

Endorsed

**FIRE ECOLOGY AND MANAGEMENT OF
SCOTTS BLUFF AND AGATE FOSSIL
BEDS NATIONAL MONUMENT:
Final Report. April 1, 1994.**

FIRE ECOLOGY AND MANAGEMENT OF SCOTTS BLUFF AND AGATE FOSSIL BEDS NATIONAL MONUMENT: Final Report. April 1, 1994.

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INTRODUCTION

- The bulk of the reporting on this project was in the form of a comprehensive master's thesis submitted to the National Park Service in July, 1993. The 188 page thesis was structured to meet research objectives specified in the original proposal and was jointly written by the masters candidate, Kyle Wendtland, and the project Principal Investigator, Jerrold Dodd. In addition to the thesis, a user friendly Personal Computer-based vegetation data analysis program and users manual, VEGECALC, that was designed specifically for this project and prepared by Reeves and Dodd was also submitted to the NPS in 1993.

In accordance with the January 17, 1994 request of Gary Willson, the Project Officer for this NPS project, this report is submitted to complete our obligations to the NPS by providing recommendations for fire management and monitoring of long-term vegetation dynamics at Scotts Bluff and Agate Fossil Beds National Monuments. In addition to the written recommendations Dodd will make an oral presentation of results and recommendations to Gary Willson and the NPS staff at Scotts Bluff and Agate Fossil Beds National Monuments in late spring, 1994. Further, Dodd agrees to serve as a resource to the staff of SBNM-AFBNM as they develop specific long-term management and vegetation monitoring plans. Recommendations made below are based on details presented in the thesis and on the Principal Investigators' general experience in grassland ecology and management in the northern mixed prairie of the Northern Great Plains.

RECOMMENDATIONS

USE OF PRESCRIPTION BURNING AND GRAZING FOR VEGETATION MANAGEMENT

Native Plant Communities

Prior to the influence of European civilization the grasslands of the western Great Plains were subjected to periodic heavy grazing by migratory herds of bison and point fire return intervals that averaged 5 to 30 years (Wendtland and Dodd 1992). The longer intervals were associated with lands that have numerous natural fuel breaks. In fact, grasslands of the region that routinely produced spatially continuous grass cover may well have had return intervals of less than 5 years and as short as 2 to 3 years. The grasslands in both Scotts Bluff and Agate Fossil Beds were contiguous to massive areas of grassland. Since both SBNM and AFBNM routinely have continuous cover of fuel loads that exceed the minimum necessary to spread fire during late summer and early fall it is prudent to conclude these specific areas probably had fire return intervals of 5 years or less. Most of the fires within the Monuments would have

originated, primarily, from fires ignited by lightning that occurred up to many miles away on adjacent grasslands in mid- to late summer and possibly early fall¹. Exceptions to this are the few woodland and grassland communities isolated by the non-vegetated portions, i.e. fuel breaks, of the bluffs at SBNM. These small sites would only have burned when struck by lightning and, consequently, would have burned less frequently--perhaps every 20 to 30 years.

If the management goal is to manipulate vegetation to resemble its pre-European settlement structure and species composition by reintroducing the ecological effects of natural fires then a prescription burn program should be implemented. The plan should consist of summer fires, probably in August, with a fire return interval of 5 years or less i.e., 20%, or more, of the area of each Monument, including riparian zones, should be burned per year. This policy should allow both subtle and dramatic changes (which will occur mostly in arborescent communities) in the Monuments' terrestrial ecosystems to occur and eventually return these fire adapted ecosystems to their pre-settlement state.

The prescriptions and plans for these summer burns must obviously meet fire safety requirements. However, it is equally if not more important that the prescriptions allow the proper ecological impacts on the ecosystems. Therefore, spring fires or even August fires conducted under prescribed conditions that result in a cool and highly controllable fire have different ecological impacts than high intensity fires that are more characteristic of the pre-settlement summer wildfires. In order to satisfy the safety as well as ecological requirements it will be necessary to develop wider fuel breaks than are necessary for cooler fires. If it proves absolutely impossible, due to technical or political limitations, to conduct summer burns then fall burns should be done. If fall burns are used they should be done every two to three years. Spring burning has such different impacts on these grassland communities that they should be avoided completely.

