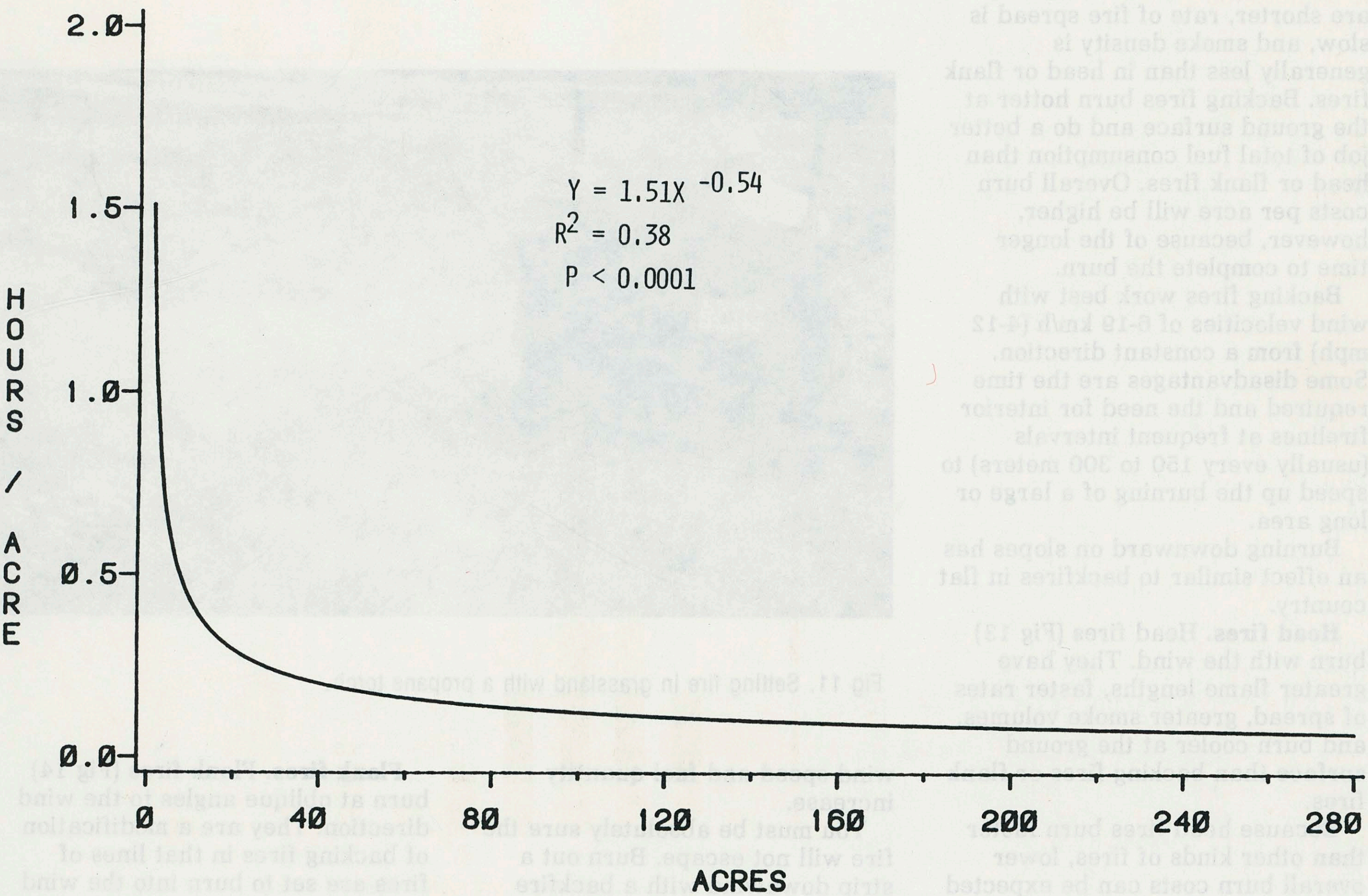


Fig 9. A regression of the relations of work-hours per acre on fire size.

## Methods of spreading fire in grasslands

After fires are started with matches or sparkers, the firelines are then spread with the drip torches (Fig 10) or propane torches (Fig 11). Fusees and helitorches are often used in other regions of the country but infrequently in our region because of the high cost factor in relation to the size of burn areas.

### Kinds of fires

There are three basic kinds of prescribed fires: (1) backing, (2) head, and (3) flank fires.

**Backing fires.** Backing fires (Fig 12) burn into the wind. Fire is started along a prepared base line, such as a road, plowed line, stream, wetland, or other barrier, and allowed to burn into the wind.

Backing fires are generally the easiest way to burn. Flame lengths are shorter, rate of fire spread is slow, and smoke density is generally less than in head or flank fires. Backing fires burn hotter at the ground surface and do a better job of total fuel consumption than head or flank fires. Overall burn costs per acre will be higher, however, because of the longer time to complete the burn.

Backing fires work best with wind velocities of 6-19 km/h (4-12 mph) from a constant direction. Some disadvantages are the time required and the need for interior firelines at frequent intervals (usually every 150 to 300 meters) to speed up the burning of a large or long area.

Burning downward on slopes has an effect similar to backfires in flat country.

**Head fires.** Head fires (Fig 13) burn with the wind. They have greater flame lengths, faster rates of spread, greater smoke volumes, and burn cooler at the ground surface than backing fires or flank fires.

Because head fires burn faster than other kinds of fires, lower overall burn costs can be expected per acre of burn. Containment becomes more critical, however, as wind speed and fuel quantity increase.

You must be absolutely sure the fire will not escape. Burn out a strip downwind with a backfire wide enough to control the head fire.

Fig 10. Setting fire with a drip torch.


Fig 11. Setting fire in grassland with a propane torch.

**Flank fires.** Flank fires (Fig 14) burn at oblique angles to the wind direction. They are a modification of backing fires in that lines of fires are set to burn into the wind but at angles to the wind direction.

Flank fires are often used to

Fig 12. Backing fires have short flame length and little smoke.

Fig 13. Head fires produce longer length flames and lots of smoke.

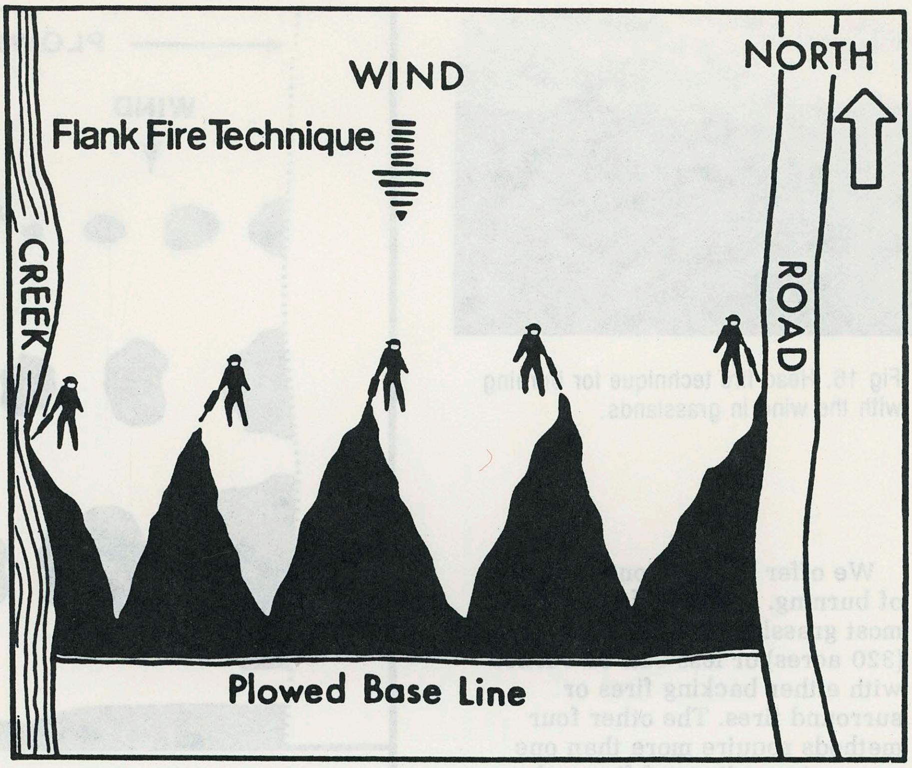


Fig 14. Flank fires burn at oblique angles to the wind direction.

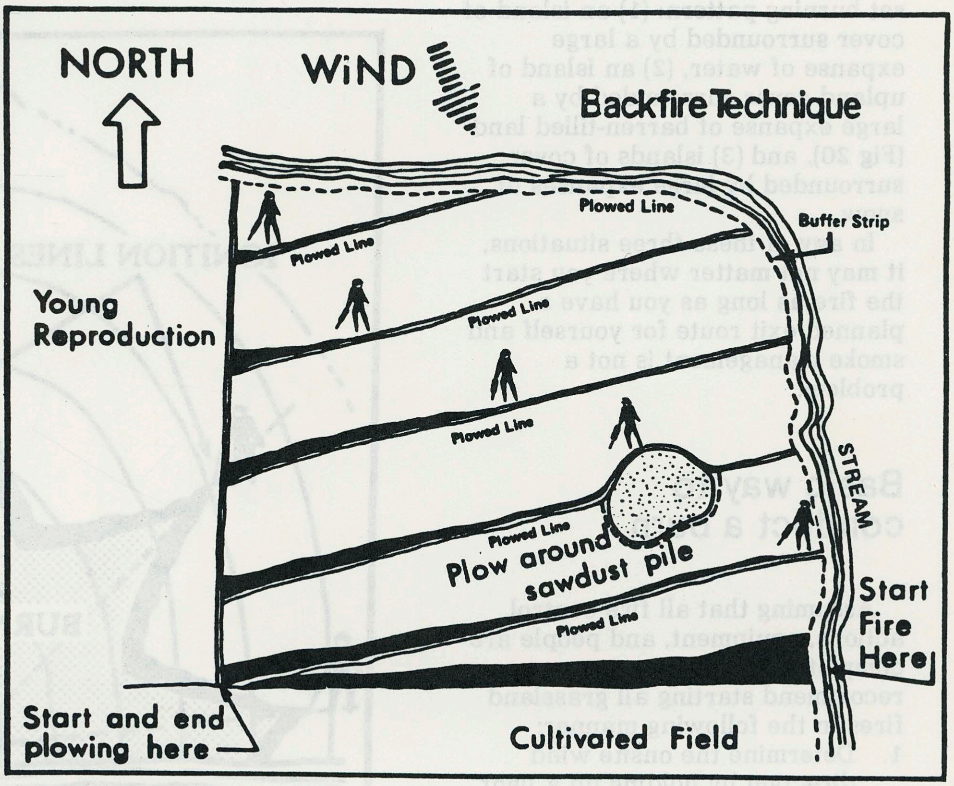


Fig 15. Backfire technique for burning grasslands against the wind.

secure the flanks of a head fire as the head fire progresses. This method of firing can stand little variation in wind direction and needs expert crew coordination and timing.

## Basic patterns of burning grasslands

Mobley et al (1977) presented in-depth descriptions and visual examples of several different patterns of applying fire: (1) backing fire, Fig 15; (2) strip-head fire, Fig 16; (3) flank fire, Fig 14; (4) spot fire, Fig 17; (5) chevron burn, Fig 18; and (6) center, surround, circular, or ring fire, Fig 19.

Fig 16. Head fire technique for burning with the wind in grasslands.

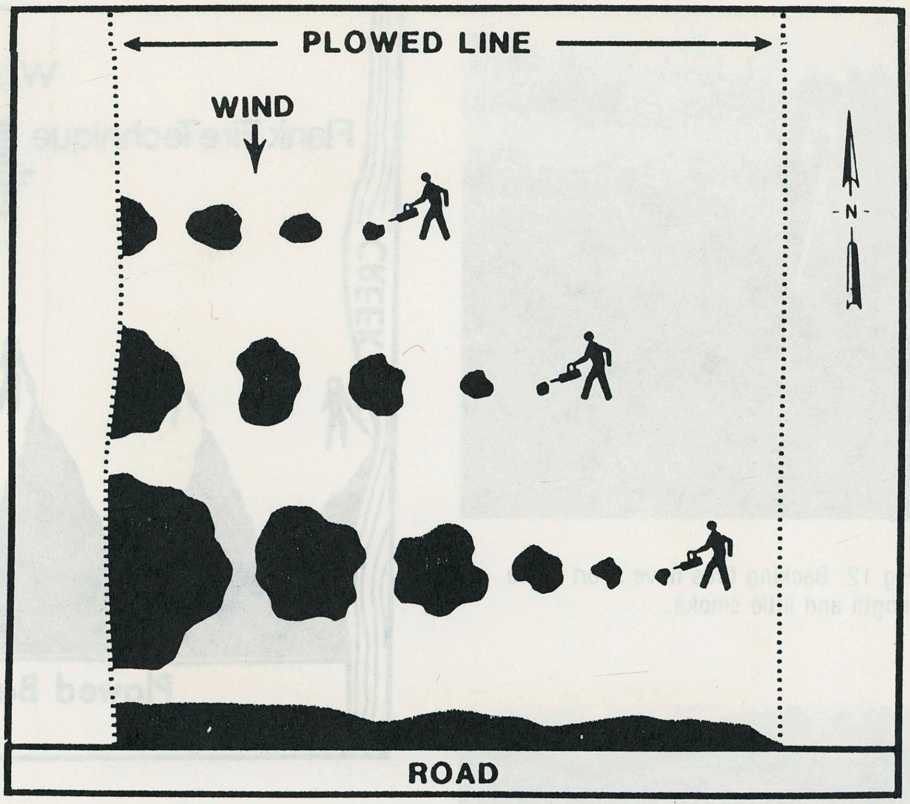


Fig 17. Spot fire technique for setting fire in grasslands.

We offer no additional patterns of burning. We have found that most grassland burns of 130 ha (320 acres) or less can be burned with either backing fires or surround fires. The other four methods require more than one person to set lines of fire and are more practical to use on larger burns.

There are three situations in which there may be no need for a set burning pattern: (1) an island of cover surrounded by a large expanse of water, (2) an island of upland cover surrounded by a large expanse of barren-tilled land (Fig 20), and (3) islands of cover surrounded by large expanses of snow.

In any of these three situations, it may not matter where you start the fire as long as you have a planned exit route for yourself and smoke management is not a problem.

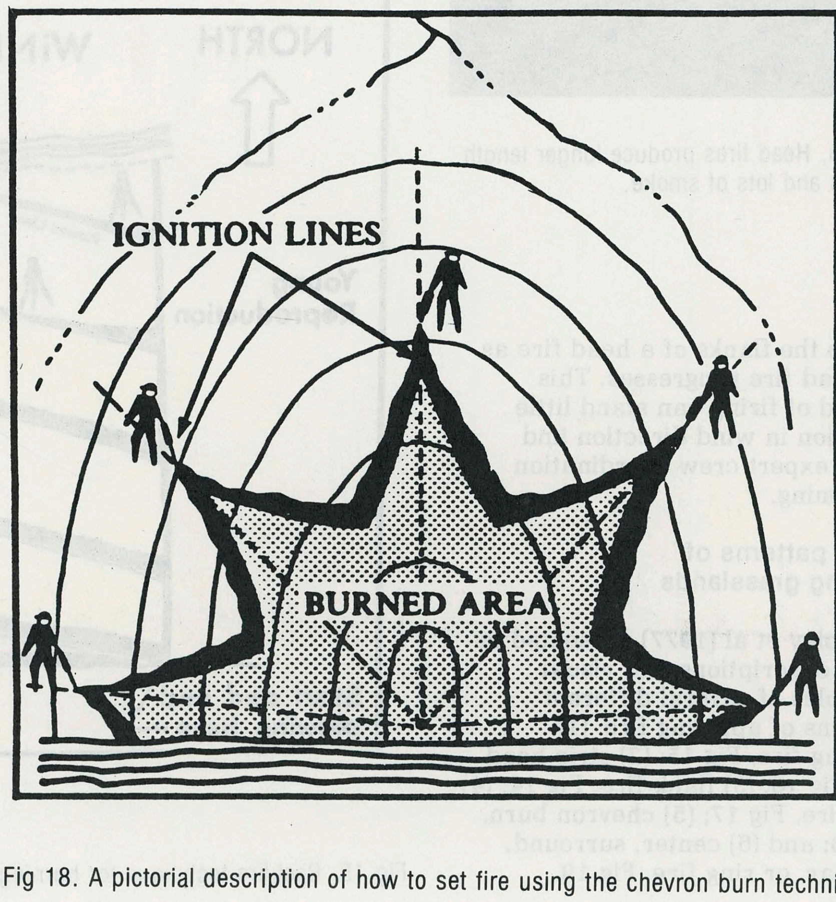


Fig 18. A pictorial description of how to set fire using the chevron burn technique.

## Basic way to conduct a burn

Assuming that all fire control actions, equipment, and people are complete and ready, we recommend starting all grassland fires in the following manner:

1. Determine the onsite wind direction by holding up a light cloth or by watching the smoke and fire behavior from a small (less than 2 sq m) test fire (Fig 21).

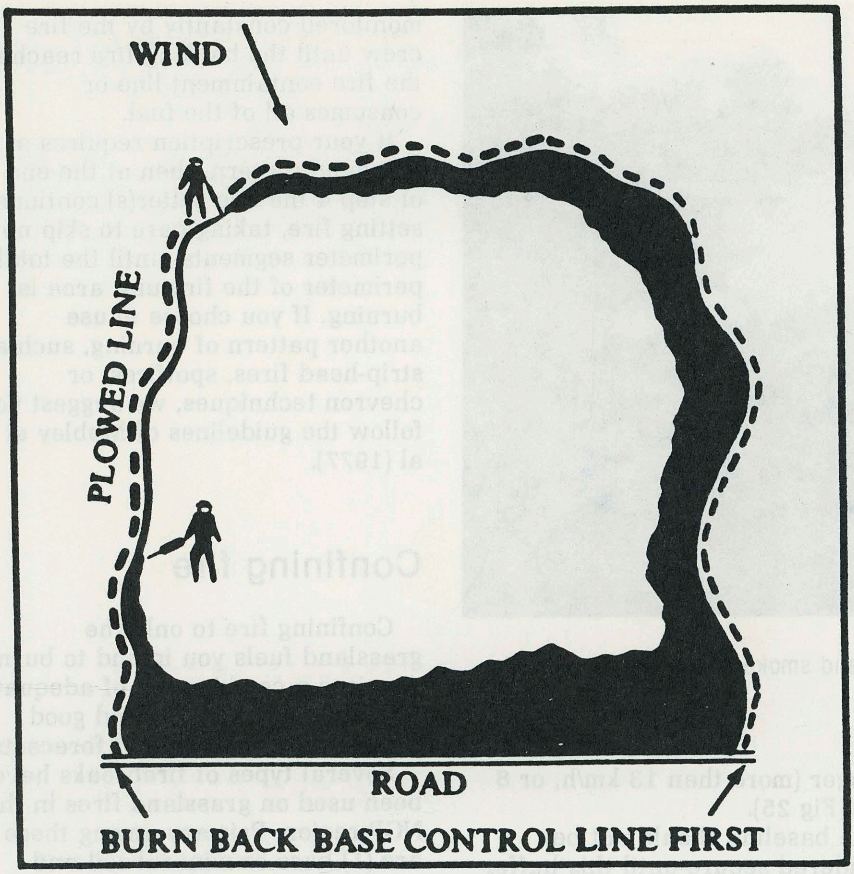


Fig 19. The ring, surround, or circular burning technique.

Fig 20. Burning an island of grassland cover surrounded by cultivated land.

2. Put out the test fire, then plot the wind direction as an arrow on your burn unit map. The point where the arrow strikes your farthest downwind firebreak or fire containment line is the baseline where you start the fire.
3. At the baseline, again go over the basic burning plan and procedures with your crew, explain alternate courses of action on the map (Fig 22) should the wind shift or should the fire breach a fire control line. (Examples of burning plans are found in appendices A, B, and C.) Inform the crew where you, the fire boss (Fig 23), will be during the sequence of the burn and how to keep in constant communication with you. Also provide contingency fire control plans for 90-, 180-, 270-, and 360-degree wind shifts.
4. If your crew has only one person setting fire and the wind is blowing perpendicularly toward a baseline firebreak, then start the backing fire at one end of the baseline. If the wind is blowing diagonally across a burn unit, start the backing fire at a corner or bend in the baseline.

If only one person is setting fire and starting at a corner, the fire should be set in a series. First set 100 m or less of fireline on one side and then about the same length on the other until a backing fire has been established along about a fourth of the perimeter length.

If your crew has two people setting fire and the wind is blowing perpendicularly to your baseline, start the fire at the midpoint of the baseline with fire setters moving in opposite directions from the midpoint (Fig 24). When the wind is blowing diagonally across your burn unit, start at the downwind corner with the people setting fire moving away from each other.

It is much easier to start a fire at a corner with two fire setters than with one. Corners and points are higher risk areas to burn than gradual curves, so when possible bend your fire containment lines

Fig 21. Determining onsite fire behavior and wind and smoke direction from a small test fire.

Fig 22. The basic burning plan for each burn should be outlined on a detailed aerial photograph or field map.

around corners and obstacles rather than using sharp angles.

After setting the fireline along the full length of the baseline and rechecking fire containment measures along the baseline, monitor the backing fire until it has burned a buffer strip 30 m (100 ft) wide. Increase the buffer strip to 60 m (200 ft) in width if winds are stronger (more than 13 km/h, or 8 mph) (Fig 25).

The baseline should not be considered secure until this buffer strip has been burned. Then and only then, can the fire boss prescribe action to complete the rest of the burn.

Steps 1 through 4 as presented above are recommended for any grassland fire. At the end of step 4, the rest of the burn can be completed with whatever burning pattern that fits your objectives, equipment, and fire crew size and experience.

For example, if your prescription requires a backing fire pattern, at the end of step 4 you set no new fireline and the old fireline is monitored constantly by the fire crew until the backing fire reaches the fire containment line or consumes all of the fuel.

If your prescription requires a surround pattern, then at the end of step 4 the fire setter(s) continue setting fire, taking care to skip no perimeter segments, until the total perimeter of the fire unit area is burning. If you choose to use another pattern of burning, such as strip-head fires, spotfires, or chevron techniques, we suggest you follow the guidelines of Mobley et al (1977).

## Confining fire

Confining fire to only the grassland fuels you intend to burn requires a combination of adequate firelines or firebreaks and good weather information and forecasts.

Several types of firebreaks have been used on grassland fires in the NGP region. Primary among these are (1) bare or mineral soil and tilled farmlands, roads, or trails; (2) streams, lakes, and wetlands; (3) wetline; (4) chemical retardants; (5) foam retardants; (6) mowed or hayed, or (7) burned or blackline strips or areas; (8) flappers and backpack water pumps; and (9) snowbanks.

Usually two or more types of firebreaks will be used on any one fire. Do not forfeit prescription objectives to get by with an easier or cheaper confinement method. Remember, fires are more difficult and dangerous to confine than to set.

Fig 23. The fire boss should keep the entire crew informed of his position during the sequence of the burn and of the procedure for constant communication among all crew members.

## Bare ground or mineral soil firebreaks

Cultivated or bladed bare soil firebreaks 5 m (15 ft) wide are probably best, but they are also the most expensive to establish and maintain in grasslands. If cultivated firebreaks are used during two or more successive years, problems with landscape scarring, soil erosion, and weeds can occur.

This type of firebreak (Fig 26) can be established by tilling with farm plows or disks, with bulldozers, road graders, or with soil sterilants. When implements or machinery are used to make bare soil, the vegetation and litter residue should be worked away from the prescription burn area along the firebreaks.

Erosion and landscape scar problems can be minimized on bare soil firebreaks by moving and spreading the former vegetation and debris back onto the firebreak after the completion of a burn. With this method, annual weeds will establish in one year and secondary succession of more permanent cover will evenly restore vegetation on the sites in the following few years.

Cultivated firebreaks can be established several days in advance of the prescription fire. Cultivated or bare soil firebreaks are also useful for fire research where experimental plots need annual protection as well as control during treatment. Flame lengths and chances of fire escaping along firebreaks can be reduced by mowing vegetation for 2-3 m (6-9 ft) on each side of the firebreak.

## Fire confinement lines

Costs of fire confinement can be reduced if natural and artificial firelines such as highways, roads (Fig 27), trails, tilled farmland, streams, lakes, wetlands (Fig 28), and snowbanks are utilized in fire plans. These firebreaks are only usable if they conform with smoke management and other prescription planning. Many small grassland areas can be burned using only the

Fig 24. Two people starting a backing fire at the midpoint of the baseline when the wind is blowing perpendicular to a baseline firebreak.