There are few absolute certainties in predicting responses of these grasslands to fire. Therefore, it is important to monitor progress of these communities and particularly populations of exotic plant species. If it appears that exotic species begin to invade the native communities then the situation must be investigated and adjustments to management made. Prescription herbicide programs should be continued in both Monuments as needed. It may also be necessary to incorporate prescription grazing by large ungulates (bison, cattle, or sheep) in conjunction

¹ It is important to note that the primary factors regulating length of point fire return intervals in pristine grassland environments was continuity of fuel and fire spread conditions. Individual fires covered massive areas of the Great Plains. Under presettlement conditions a fire that burned a particular geographic point usually originated from a lightning strike that happened many miles away. In some cases these fires would have been fast moving wind aided fires but in many cases these fires would have been slow moving fires that moved 10's or 100's of miles over many days or weeks. Based on examinations of the behavior and extent of fires in ecologically similar but undeveloped grasslands of Mongolia today the area of a single fire could easily have been 100,000's or even millions of acres.

with the other vegetation management tools. We will delineate two examples where such practices might be desirable.

Generally speaking, grassland types that are ungrazed for long intervals of time tend to have reduced populations of forbs and abnormal accumulations of litter and standing dead plant material. This situation can be mitigated by grazing with large ungulates, such as bison or cattle, that preferentially select grass plants for their diet. Another example is the expansion of exotic plants, such as leafy spurge, into native or successional grasslands. Several managers have achieved effective control of leafy spurge with various singular applications or combinations of burning, herbicides, and grazing by sheep. Although the thought of using domestic animals to restore natural impacts within the Monuments may sound repugnant to some they are the only feasible choice in many instances (Plumb and Dodd 1993).

Bison are very difficult and expensive to handle and it is almost impossible to make arrangements for intermittently grazing bison in any area. Sound scientific research indicates that cattle and bison have similar impacts on plant communities. Cattle are readily available in the region and can be easily manipulated to impose ecologically correct large herbivore grazing impacts on both SBNM and AFBNM. Therefore, the prospect of introducing large ungulates on a prescription basis in the first example clearly favors cattle over bison. In the case of leafy spurge the beast of choice appears to be sheep or possibly goats.

Oldfield Succession Sites

Numerous areas within SBNM and AFBNM are occupied by abandoned croplands. In the cases where "natural" succession is expected to move these toward climax communities a separate fire management plan is required. We include natural in quotes above because succession that occurs on these sites today is in the presence of certain exotic species that were not in the Great Plains at the time of settlement. Since some of these species, especially cheatgrass (*Bromus tectorum*), are capable of dominating these sites for 50 or more years these sites do not meet the standard of natural succession. Therefore, "unnatural" approaches are probably justified in manipulating these communities toward more natural mixtures of native plants.

Our investigations of the abandoned croplands in AFBNM revealed several important facts (Table 1). The first is that nearly 30 years of succession has resulted in only a very simple community that is dominated by cheatgrass. This very competitive grass accounts for more than two-thirds of aboveground net primary productivity and perennial grasses make up less than 5% of AGNPP. Native and exotic forbs make up the remainder of the community. In contrast, native perennial grasses contribute more than 95% of total AGNPP on the regions native grasslands. It is doubtful that native plants will dominate this community within the next 50 years or even longer unless something is done to weaken cheatgrass.

In our experiment, cheatgrass was substantially reduced in the first growing season following summer and fall burning and the residual effects of this treatment extended into the

Table 1. Production (peak standing crop, July, mean $\pm$ standard error, g/m², N=30) of major species and ecological functional groups of plants by year and fire treatment (CN=Control, FA=Fall burn, SU=Summer burn, SP=Spring burn) for cheatgrass dominated abandoned cropland study site at Agate Fossil Beds National Monument. AGSM=Western wheatgrass, STCO=Needleandthread grass, TOTPG=Total perennial grasses, BRTE=Cheatgrass, SPCO=Scarlet globemallow, OFORB=Other forbs, SAIB=Russian thistle, TPROD=Total plant production.