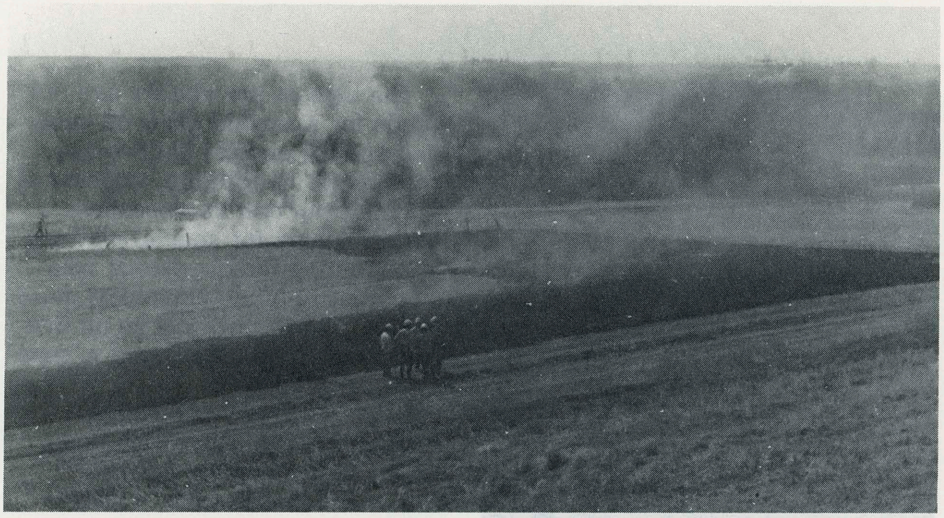

Fig 25. Back burning a buffer strip 30-60m (100-200 ft) wide before setting a head fire.

Fig 26. A barren soil firebreak made with a tractor and disk.


Fig 27. Roads can be good fire breaks but smoke can be a problem sometimes.

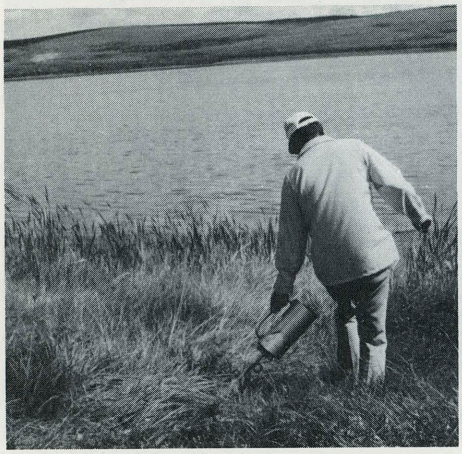

Fig 28. Using a wetland as a firebreak.

available natural or artificial firebreaks.

These firebreaks have few inherent problems except for potential smoke problems along roads or trails (Fig 27).

## Chemical retardants

Chemical retardants are usually applied on the fireline just prior to fire initiation. Retardants are excellent for fire confinement, and their use can eliminate tillage scars in native prairie.

The biggest drawbacks are the needs for a second crew on each fire and for special application equipment. In addition, the cost of the material can be expensive. Requirements for special clothing and training for the people who mix and apply the chemicals must be met. There also will be no fire containment on all sides of a burn area.

Some chemical retardants contain phosphorus which can affect native prairie through unnatural fertilization, which in turn might affect species composition or biomass production.

## Foam retardants

Foam retardants can be applied on a fireline just prior to fire initiation (Fig 29). They are excellent fire confinement tools, but they have the drawbacks of an additional crew and special equipment.

Some advantages of using foam over water and chemical retardants are that (1) foam expands the amount of water available and extends a given water supply 3 to 10 times, (2) it incorporates the characteristics of a wetting agent, (3) it has smothering and insulation effects, and (4) foam is more persistent and visible than water.

## Wetlines

Confining fires with wetline techniques (Fig 30) is similar to applying chemical and foam retardants, except that the water can be applied with simpler equipment and larger tankers will be necessary to carry large volumes of water.

Unlike retardant chemicals, water or wetlines can evaporate rapidly in fine grassland fuels, requiring that you be more cautious during fire initiation. The advantages of wetline techniques are that water is cheap and that simple equipment, even farm-type

Fig 29. Applying chemical retardant as a firebreak.

sprayers, can be used during application.

Wetting agents can be added to the water to enhance its cohesiveness to fuels. Several different wetline techniques have been described by Martin et al (1977).

### Mowing and haying

Firebreaks made by mowing or haying are probably the least desirable of the confinement types, especially if other techniques such as wetlining are not used at the same time.

We recommend that mowed or hayed firebreaks be extremely wide. The cut vegetation should be removed prior to setting the fire, and the prescription should call for a constant wind direction and speed.

Although this type of firebreak can be established several days in advance, more workers and perimeter surveillance are necessary to prevent fires from escaping by burning across vegetation that remains after mowing or haying, even though the fuel may be low to the ground.

Fig 30. Using a wetline as a firebreak.

### Flappers, backpacks, shovels, and rakes

We do not recommend trying to complete larger burns with only flappers, backpack water sprayers, shovels, and rakes, even though this equipment is required at most fires. Prescription fires can be contained with such tools alone (Fig 31), but costs in labor and time are great in proportion to the burn area.


Fig 31. Containing a fire with a backpack pumper and a flapper.

### Burned firebreaks

A common type of firebreak is a black-line strip that is burned to remove most fuels prior to burning the whole area. This requires setting and containing fires two different times on the same land area and usually requires the use of special water or retardant applicators.

### Snowbanks

Snow banks are a seasonal type of firebreak and are most useful when burning high-risk or difficult areas. For example, odd areas, rubbish, barnyards, manure piles, and old buildings (Fig 32) are safe to burn with full snow cover.

The primary types of firebreaks used by USFWS personnel are shown in Fig 33. In the prairie pothole region, combinations of bare soil, roads or trails, and streams or wetlands were used more than a single type.

## Smoke management

Smoke can sometimes be an undesirable element of a prescription burn. Every grassland fire emits smoke, and the fire boss is responsible and liable for any damages or air pollution violations due to smoke.

Fig 32. Burning unwanted buildings is best done when the ground has a full cover of snow.

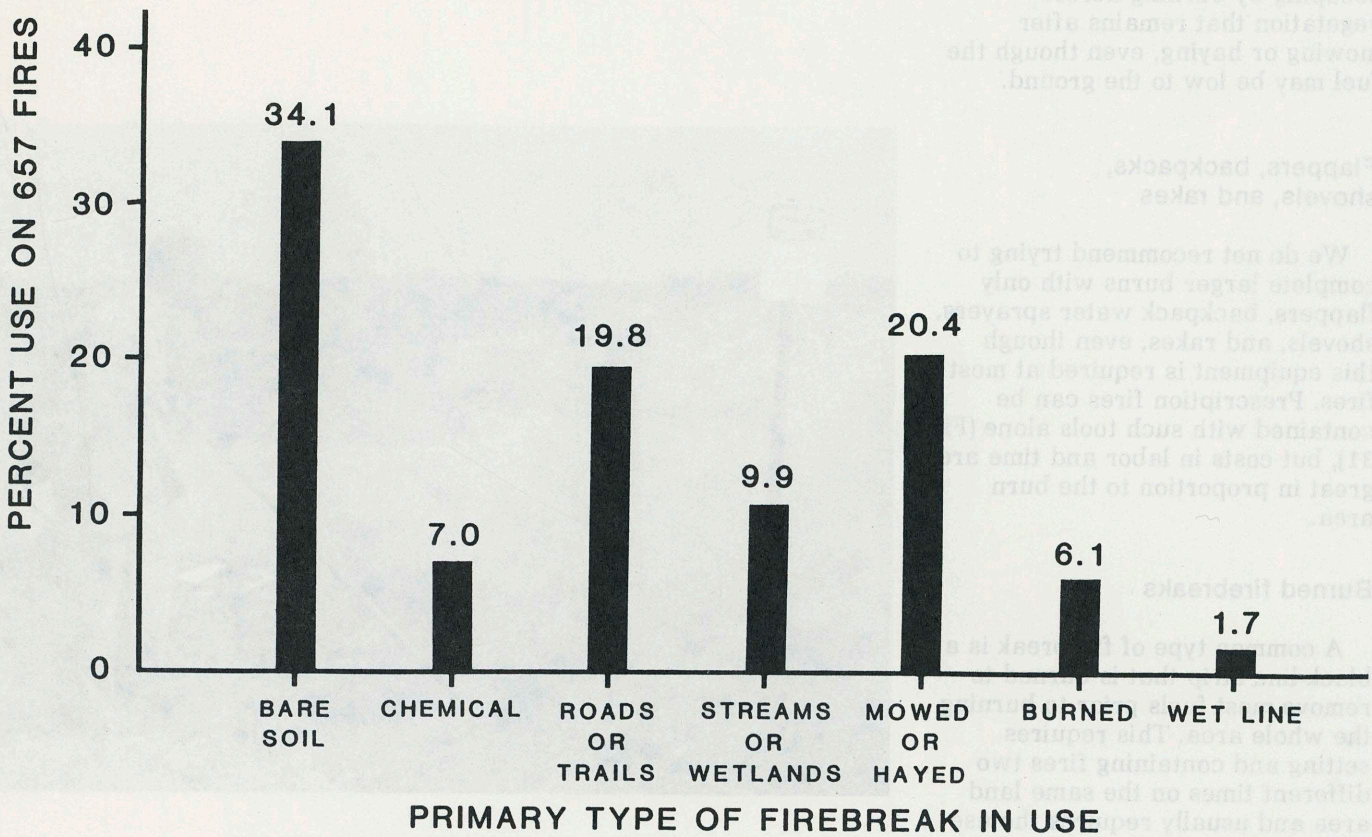


Fig 33. Percent of 657 fires by the primary type of firebreak in use on each fire on USFWS lands, 1965-1984.

Smoke can be highly visible and attract unnecessary attention. Smoke can also reduce visibility on highways and roads. We have spotted smoke from a 32-ha (80-acre) grass fire at a distance of 64 km (40 miles).

Smoke management is designed before the first match is struck. During preburn planning, use your knowledge of fuel moisture conditions, amounts of dead plant materials present (litter), and wind direction and speed.

General considerations for smoke management on any fire are:

1. Moist fuels produce more smoke than dry fuels.
2. Head fires produce more smoke than slower backing fires which give more complete consumption of fuel.
3. Smoke problems at night are more hazardous than during daylight.
4. Stable air mass conditions can cause air inversions which restrict smoke convection and dispersion. Unstable atmospheric conditions are usually better for smoke management.

Critical considerations for smoke management include the following:

1. A 360-degree check for possible restrictive air space (e.g. wilderness areas or national parks).
2. A 360-degree check for sensitive areas such as residences, highways, golf courses, airports, and public institutions.
3. A check of sensitive areas downwind of firebreak and fire containment locations, and of the wind direction and smoke flow necessary to reach these locations.
4. A check of the sensitive areas downwind and 45 degrees either side of initial wind direction. This will allow compensation for a wind shift which can cause a change in smoke flow.
5. An estimate of the length of time necessary to conduct the burn, plus a margin of error for wind shift or loss of speed, to predict smoke duration.
6. Notification of nearby residents, local fire departments, and if necessary, publicity about the burn through news media before burning.

Proper preburn planning and surveillance of restrictive and sensitive areas will minimize smoke management problems and adverse public reaction.

## Fire setting and confinement equipment

The following list provides a checkoff of items needed to set, contain, or extinguish grassland fires. We have placed asterisks beside the items necessary to all crews. The items without asterisks are optional or may be practical only on large burns.

Matches and/or sparkers*
Two-way radios (vehicle and portable)*
Flappers*
Rakes or hoes
Shovels
Fusees
Torches (drip or propane)*
Backpack pumps
Fire extinguisher (all vehicles)*
Extra torch fuel*
Extra engine fuel and oil*
Wire cutters (all vehicles)*
First aid kits and air splints*
Fire shelters*
Maps of burn unit and locale*
Drinking water*
Aerial ignition devices
Helitorch
Smoke masks, respirators
Goggles (chemicals)
Binoculars (1 pair/vehicle)
Fire pumper units*
Water tanker unit
Foam unit
Tool kit*
Bulldozers
Road graders
Tow chains, cables, or ropes*
Handyman jacks*
Chain saw
Chemical retardants (wet or dry)
Wetting agent
Belt weather kit*
Hard hats*
Tractor plus plow or disk
Safety clothing, e.g., Nomex*

As an additional precaution, extra sets of the necessary (*) items or an equivalent item should be kept on hand by each crew. A long handled scoop shovel is equivalent to a flapper; a road grader with blade is equivalent to a tractor and plow. Sometimes, budget and manpower constraints can be offset by equipment substitutions.

## Weather conditions

There is probably no element of a prescription burn more important than weather. Wright and Bailey (1980) contend that the secret to all prescribed burning is to let the weather work for you.

Weather is the main controlling agent of fire behavior, smoke behavior, fuel condition and flammability, and fire containment; all of these affect the success and safety of the burn.

### Important weather variables

The weather variables most applicable to prescription burns are air temperature, relative humidity, wind direction, wind speed, precipitation, and air mass stability (Sando 1969). Because most of the NGP has low topographic relief, general weather patterns are usually not affected by topographic features.

A combination of wind speed, relative humidity, temperature, and solar insulation largely determines fuel condition which, in turn, affects fire behavior.

Seasonal wind direction is important when burning near areas having restrictions or smoke regulations. Daily and seasonal precipitation patterns often determine when burns can be conducted, whereas days since measurable precipitation (greater than 1 mm, or 0.01 in) determine the severity of the fire or completeness of a burn in terms of fuel consumption.

## Temperature

Air temperatures higher than 20 degrees C (68 F) are recommended when prescriptions call for total fuel consumption. These include initial reclamation burns or burning to reduce undesirable plant species and medium to heavy coarse fuels like brush or trees.

Hot (high intensity) fires also produce higher risks than cool (low intensity) fires, thus requiring more emphasis on control measures.

Day length in the NGP varies from 8 hr in December to 16 hr in June. Hottest parts of a day during the main burning season (March-November) generally occur between 1100 and 1600 hr. Temperatures generally drop after 1600 hr and are usually coolest within 2 hr of daybreak.

Fire behavior and fuel conditions are most unpredictable when temperatures are rising during morning hours. This should be considered in any burn action plan. Temperatures between 21 and 32 degrees C (70 to 90 F) would be optimum for complete burns in the NGP.

## Relative humidity

Relative humidity is an expression of the actual amount of moisture in the air compared to the total amount the air is capable of holding at that temperature and pressure.

A temperature rise of 11 degrees C (20 F) from sunrise to midafternoon reduces the relative humidity by about one half. A similar temperature drop in late afternoon or early evening can cause relative humidity to rise by twofold.

However, when a cold front passes over an area, the temperature drop is usually accompanied by a drop in humidity. The lower humidity is a result of a change in air mass from warm and moist to cold and dry.

Preferred relative humidity for prescribed burning varies from 25 to 50%. Under certain conditions, a wider range of relative humidities—as low as 20% and as high as 80%—can produce satisfactory burns.

When relative humidity is as low as 20%, prescribed burning is dangerous because fires are more intense and spotting is more likely. When the relative humidity is higher than 50%, fires may not burn an area completely or may not burn hot enough to accomplish the desired result.

Relative humidity changes can quickly affect the moisture content and flammability of grassland fuels. Increases in air temperature and solar radiation cause relative humidity to drop, and falling temperatures and cloudiness or darkness cause relative humidity to rise.

Because relative humidity is so dependent on temperatures, sunlight, and precipitation, it is not a good weather variable to use for predicting fire behavior. Grassland fuels can be burned under certain conditions at any level of relative humidity (0 to 100%); however, we recommend that most prescription burns be done when relative humidity is between 20 and 80%.

## Wind

Prescribed fires behave in a more predictable manner if some wind movement is present.

The most desirable wind speeds for burning in the region are fairly steady winds between 8 and 29 km/h (5 and 18 mph), but specific conditions may tolerate higher speeds.

Persistent winds from a constant direction before, during, and after a burn provide the safest conditions for burning. Gusty or variable winds are indicators of unstable atmospheric conditions. Immediate changes in wind direction can cause instant fire control and smoke management problems.

Probable wind directions for any particular burn should be obtained just prior to burn time and from your best weather forecast source. Placement of firebreaks and other fire containment measures and smoke management are largely dependent on wind direction.

In this region, changes in wind direction are most likely to occur following calm or low wind speeds, and when winds are from east or northeast directions. Northwesterly winds are the most persistent.

Examples of some average prevailing wind direction information are shown for a sample of U.S. Weather Bureau reporting stations (Fig 34). This type of information is good for planning, but only local experience and forecasts should be relied upon for specific burns.

Average wind speeds are greatest in late winter and early spring (March-May) and least during summer (July-August). Daily wind speeds during the main burning season are least variable from about 1000 to 1600 hr.

Calm or low wind speed (less than 3 km/h, or 2 mph) days are not necessarily good burning days. Fire spread will be slow; the fire will take longer to complete and result in higher containment and labor costs; the fire will create its own wind and may change its own direction; and heat will dissipate more slowly, sometimes resulting in damage to non-target plant species.

## Precipitation

Amounts of rain (or rain itself) are difficult to predict. Knowledge of the precipitation date and amount prior to a burn will be helpful in predicting fire behavior and intensity and will help you decide what control measures are necessary. Expect more smoke from moist than from dry fuels.

Grasslands have been burned successfully just 9 hr after 1.2 cm (0.5 in) of rain. Cool burns are achievable when 1.2 cm or more of rain has fallen 24 to 36 hr prior to the burn. Hotter fires usually require 5 or more dry days prior to burning, but the drying time is dependent on solar radiation, air temperature, and wind speed. Average rainfall is highest in June; as a result, vegetative growth is greatest in June and early July. Consequently, burning conditions during June and early July are regulated by precipitation events more than in other months.

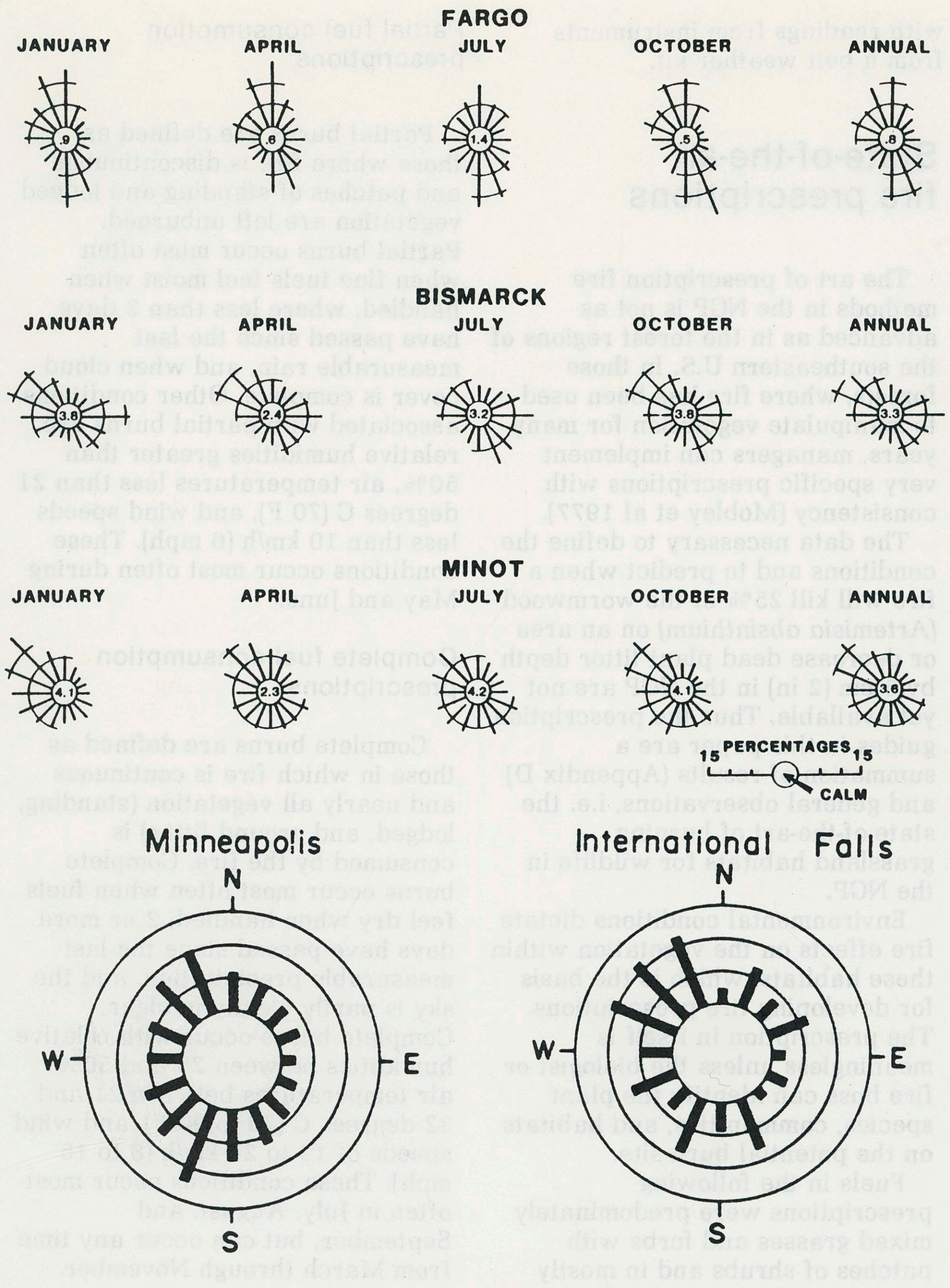


Fig 34. Average prevailing wind direction for some U.S. Weather Bureau reporting stations.

## Sunshine

Although we did not record sunshine duration or solar radiation during prescribed burns, we did notice some obvious differences in flammability of grassland fuels on sunny, partly sunny, and 100% overcast days. Fires spread faster and could be set sooner after rain on days with full or partial sunshine than on heavily overcast days.

Mobley et al (1977) reported that wide differences existed between air and fuel temperatures when fuels were exposed to sunshine and that moisture moved readily from the warm fuel to air, even though the relative humidity was high.

## Atmospheric stability

Atmospheric stability is the resistance of the atmosphere to vertical motion. A prescribed fire generates vertical motion by heating the air, but the strength of convective activity over a fire is affected by the stability of the air mass.

Strong convective activity will increase the drafts into the fire and can result in erratic fire behavior.

When the atmosphere is stable, a small decrease in temperature occurs with an increase in altitude. Under stable conditions, inversions can develop in which temperature actually increases with height.

Stable air tends to restrict convection-column development and produces more uniform burning conditions. However, combustion products are held in the lower layers of the atmosphere, especially under temperature inversions, and visibility may be reduced because of smoke accumulation. Temperature inversions can also be a problem at night.

When the atmosphere is unstable, there is a large decrease in temperature with height. Once air starts to rise, it will continue to rise, and strong convective activity may develop over the fire. Strong indrafts will help confine a fire to its prescribed area.

In extreme cases, the effect of air mass instability on fire behavior results in erratic spread rates and spotting. The burn no longer meets the prescription and might have to be extinguished.

Forecasts of low-level stability, inversion layers, or unstable conditions can be obtained from fire-weather forecasters. Local indicators at the fire site should also be observed. Indicators of stability are steady winds, clouds in layers, and poor visibility due to haze and smoke hanging near the ground. Unstable conditions are indicated by dust devils, gusty winds, good visibility, and clouds with vertical growth.

## Weather information sources

Three sources of weather information are available. Use at least one of these before starting prescription fires and during burning. The sources are (1) National Weather Service (NOAA),

(2) Fire Damage Rating System (not available in all states), and (3) local observations.

Field observations of weather should be made at or near the prescribed burn area before and during burning. Such observations serve as a check on the weather forecast and keep the burning crew up-to-date on any changes or effects of local influences.

Compact belt weather kits containing a psychrometer and windspeed measuring instrument are available. With this kit, and by observing cloud conditions and other weather indicators, a competent observer can obtain a fairly complete picture of current weather.

Successful grassland burning and smoke management is based largely on adequate weather knowledge. Before a fire is set, the weather forecast should be known for at least the next 24 hr and when possible for the next 48 hr. A weather forecast for the next 4 to 5 days might be necessary on a large fire with high risk or potentially bad smoke management problems.

The National Weather Service (NOAA) is usually the best source of local weather forecasts and information, particularly for forecasts of several days in advance. Most states have at least one toll-free telephone number available to cooperators or agencies. Ask for a spot weather forecast. Permanently staffed airport terminals are another good source of daily NOAA forecasts. Some National Weather Service offices will also furnish daily fire danger forecasts.

Secondary sources of weather forecasts and outlooks are the meteorologists at local television or radio stations, who should be able to provide reliable 48-hr advance forecasts. Many local radio stations or weather radios provide an early morning daily agricultural forecast from 0600-0900 hr that gives relative humidity, wind, temperature, etc.

Current weather information may be checked via two-way radio communication with an automatic or instant indoor-outdoor weather station at a local headquarters, or with readings from instruments from a belt weather kit.

## State-of-the-art fire prescriptions

The art of prescription fire methods in the NGP is not as advanced as in the forest regions of the southeastern U.S. In those forests, where fire has been used to manipulate vegetation for many years, managers can implement very specific prescriptions with consistency (Mobley et al 1977).

The data necessary to define the conditions and to predict when a fire will kill 25% of the wormwood (*Artemisia absinthium*) on an area or decrease dead plant litter depth by 5 cm (2 in) in the NGP are not yet available. Thus the prescription guides in this paper are a summation of results (Appendix D) and general observations, i.e. the state-of-the-art of burning grassland habitats for wildlife in the NGP.

Environmental conditions dictate fire effects on the vegetation within these habitats, which is the basis for developing fire prescriptions. The prescription in itself is meaningless unless the biologist or fire boss can identify the plant species, communities, and habitats on the potential burn site.

Fuels in the following prescriptions were predominately mixed grasses and forbs with patches of shrubs and in mostly prairie habitats. Nearly all of the fuels were less than 1.5 m tall, and brush and shrub stems averaged less than 2.5 cm in diameter.

### Low-risk prescription

Low-risk environmental conditions restrict the ignition or the spread of fires. Plots with complete snow or ice cover, or those ignited during rainfall rates higher than 0.05 cm/h, do not burn.

These are, however, good conditions for burning stockpiles of unwanted fuels such as manure piles and buildings, since such fuels are usually high-risk elements during regular prescribed burns.

### Partial fuel consumption prescriptions

Partial burns are defined as those where fire is discontinuous and patches of standing and lodged vegetation are left unburned. Partial burns occur most often when fine fuels feel moist when handled, where less than 2 days have passed since the last measurable rain, and when cloud cover is complete. Other conditions associated with partial burns are relative humidities greater than 50%, air temperatures less than 21 degrees C (70 F), and wind speeds less than 10 km/h (6 mph). These conditions occur most often during May and June.

### Complete fuel consumption prescriptions

Complete burns are defined as those in which fire is continuous and nearly all vegetation (standing, lodged, and ground litter) is consumed by the fire. Complete burns occur most often when fuels feel dry when handled, 2 or more days have passed since the last measurable precipitation, and the sky is partly cloudy to clear. Complete burns occur with relative humidities between 25 and 50%, air temperatures between 21 and 32 degrees C (70 to 90 F), and wind speeds of 13 to 24 km/h (8 to 15 mph). These conditions occur most often in July, August, and September, but can occur any time from March through November.

### High risk prescriptions

High risk fires are defined as those fires that are conducted during undesirable climatic conditions. High risk fires can always be expected with a combination of high winds, low humidity, high temperatures, and no recent precipitation. These conditions are most probable with wind speeds greater than 32 km/h (20 mph), relative humidity less than 20%, and air temperatures higher than 35 degrees C (95 F). These conditions occur most often in July, August, and September, but can occur any time from April through October.

### Climatic conditions on recent fires

The climatic conditions during which recent prescription fires were conducted on USFWS lands are shown in Figs 35-38. Over 90% of USFWS prescription burns were conducted with air temperatures of 5-33 degrees C (41-90 F) (Fig 35), relative humidities of 21-80% (Fig 36), and wind speeds of 1.6-32 km/h (1-20 mph) (Fig 37). No wind direction appeared to be favored (Fig 38).

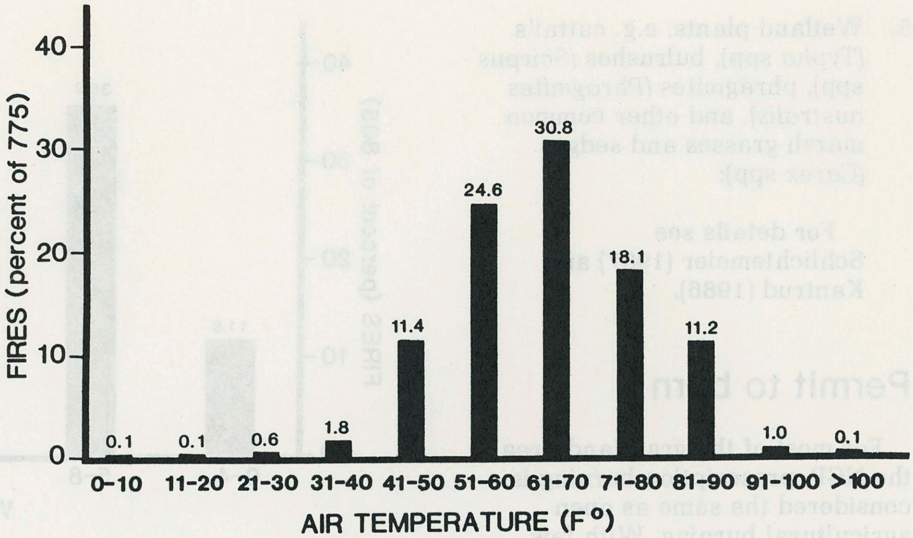


Fig 35. Percent of 775 fires by ambient air temperatures at the start of each fire on USFWS lands, 1965-1984.

### General prescriptions

Nearly all upland habitats in the NGP can be burned during any month of the year when there is no snow or ice cover on the ground. Our purpose here is not to describe burning strategies for individual species but to present some examples of when to burn selected habitats.

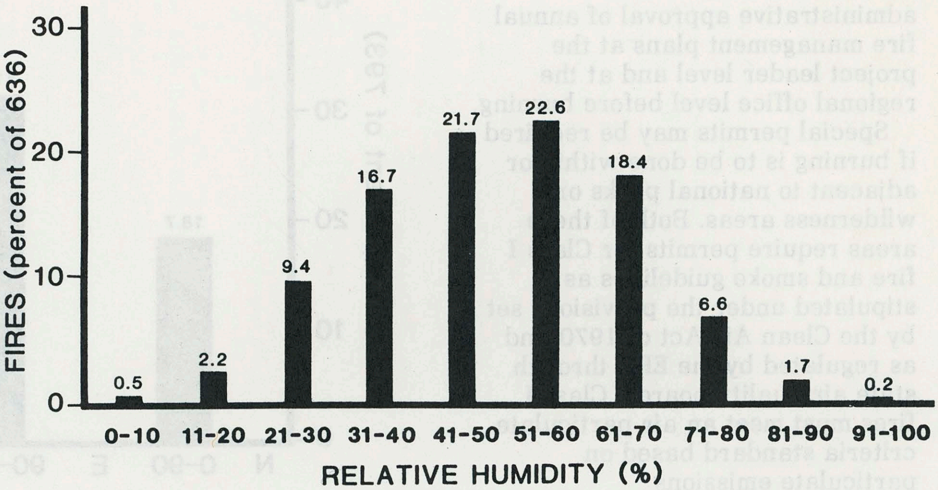


Fig 36. Percent of 636 fires by ambient relative humidity at the start of each fire on USFWS lands, 1965-1984.

1. Warm-season species, e.g. big bluestem (Andropogon gerardi), and little bluestem *(A. scoparius)*, Indiangrass *(Sorghastrum avenaceum)*, switchgrass *(Panicum virgatum)*, gentians *(Gentiana* spp), and Maximilian's sunflower *(Helianthus maximiliana)*:

   Best increases in seed production, vigor, and canopy cover are obtained with late spring (May-June) burns.

2. Cool-season species, e.g. green needlegrass *(Stipa viridula)*, Kentucky bluegrass *(Poa pratensis)*, needle-and-thread *(Stipa comata)*, western wheatgrass *(Agropyron smithii)*, quackgrass *(A. repens)*, pasque flower *(Anemone patens)*, and white onion *(Allium textile)*:

   Best responses are obtained with very early spring (March-April) or late summer (August-September) burns.

3. Mixtures of exotic cool-season grasses and legumes, e.g. smooth brome *(Bromus inermis)*, tall *(Agropyron elongatum)* and intermediate *(A. intermedium)* wheatgrass, alfalfa *(Medicago sativa)*, and sweetclovers *(Melilotus* spp):

   Best response with burns during March to June; least response by legumes in late summer-early fall burns.

4. Shrubs, e.g. western snowberry *(Symphoricarpos occidentalis)*, silverberry *(Elaeagnus commutata)*, chokecherry *(Prunus virginiana)*, and raspberry *(Rubus* spp):

   Spring burns (May-June) generally induce shrubs and brush to sprout, but frequent fires may reduce the frequency of woody plant cover.

5. Wetland plants, e.g. cattails *(Typha* spp), bulrushes *(Scirpus* spp), phragmites *(Phragmites australis)*, and other common marsh grasses and sedges *(Carex* spp):

For details see Schlichtemeier (1967) and Kantrud (1986).

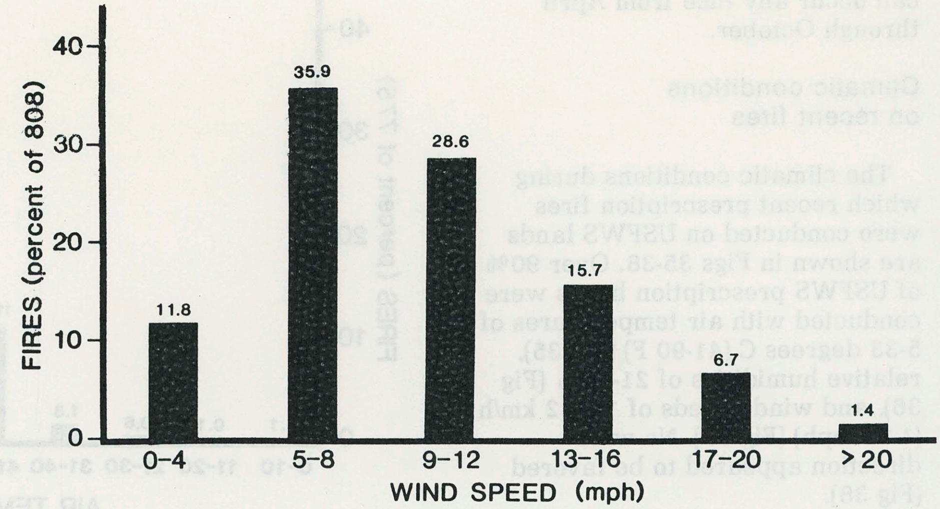


Fig 37. Percent of 808 prescribed burns by classes of wind speed at the start of each fire on USFWS lands, 1965-1984.

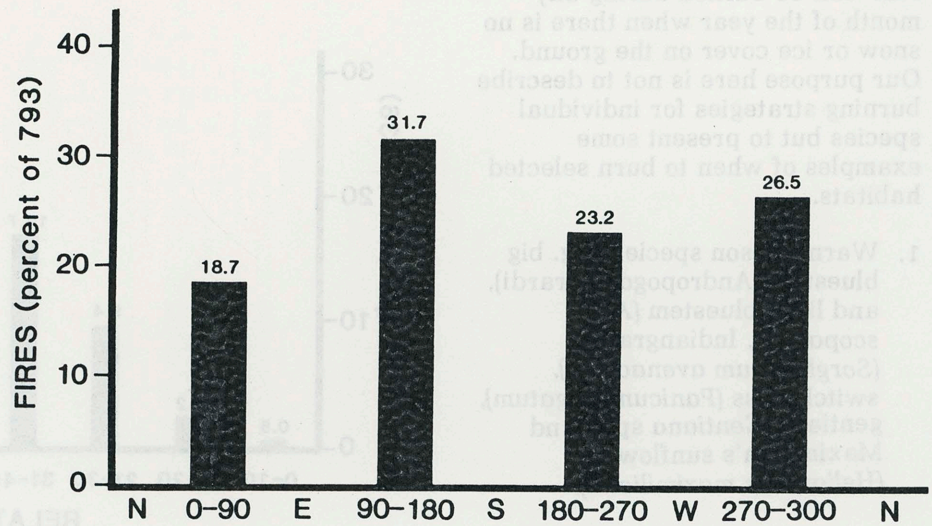


Fig 38. Percent of 793 fires by 90-degree quadrants of wind direction on USFWS lands, 1965-1984.

## Permit to burn

For most of the grassland area in the NGP, prescription burning is considered the same as open agricultural burning. With few exceptions, grassland burning variances and permits can be obtained on an annual basis from the appropriate state regulatory department.

Many public agencies, e.g. the USFWS, also require line administrative approval of annual fire management plans at the project leader level and at the regional office level before burning.

Special permits may be required if burning is to be done within or adjacent to national parks or wilderness areas. Both of these areas require permits for Class I fire and smoke guidelines as stipulated under the provisions set by the Clean Air Act of 1970 and as regulated by the EPA through state air quality boards. Class I fires must meet an air particulate criteria standard based on particulate emissions.

### Burn site constraints

Each burn site has its own set of constraints and sensitive issues. Final inventory and evaluation of the total set of constraints for each proposed burn site will help you decide if the site should be kept in your overall annual burn plan (see appendices E and F).

We recommend that all potential burn sites be arranged sequentially, starting with those sites with the least constraints. Constraints can be economical (high cost per unit of burn area); operational (poor access or repeatedly a high-risk fire problem area); environmental (highly erodible soil or high risk of air pollution); administrative (site includes a wilderness area or endangered species); regulatory (a moratorium on open burning); and conflictive (adverse publicity, multiple use area for both domestic livestock and wildlife production, or research versus management objectives).

Examples of sensitive issues or constraints include smoke problems in relation to residential areas, airports, highways, and roads; the presence of electrical poles and wires; adjacent farm crops or livestock; coal or oil deposits; presence of endangered biota or nesting and fawning areas; sensitive neighbors; or poor access for backup fire fighting or emergency medical equipment.

Deal with many of the constraints and sensitive issues well in advance of the actual time to burn. Leave time to recheck such things as the presence of livestock within a few hours or days of the burn. We recommend that a standard checkoff list be used on each grassland fire.

### Wilderness fires

The use of prescription fire in wilderness areas is still questionable. Wilderness as a term is a cultural value and not necessarily a natural value.

Pyne (1982) reported that not until the 1960s was it deemed more important to introduce fire than to suppress it in most wilderness areas. A fundamental change in philosophy held that, through prescribed fire, the "goodness" of the wilderness and its natural processes can be distributed to other landscapes.

There are only three grassland wilderness areas in the NGP: C.M. Russell NWR in Montana and Chase Lake and Lostwood wilderness areas in North Dakota, all of which are a part of the national wildlife refuge system administered by the U.S. Fish and Wildlife Service.

According to the USFWS refuge manual, wildfires in wilderness areas will be aggressively suppressed unless there is a previously approved plan for modified action or prescribed fire. Variances may be granted for either greater or less than standard suppression.

Obtain proper authorization before burning wilderness areas.

## Training fire crew members

Burning grasslands is not particularly difficult or dangerous if at least one crew member has some regional experience or training in the use of fire.

Private land managers often learn burning techniques from their own trial and error, but public land managers are subject to strict administrative guidelines relative to fire use. All public employees involved with the use of prescription fires must have a minimum standard for training and/or experience.

For people with major supervisory responsibility on fires, Wright and Bailey (1980) recommended a minimum of 2 years of prescription burning experience which is to include planning, conducting, and evaluating burns to achieve prescribed effects in a safe manner under a range of weather conditions.

### Classroom and field instruction

For smaller prescription fires on public grasslands in the NGP, all crew members should have the S-130 Basic Firefighter or an equivalent course. Under no circumstances should personnel conduct prescribed burning without completing the required training.

Fire bosses or supervisors should have additional instruction that includes a course on fire behavior. Large fire situations requiring interstate, interagency, or interregional movement of personnel should meet the minimum standards of the National Interagency Fire Qualification System (NIFQS) as published in the NIFQS Handbook of May 1979. Personnel who are part of interagency fire teams or crews should possess "red cards" which are fire job qualification cards certifying ability and training.

Initial classroom instruction usually consists of lectures, films, workshops, symposiums, demonstrations, familiarization with clothing and equipment, and field exercises. Advanced classroom instruction usually involves simulation exercises and mathematical modeling for predicting fire behavior.

Qualification for jobs on a fire crew requires classroom and field instruction plus hands-on fire experience.

### Fire management experience

People who have not used fire must first overcome their fears and inhibitions about the practice (Martin 1978). It is hard to strike that first match. Even seasoned users know that, with fire, something can always go wrong, that things can get out of control. Firing a prairie will appear to be a drastic move, "when maybe nature would take care of itself."

Too often, people use even the flimsiest of excuses not to burn, and this is just as wrong as burning without caution.

Whenever possible, we suggest that beginning burners work as observers, photographers, or even as apprentice trainees on a prescription fire, but always with direct supervision by an experienced and trained person.

Occasionally circumstances prevent any experience and one must experiment alone with a burn. Under these conditions, the first burn should be very small, just a fraction of an acre, and not too difficult. Conduct the burn where there is low escape risk such as on an island in an open wetland, on a hilltop surrounded by snow, or in a area of upland surrounded by plowed ground.

If you are on a prescription burn, take time after the fire is out to review, from the "why" of the planning to the burning itself. Too often, volunteers and trainee workers are simply given orders but never explanations by the burn boss.

In proper training programs, the importance of each piece of equipment and each task must be explained fully or problems will show up in future efforts.

## Safety

The safety of the people on your burn is your highest priority. Safety is promoted through training, removal of hazards, and through provisions for personal protective equipment and devices.

Be as careful on a small fire as on a large one; the "small" may indeed grow to "large." Besides the fire crew, plan for the safety of any other persons in the vicinity.

Many more people are injured than are killed by fires. Most fatalities occur during times of extreme fire danger or during high risk burns when people experience heat stress or are overcome by smoke inhalation.

### Physical fitness standard

The "Step Test" is a commonly used standard to rate the fitness of each crew member before going out to the fire. The step test is performed by stepping on and off a bench (40 cm, or 15¾ inches, high for men and 33 cm, or 13 inches, high for women) at the rate of 90 steps/min for 5 minutes. At the end of the 5 minutes of stepping, wait 15 seconds and then take a pulse reading for 15 seconds. The score is determined from a physical fitness calculator (U.S. Forest Service). Fire crew members should have a score of 45 or higher. There is also an alternate test of running 2.4 km (1.5 miles) in a prescribed time.

Occasionally, logistics and staffing result in some crew members not being physically fit. Common sense must prevail; less fit, usually older, weaker, and heavier people should be assigned to the less strenuous fire jobs and away from dense smoke and high heat stress situations. This is usually easy to plan because each fire job requires different physical effort, e.g. truckdriving vs. using a flapper on the fireline.

### Safety clothing

All people actively involved in conducting a prescription fire should wear safety clothing that, at minimum, includes:

1. hightop, 20-cm (8-inch) or higher leather boots or work shoes with non-slip soles and leather laces. Steel-toed shoes should not be worn for fire duty.
2. cotton or wool socks
3. Nomex slacks or pants, loose fitting, with the hems lower than the shoe tops
4. Nomex long-sleeved loose fitting shirts
5. leather gloves
6. hard hat
7. leather belt and/or natural fiber suspenders
8. belt pack case with an aluminum emergency fire shelter
9. cotton undergarments
10. goggles

Additional safety clothing or equipment may be required on specific jobs or situations. These might include:

| | |
|---|---|
| AM radio | flashlight |
| canteen | wire cutters |
| compass | first aid kit |
| flares | extra batteries |
| lip balm | ear plugs |
| map | handerchief |
| knife | ear muffs |
| food | face shield |
| matches | crash helmet |

Specific instructions should be given to not wear clothing fabrics that will melt or flame easily. These include nylon, polyesters, and plastics.

### Life-threatening situations

Serious fire encounters should be avoided at all costs; materials can be replaced whereas life is lost forever.

Some obvious indicators of potentially hazardous conditions are (1) flame lengths exceeding 1.2 m (4 ft), (2) fire brands or spot fires occurring ahead of the main fire front, (3) smoldering fires over a large area, (4) a sudden increase in wind speed or a large change in wind direction, and (5) thick, massive smoke held close to the ground for lengthy periods during darkness.

Unless you are trying to help another person, these are times to use your alternate escape route. When in doubt, **get out!**

### Equipment purchase and repair

Soon after the last fire of the burning season, repair and purchase equipment and start preparing for the next year's burning season. Fire work is hard on equipment. Purchase becomes a necessity when old equipment or clothing wears out or becomes unsafe and when new and better items become available.

Every item should be checked in a standardized annual evaluation process. When it comes to personal safety, no repair is too menial or too large, from the replacement of a button to an engine overhaul.

Make daily checks of all equipment after the completion of each burn. This may require a maintenance schedule different than the usual 8-hour daylight workday.

### Publicity

Publicity is necessary for every prescription fire. The local fire department chief and any neighbors within a reasonable distance of the burn unit should be notified in advance of a burn as well as on the burn day. Some localities may also have township or state pollution officers who should be contacted.

If necessary, provide all of these people with your name, office telephone number, agency affiliation, and when and how long the burn will probably take. If at the last moment the burn is cancelled, notify these same people.

Each burn crew member should know the names and phone numbers of the neighbors, the fire department, and nearest medical facility.

The general public should be informed of your plans and results of your use of fire as a grassland management tool. This is often done locally with articles in newspapers or magazines, or with illustrated slide talks or field tours before and after a fire.

Provide the press with a fact sheet of pertinent burn details for accurate reporting. Journalists are not required to show you advances of their stories, but ask anyway, so you can have input into the screening or editing of the final products.

If your publicity is to be aired on national media, you should pursue the necessary clearance with your superiors before you act or publicize.

### Equipment check and testing

Crew members should check over all equipment necessary for their job. We recommend that all motorized vehicles and equipment be operated until the engine is warmed up, then be turned off and restarted again under warm-motor temperatures.

All pumper units should be tested for spray pressure and spray patterns at all manual nozzle settings. All equipment and auxiliary containers should be checked for proper levels of fuel, oil, water, or other chemicals. Two-way radios and other communication equipment should be tested for working conditions and signal distance.

As an additional precaution, the fire boss may want to poll crew members about their own personal attitude and health status prior to setting the fire.

### Last-minute instructions

The fire boss, and only the fire boss, should give the last-minute instructions to the crew, but not until all of the preburn plans, publicity, preparations, weather checks, and equipment testing have been completed and meet fire boss approval.

At final instructions, the fire boss should go over the prescription plan for setting fire, containment actions, escape routes, plans for possible wild or escaped fire situations, and final reconnaissance and mop-up after the fire.

These instructions should be clear and understood by all crew members and they should include the chain of command and the location and job obligations of each crew member before, during, and after the fire.

A pre-burn environmental assessment (Appendix D) of each burn unit should be done a few days prior to the burn by a biologist experienced with fire. A biologist who is lacking in fire experience should consult another person with prescription fire experience. As a minimum, environmental assessments should include:

1. Estimating the amount and kind of fuels present.
2. Listing the growth and phenological stage of some key plant species.
3. Noting the seasonal activities of key faunal species (e.g. peak nesting period of ducks).
4. Surveying the condition of natural and artificial fire containment barriers and the proposed fire unit boundaries.
5. Rechecking the obvious sensitive areas or physical constraints.
6. Taking pre-burn photographs and marking locations.
7. Visually verifying the correctness of the main habitats on the base work map.
8. Noting past precipitation amounts and dates.
9. Noting any unnatural or abnormal conditions, e.g., lodged fuels that might affect fire behavior.
10. Noting any high risk environmental areas that might need to be excluded from the burn area.

The pre-burn environmental assessments should be made available to the fire boss as soon as possible.

## Post-burn monitoring, mop-up, and cleanup

The fire is not over until all of the burn unit and its fuel are cold and not producing smoke. There are three basic steps to post-burn assessment:

1. perimeter monitoring
2. necessary mop-up of smoking or burning pieces or patches of fuel
3. site cleanup.

The last two steps do not begin until the fire has burned across the burn unit.

### Perimeter monitoring

Perimeter monitoring of the burn unit is a continuous function from the onset of the fire until the fire boss proclaims the fire to be out and cold.

After the main passage of the fire, monitoring intensity can be lessened. Usually, one person can periodically drive around the perimeter of the burn unit, watching for fires or smoke.

### Mop-up

Mop-up includes any actions to put out smoke, hot coals, or flames from anything within the burn unit or within spot fire distances.

Mop-up actions may include drenching with water or fire retardant chemicals, smothering with a covering of soil or sand, flapping and raking the fuels apart, or, if time permits, just monitoring the area until everything gets cold and there is no more smoke production.

Occasionally junk piles, old barnyard manure piles, buried fence posts, etc, may burn for many days underground and then resurface across a fireline and start a wildfire. In these cases mop-up actions may be more complex and require heavy equipment to either bury or extinguish the smoldering material.

### Site cleanup

Post-burn site cleanup may be as simple as removing all personnel and equipment from an area or as complex as renovation of firebreaks and the removal of undesirable rubbish. Site cleanup activities should not begin until the burn unit is declared cold and all monitoring and mop-up are complete.

## Evaluation of fire effects on the environment

Evaluations (Appendix D) should be coordinated with objectives yet be concise, informative, and easy to do. Evaluations will become easier in the future because of the knowledge and experience gained with each fire.

## Evaluation of a grassland burn

Fire evaluation begins at preburn planning. The evaluation procedures should be made relative to fire effects on environmental variables and to any problems relative to fire behavior, burning patterns, fire control, personal safety, or adequacy of manpower and equipment.

Post-burn evaluations are the key to better future fire prescriptions.

### Adequacy of plans and preparations

An evaluation of the preburn, burn, and post-burn operations should take place soon after the burn is complete and should answer:

1. Were there any accidents?
2. Were there any fire control problems (escapes or near escapes)?
3. Were there any smoke or air pollution problems?
4. Was the burning pattern correct?
5. Was the burn practical, considering the constraints and sensitive issues or areas?
6. Were there any unexpected detrimental fire effects on the soil, water, vegetation, or wildlife?
7. Was there any adverse post-burn publicity or reactions?
8. Were the primary objectives met?
9. Should this grassland unit receive consideration for future fire management, or should alternate land use practices be used?
10. What would you do differently the next time this area is burned?

### Adequacy of the prescription on habitat manipulation

An evaluation of fire effects on the vegetation should be done in two or more steps.

Step 1 evaluations are usually made soon after the completion of the burn and include delineation of the burn unit on a map or aerial photo, description of the burn on the fuel load, an explanation of problems or successes, and directions for future action on successive burns of the same unit. Example questions for step 1 evaluations are:

1. Was the proper habitat manipulation (e.g. partial burn) achieved under the present fire prescription?
2. Were target exclusion areas left unburned?
3. How were woody species affected by the fire (leaves wilted, bark burst open, totally consumed, roots burned underground, etc)?
4. Did the fire create excessive soil exposure? It may not be possible to determine this until after a moderate amount of rain (0.5 inch) has settled the ash cover.

Step 2 evaluations are usually made at least 30 days or more after a fire and periodically during several post-burn years. Example questions for step 2 evaluations are:

1. Did the burn increase the biological productivity of the area (e.g. increased nesting success, increased plant species diversity)?
2. Did the burn enhance target plant species numbers or coverage?
3. What percentages of nuisance or noxious plants were killed or reduced by the burn?
4. Was the composition of the plant and animal communities altered by the fire? If so, how much?
5. For how many years after the fire were livestock gains still noticeable?
6. How many post-burn years of vegetative regrowth were necessary to bring litter accumulations back to the preburn status or condition?

A list like this could be very extensive, but for your records the primary evaluation should be kept in line with your objectives, preburn planning, and your prescription. It should be brief and yet descriptive.

Step 2 evaluations may be as simple as comparing a series of post-burn pictures of photo stations or as complex as evaluating waterfowl or game bird nesting success. Your post-burn evaluations are largely dictated by your preburn plans. Both are necessary for a successful, continuing burning program.

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# Appendix A:

An example of an extensive fire plan. This plan was developed for a specific site and, therefore, should not be copied as appropriate for anywhere else.

## SITE FIRE PLAN FOR BLUESTEM PRAIRIE
August 1983

1. Site:

Bluestem Prairie, Clay County, Minnesota. 1,200 acres. #14-2

2. Elements:

| | | |
|---|---|---|
| PC | black soil prairie NW Mn | B3/A |
| SP | Spartina gracilis | B3 |
| SP | Orobanche fasciculata | B3 |
| SP | Tofieldia glutinosa | B3 |
| SA | greater prairie chicken | B3 |
| SA | loggerhead shrike | B3 |

Also noteworthy: fen-like areas, Carex scirpiformis, Calamagrostis montanensis, sharp-tailed sparrow, Henslow's sparrow, upland sandpiper, prairie vole. Exact EO locations not currently known for all elements.

The prairie type has been further divided by Dziadyk and Clambey (1983) into communities dominated by 1) Bouteloua gracilis and Stipa spartea, 2) Andropogon scoparius and Sporobolus heterolepis, and 3) Andropogon gerardii and Calamagrostis inexpansa.

3. Status:

Site is owned by TNC, leased as a Scientific and Natural Area (SNA) to the State of Minnesota. Native prairie in Buffalo River State Park is adjacent to the north. 160 acres of prairie will probably be added to the preserve in 1983. No change in status is foreseen.

4. Fire Units:

Maps attached. The current preserve has four fire management units (I, II, III, IV). Boundaries between fire units approximately follow section or quarter section lines, except for the boundary between units III and IV which follows a course of relatively high ground.

Appendix A. (cont.)

Lines dividing units run east and west. This is appropriate since the land generally slopes from high elevations in the east to low elevations in the west. Each fire unit thus includes a range of high to low elevations and representations of most of the different soil types and prairie communities present. (See maps in Minnesota DNR 1980).

Perimeter breaks on the west side are close to occurrences of Spartina gracilis, and these should be avoided in firebreak preparation.

An earlier plan (Minnesota DNR 1980) called for eight fire units. Unless TNC receives more help from DNR with fire break mowing and prescribed burning, that plan is not feasible. The current proposal results in relatively large units, but is considered feasible. Units may be divided into smaller compartments to facilitate burning but this is considered discretionary.

The potential 160 acres addition to the south is tentatively designated as Unit V.

5. Objectives, Constraints on Site Planning:

A general objective is to produce a rotating mosaic of different structural conditions in the prairie. Two types of structures are considered: depth of mulch and plant density at different height strata. It is well documented that prairie plants (Weaver and Rowland 1952) and animals (Kantrud 1981, Kirsch et al. 1978) respond differentially to mulch and vertical structure. By producing unit to unit variation in structure we should be able to perpetuate the full diversity of native prairie species present on the site.

Specific objectives for Bluestem Prairie are:

1. Using the natural process of dormant season fire, remove 70% or more of the fine fuel litter in each fire unit at least once in 5 years. A 3 year fire interval is optimal. Allow mulch to accumulate between removals.

2. Maintain unit to unit variety of plant densities at different height strata. This will vary, in part, with the number of growing seasons since the last fire.

3. Accomplish objectives 1 and 2 in a mosaic, rotational pattern. Never burn more than 40% of the prairie in one season and year.

4. Maintain the principle native grasses in greater abundance than the introduced exotic, Kentucky bluegrass (Poa pratensis).

5. Maintain trees and shrubs to approximate their current distribution, with the exception of cottonwood trees along the artificial drainage ditches.

6. Adjust management if it appears to be responsible for significant reductions in any of the five special species (ranked B3).

7. Use special treatments as advisable to reduce sweetclover (<u>Melilotus spp.</u>) and state-listed noxious weeds on the preserve.

The major constraints on fire management with intentional burning are the large size of the preserve and high value private buildings near the preserve. Public misunderstanding of fire management has been as impediment in the past. It is important to burn when winds will not carry smoke into sensitive areas and to explain fire management to local residents. These units require more crew and equipment and more secure firebreaks than most other smaller prairie preserves in the state.

6. <u>Schedule</u>:

| | Units | | | | |
|---|---|---|---|---|---|
| Year | I | II | III | IV | V |
| 1 | | | S/F | | |
| 2 | May | S/F | | | S/F |
| 3 | May | | | S/F | |
| 4 | (May) | | S/F | | |
| 5 | | S/F | | | S/F |
| 6 | S/F | | | S/F | |
| 7 | | | S/F | | |
| 8 | | S/F | | | S/F |
| 9 | S/F | | | S/F | |
| 10 | | | S/F | | |
| 11 | | S/F | | | S/F |
| etc. | | | | | |





7. <u>Rationale</u>:

The fire schedule calls for burning on a three year rotation, with burns conducted in either spring or fall (S/F). Fire management may slip up to two years behind schedule before failing the fire frequency objective. Initially, a different treatment is assigned to Unit I. The two or three successive May burns in Unit I are intended to set back the exotic Kentucky bluegrass (see Justification). There is large old field in the eastern parts of units III and IV, but annual burning would not be helpful there because of low productivity. Other disturbed areas in the site are not significant enough to warrant special recovery efforts with fire treatments.

Spring burning can be any time from snowmelt through about mid May. Fall burning is usually any time after the first hard frost, but preferably after leaf drop of woody vegetation. Fire timing may be narrowed if exotic or shrub species are observed to become problems (see Justification).

Very little information is known on the fire responses of the site's element species, with the exception of prairie chickens (see Justification). Loggerhead shrikes prefer low shrubs mixed in open prairie. The normal patchiness of burns and the three year fire interval will probably provide sufficient low shrubs for the species.

No fire effects data are available for <u>Orobanche</u> <u>fasciculata</u>, <u>Tofieldia</u> <u>glutinosa</u>, or <u>Spartina</u> <u>gracilis</u>. Information is available on <u>Spartina</u> <u>pectinata</u> which suggests how <u>S.</u> <u>gracilis</u> may respond to fire.

Hadley (1970) found <u>S.</u> <u>pectinata</u> to have 15 times greater weight per $m^2$ in spring burned plots compared to unburned controls. Pemble et al. (1973) showed flowering by <u>S.</u> <u>pectinata</u> to be stimulated by spring burning. This unpublished study was conducted on a tract adjacent to Bluestem Prairie. Kirsch and Kruse (1973) reported a decline in <u>S.</u> <u>pectinata</u> following burning. Thus, two of three studies show a positive effect.

The assumption is that periodic fall and spring burns, generally recommended for tallgrass prairie management, will be appropriate for these members of the tallgrass community (see Justification).

8. <u>Other Vegetation Management</u>:

The objectives call for maintaining unit to unit variation in vertical structure but no specifications to increase structural diversity within units. There are two ways in which this may be considered in the future.

Appendix A. (cont.)

The greater prairie chicken prefers low stature and low litter areas for courtship displays in spring. This is not provided except if units are burned the previous fall. Prairie chicken tend to go off the preserve onto adjacent cultivated and grazed fields for courtship behavior. They may be encouraged to stay on Bluestem Prairie by localized mowing or fall burning. If done, this would have no major effect on the scheduled burning program.

Variation in plant structure within units is increased by light to moderate grazing by large herbivores. At present there seems to be no compelling benefit from this and it would probably favor introduced and weedy native species.

Haying is not considered an optional alternative to fire, but could be used as a contingency if burning becomes temporarily impossible within 5 year intervals due to constraints.

Especially wide perimeter firebreaks are prepared as a fire control measure, but this has no effect on the burning program.

Spot herbicide treatment of certain weeds, such as leafy spurge, likewise has no effect on prescribed burning.

The biennial sweetclover (Melilotus spp.) is a problem in Bluestem Prairie. No solution is at hand but mowing late first year plants or second year plants may be utilized to reduce the problem. This might affect fuels for burning, but should require only minor adjustments in scheduling fires.

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1 Copies of each are in TNC MRO literature files.

## PRESCRIBED FIRE PLAN

**Site:** Bluestem Prairie **#:** **County, State:** Clay Co., MN

**Protection Status:** Owned by TNC, leased to State as Scientific & Natural Area.

**Qualified Fire Leader(s):** Jeff Weigel

**Sources of emergency assistance (location, phone):**
**Fire:** Glyndon 218/498-0100 **Medical:** Moorhead 218/293-7744

**PERMITS REQUIRED, SOURCE*** *see attachment

**State Pollution Control:** Open burning: Ron Swenson, 612/296-7300, Roseville, MN.

**State Forestry:** Burn, Dist. Forester, 218/732-3309 or 218/299-5041, Park Rapids, MN.

**County Permit:** Clay Co. Planning Dept., Jack Frederick, 218/233-2781, Moorhead, MN.

**Local Permit:** None required, notify Riverton Twsp. Board: Jepson & Becket, see below.

**Other:** None

**NOTIFICATIONS:** *see attachment

**Fire Departments:** Glyndon, Chief Jerry Green (H) 218/498-2244, Fire # 498-0100

**State Law Enforcement:** State Patrol 218/237-7756

**Local Law Enforcement:** Clay Co. Sheriff, Moorhead, 218/236-8181

**Other Officials:** DNR Conservation Officer, Tom Campbell, Hawley 218/483-4241; Denton Jepson, 498-2895 and Everett Beckett (h) 498-2516, (w) 233-5787. Media: Hawley Herald 218/483-3306, Fargo Forum 701/235-7311, Dorothy Collins.

(Attach a list of neighbors, other contacts to make before burning.)





**Prescribed Burn Plan for:** Bluestem Prairie 

| Fire Unit | Size Total/ Burnable | Target Fire * Dates & Time | Legal Description |
|---|---|---|---|
| I | 240 acres/200 acres | May for next 2-3 yr. | NW-¼ & S-½ of NE-¼, Sec. 15. |
| II | 320 acres/270 acres | Oct. or Apr. | SW-¼ & SE-¼, Sec. 15. |
| III | 420 acres/400 acres | Oct. or Apr. | In E-½ Sec. 22 & W-½ Sec. 23. |
| IV | 220 acres/200 acres | Oct. or Apr. | In E-½ Sec. 22 & W-½ Sec. 23. |

*See Site Fire Plan.
All burns start after 2 pm, are completed by 9:30 pm.

| Fire Unit | Major Fuels and Fuel-related Objectives: |
|---|---|
| I IV | Mostly tall grass, about 2-5 tons/acre. Reduce litter by 70%, prevent new encroachment of woody shrubs/trees. Flame length and rate of spread predicted to be 8-15 ft. and about 300 ft/min. at hot end of prescription, 4 to 8 ft. and about 90 ft/min. at cool end of prescription. This is based on calculations with T1-59 modified by experience. |

| Fire Unit | Tempera-ture | Relative Humidity | Wind Speed MPH/ Direction* | Days since rain of fuel conditions |
|---|---|---|---|---|
| I | 55-70° | 30-50% | 5-15 W, SW or S best. | 2 or more days since rain. |
| II | same | same | 5-15 S best | same |
| III | same | same | 5-15 W or SW best | same |
| IV | same | same | 5-15 W, SW, W best | same |

*Direction preferred which minimizes smoke in direction of roads and houses, but this is not a condition of burning.

Appendix A. (cont.)

**Prescribed Fire Plan for:** Bluestem Prairie pg. 3

| Fire Unit | Equipment Items, Number Required. Use attachment if more space needed. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Pump Cans | Swatters | Drip Torch | Torch Fuel | Tank Truck | Radios | Weather Kit |
| I-IV | # 6 + | # 4 + | # 2 | # 10 gal | # 1 DNR unit | # 3 | # 1 |

Truck borrowed from DNR. All other equipment - TNC.
* Water available at State Park HQ.

| Fire Unit | Crew Size, Qualifications | Firebreak Specifications |
|---|---|---|
| I | 8 people, see TNC guidelines | Mow and rake 30' wide or road |
| II | 8 people, see TNC guidelines | same |
| III | 10 people, see TNC guidelines | Mow and rake 30' wide |
| IV | 8 people, see TNC guidelines | Mow and rake 30' wide |

| Fire Unit | Hazards on and close to Fire Unit | Expected fire Duration |
|---|---|---|
| I | Heavy fine fuels; smoke on roads, in houses; fire in adjacent fields and buildings. | 3 to 5 hrs. |
| II | same | 3 to 5 hrs. |
| III | same | 3 to 6 hrs. |
| IV | same | 2 to 4 hrs. |

**Source of crew:** 6 TNC, 2 or more volunteers
**Estimated cost of fire work:** About $1,000 per yr. for crew and travel.
**Are any exceptions requested to Nature Conservancy guidelines and standard procedures?:** Yes **Specify:** Firebreak specification is below Guidelines standard.

**Attach checklist for reference just prior to burning.**
**Attach map showing firebreaks and major features of unit(s).**

**Plan Prepared by:** Jeff Weigel **Date:** 20 Sept. 1983

**Plan Approved by:** **Date:**

**Is approval by Regional Attorney Required?:** No **If yes:**
**Plan Approved by:** **Date:**

Appendix A. (cont.)

**Prescribed Fire Plan for:** Bluestem Prairie Attachment

LIST OF NEIGHBORS, OTHER CONTACTS TO MAKE BEFORE BURNING

1. Vernon Anderson -lives on east boundary
2. Al Arneson, Sr. -owns land to south
3. Al Arneson, Jr. -owns land to south
4. Everett "Bud" Beckett -lives west of tract, on Town Board, 498-2516 (h), 233-5787 or 233-1561 (w) CONTACT ALL BURNING DAYS.
5. Don/Lois Vincent -live along tract, helpful neighbors.
6. Gary/Judy Miller -live west of tract, friendly, TNC members.
7. Steve Taves -Turkey farmer to north, 498-0161 (h) CONTACT ALL BURNING DAYS.
8. Devitt Farm -live along tract- may be new resident - check
9. Denton/Theresa Jepson -Town Board Chairman
10. Gerald Andel -Town Board Member
11. Lynelle Boone -Town Board Secretary -works at BRSP.

For supplementing crew:

1. Dr. Richard Pemble, Moorhead State University (w) 218/236-2572.
2. Dr. Gerald Van Amberg, Concordia College (w) 218/299-3520.
3. Dr. Gary Clambey, North Dakota State University.

Appendix A. (cont.)

**Prescribed Fire Plan for:** Bluestem Prairie Attachment

**PERMITS REQUIRED**

1. Permit for Open Burning. This is a two page form on letterhead of the Minnesota Pollution Control Agency (PCA). Permit is valid when all required information is filled in and it is signed by an authorized PCA representative. PCA requires legal description of areas to be burned to be on or attached to the permit. Numerous sites burned over a several week to several month period may be covered in one permit. TNC generally receives permits from the State Office, though permit authority also resides in PCA Regional Offices and certain county officials.

2. Permit to Burn. This is a printed form about 4 by 5 inches issued by the Minnesota Department of Natural Resources. It must be signed by a Forestry Officer or Township Fire Warden and by the Permittee, and be in possession at the time of burning. These are usually issued for only one site and a limited time interval, but more inclusive permits have been obtained. The permit has been issued by Paul Rundell, DNR Region I Resource Coordinator, Bemidji, but may also be obtained at the Park Rapids District Forestry Office.

3. County Permit. This permit needs to be picked up at Clay County Planning Dept., 2nd floor Clay County Courthouse, 807 N. 11th, Moorhead. This permit has to be taken to the fire chief, signed, and returned. In the past it has been mailed back. When picking up permits, be sure to get for other Clay Co. tracts.

**NOTIFICATIONS**

Notifications and neighbor contacts require a large effort (see attached list and map of contacts which should be continually updated). It is very important that they are done, and that good records are kept. **Steve Taves, the turkey farmer north of the RR tracks, must be contacted prior to all burns so he can activate ventilation systems in his barns.** Everett "Bud" Beckett has asked that he also be contacted prior to all burns. Call him at work if necessary. Contact the District Forester if DNR permit is obtained elsewhere.

**CREW DEVELOPMENT**

Backfire along downwind firebreak burn to 100-200 foot width. Complete with headfire. Ignitors and holding crew should watch for spot fires and perform preliminary mop-up. After igniting is completed, double-check perimeter for sleepers or smoldering spots. One crew member assigned to weather/fire monitoring. Crew may be needed along roads if smoke obscures visibility.

# Appendix B:

An example of a brief fire plan involving a low risk site within a wetland.

A. Area Identification

1. Bolstand WPA, Brookings County
   Total acreage - 40 acres
   Proposed prescribed burn acreage - 6 acres (2 islands)

   The islands are original native sod. The prescribed burn will remove mulch and reduce cool season invaders, while improving the warm season natives.

B. Burning Plan

1. Preparation for Burning

   The islands will be burned as close to May 1 as possible, but only if surrounding water is open enough to act as a good fire break. A 2-man burn team, using 2 drip torches and one 150 gallon pumper will conduct the burn, using the circular ring fire technique. Estimated cost is $100.

2. Ignition

   Fire will be ignited with drip torch in a circular ring fire pattern.

3. Holding and Control

   The prescribed burn will be done only if the surrounding water is open enough to act as a good fire break. The islands are of small size and the burn team will be adjacent to water at all times. The water serves as an escape route.

4. Mop up

   Personnel will remain in the area ½ hour after completing the burn to insure the fire is out.

# Appendix C.

An example of a brief fire plan for a site that is part of a larger comprehensive burn plan such as shown in Appendix A.

A. Area Identification

1. Coteau Prairie WPA, Deuel County
Total Acreage - 320 acres
Proposed prescribed burn acreage - 20 acres

The area is original native sod. The prescribed burn will remove mulch, and increase vigor and density of the native grasses.

B. Burning Plan

1. Preparation for Burning

The area will be burned as close to May 1 as possible. Wind will need to be in a southerly direction for smoke management. A 3-man burn team, using 2 drip torches, one 150 gallon pumper, and one 300 gallon sprayer will conduct the burn according to guidelines set forth in the Station Fire Plan. Estimated cost is $300. A phosphate line will be sprayed on the north, west and east sides of the portion north of the old road.

2. Ignition

Area north of road will be ignited first, beginning on the north side, followed by lighting the flanks from north to south.

Area south of road will be ignited from the south side of the road.

3. Holding or Control

A pumper unit will be placed on the east and west ends of the prescribed burn area. An escaped fire would be backfired from a phosphate line farther north on the WPA.

4. Mop up

The burn team will remain on the area an hour after the burn, using swatters and the pumper unit to extinguish any smoking residue within 100 ft. of burn perimeter.

## Appendix D. An example of an evaluation form for a burn site.

Residual Cover Measurements
1. Mean Height-Density Obstruction (Robel) per field:__.__dm.
2. Mean Height-Disc Readings per field . . . . . . . .:__.__dm.
3. # lbs. of Fuel per acre (clipped and dry wt.) . .:______.
4. Other . . . . . . . . . . . . . . . . . . . . . . .:______.

Plant Species that are in First or Early Bloom

1. ______ 4. ______
2. ______ 5. ______
3. ______ 6. ______

Stage of Development of Key Brush Species

| Species | Stage of Growth Development (flower, full leaf, boot, height, etc.) |
|---|---|
| 1. | |
| 2. | |
| 3. | |

Stage of Development of Key Forb Species

| Species | Stage of Growth Development |
|---|---|
| 1. | |
| 2. | |
| 3. | |

Stage of Development of Key Grass Species

| Species | Stage of Growth Development |
|---|---|
| 1. | |
| 2. | |
| 3. | |

Effects of Burn on Key Species of Brush (left standing, bark burst, burned to ground, etc.)

| Species | Effects on Plants |
|---|---|
| 1. | |
| 2. | |
| 3. | |

Effects of Burn on Key Species of Forbs

| Species | Effects on Plants |
|---|---|
| 1. | |
| 2. | |
| 3. | |

Effects of Burn on Key Species of Grasses

| Species | Effects on Plants |
|---|---|
| 1. | |
| 2. | |
| 3. | |

Notes on General Effects on the Vegetation.

Evaluation of Wildlife Effects During and After the Fire

Effects on Mammals

| Species | Type of Effect (attraction, death, etc.) |
|---|---|
| 1. | |
| 2. | |
| 3. | |

Effects on Birds or Nests

| Species | Type of Effect |
|---|---|
| 1. | |
| 2. | |
| 3. | |

Effects on Reptiles and Amphibians

| Species | Type of Effect |
|---|---|
| 1. | |
| 2. | |
| 3. | |

Other Effects on Wildlife______________.

List Any Fire Control Problem(s) Encountered

1. ______
2. ______
3. ______

List Most Probable Cause for the Problem(s)

1. ______
2. ______
3. ______

List Measures Taken to Correct the Problem(s)

1. ______
2. ______
3. ______

General Notes and Remarks

## Appendix E:

Conditions requiring immediate burn plan adjustments.

**RED FLAG SITUATIONS**
(from Mobley et al. 1977)

IF ANY OF THE FOLLOWING CONDITIONS EXIST, ANALYZE THE SITUATION FURTHER BEFORE MAKING DECISION TO BURN.

1. No written plan
2. No map
3. Heavy fuels
4. Dry duff and soil
5. Inadequate control lines
6. No updated weather forecast for area
7. Forecast does not agree with prescription
8. Poor visibility
9. Personnel and equipment stretched thin
10. Prescribe burning large area
11. Communications for all personnel not available
12. No backup plan or forces available
13. No one notified of plans to burn
14. Behavior of test fire not as prescribed
15. Smoke sensitive area downwind

IF ANY OF THE FOLLOWING CONDITIONS EXIST, CURTAIL BURNING AND PLOW OUT EXISTING FIRE

1. Fire exhibiting erratic behavior
2. Wind shifting or other change in weather
3. Smoke not dispersing as predicted
4. Road or other sensitive area smoked in

## Appendix F:

**FIRE SITUATIONS THAT SHOUT "WATCH OUT"**
(from 1980 Nat. Wildfire Coord. Group, Handbook No. 3, Washington, D. C.)

1. You are building a fireline downhill toward a fire.
2. You are fighting fire on a hillside where rolling material can ignite fuel below you.
3. You notice the wind begin to blow, increase or change direction.
4. You feel the weather getting hotter and drier.
5. You are on a line in heavy cover with unburned fuel between you and the fire.
6. You are away from a burned area where terrain and/or cover makes travel difficult and slow.
7. You are in country you have not seen in the daylight.
8. You are in an area where you are unfamiliar with local factors influencing fire behavior.
9. You are attempting a frontal assault on a fire with tankers.
10. You are getting frequent spot fires over your lines.
11. You cannot see the main fire, and you are not in communication with anyone who can.
12. You have been given an assignment or instructions not clear to you.
13. You feel like taking a little nap near the fireline.

## Appendix G:

Example of drip torch and fire retardant mixture that have been used in grassland fuels.

**DRIP TORCH FUEL MIX RATIO**

| Gasoline | Diesel | Volatility |
|---|---|---|
| 1 gallon | 4 gallons | low |
| 1 gallon | 3 gallons | moderate |
| 2 gallons | 2 gallons | high |

**LIQUID FERTILIZER MIX**
**(heavy to phosphate)**
**10 - 34 - 0**

| Water | Solute | Application |
|---|---|---|
| 10 gallons | 1 gallon | Fire breaks |
| 20 gallons | 1 gallon | Heavy Grass and Litter<br>Fighting escapes, etc. |

A 10:1 mix may be effective for up to 6 hours on a good day, but not always.