	$\frac{1}{1}$	$\frac{9}{9}$	$\frac{8}{8}$	$\frac{8}{8}$	$\frac{1}{1}$	$\frac{9}{9}$	$\frac{8}{8}$	$\frac{9}{9}$	$\frac{1}{1}$	$\frac{9}{9}$	$\frac{1}{1}$	$\frac{9}{9}$	$\frac{9}{9}$	$\frac{9}{9}$	$\frac{9}{9}$
	CN	SU	FA	SP	CN	SU	FA	SP	CN	SU	CN	SU	FA	SP	SP
AGSM	3±1	+	4±1	1±+	5±2	2±1	10±4	11±3	6±3	12±4	6±3	12±4	44±6	19±5	19±5
STCO	4±1	±	2±1	1±1	1±1	5±2	±	1±1	2±2	±	2±2	±	7±5	1±1	1±1
TOTPG	7±2	1±+	6±2	1±1	6±2	7±3	10±4	12±4	8±3	12±5	8±3	12±5	51±9	20±5	20±5
BRTE	75±4	73±4	86±4	91±5	38±4	20±3	7±1	34±3	258±6	260±13	203±14	283±8			
SPCO	2±1	+	1±1	+	3±1	+	1±+	2±1	+	+	+	+	+	+	+
OFORB ²	33	35	37	28	4	3	6	8	+	+	+	+	+	+	+
TFORB ¹	35±7	35±8	38±7	28±8	7±1	3±1	6±2	10±2	+	3±1	+	+	+	+	+
SAB	-	-	-	-	52±3	145±8	136±8	43±4	-	-	-	-	-	-	-
TTPROD	117±7	108±7	130±7	120±8	104±4	175±6	159±6	99±4	266±7	286±11	254±11	304±7			

² Other forbs includes russian thistle and all forbs other than scarlet globemallow in 1988 and 1990 but did not include russian thistle in 1989.

³ Total forbs includes all forbs in all years except 1989 when this category does not include russian thistle.

second season after burning. Both fall and summer burns, presumably, reduced cheatgrass by reducing the viable seed population and severely altering growing conditions at the soil-litter interface by reduction of the litter layer. We suspect fall burning had a greater impact on wheatgrass because fire also destroyed newly germinated seedlings of this winter annual species that normally germinates in September, before the date of the fall burn. Spring burning did not change cheatgrass production in the year following treatment. The major perennial grasses of the native communities at AFBNM are western wheatgrass and needleandthread grass. Western wheatgrass AGNPP was increased by all seasons of burning on the abandoned cropland but was favored most ($\approx$ 10-fold increase) by fall burning. Although needleandthread grass and a few other perennial grasses occur on these successional grasslands they occur only in very low densities compared to western wheatgrass. As discovered by other scientists and confirmed by our research at both SBNM and AFBNM native and, in some cases, exotic forbs are favored by both summer and fall fires.

As a means to accelerate succession towards a native plant community the abandoned croplands should be burned annually or at least biannually with hot fall burns for the next several years (possibly 10 years). This burn frequency will favor forbs and western wheatgrass and reduce cheatgrass. These sites should be monitored and as these expected changes occur the fire frequency should be shifted to once every four or five years as with the other communities in the Monument.

It is likely that annual or biannual burning is too frequent for some native species, including needleandthread grass, threadleaf sedge, and blue grama, and that a fairly simple community composed primarily of the Monuments most fire-tolerant species--western wheatgrass and scarlet globemallow and some other forbs--will result from this management within a decade. If this occurs and the cheatgrass disappears or diminishes to a very low level as expected then changing the fire return interval back to 4 or 5 years should allow other native species to gradually become established in the community. However, the dense stand of western wheatgrass should prevent cheatgrass from reestablishing as a dominant. The return of the full spectrum of native species will happen more rapidly on portions of these fire-manipulated abandoned croplands that are closer to native unplowed communities because the native communities constitute the reservoir of germ plasm.

Smooth Brome Sites

Several of the former croplands in SBNM are currently dominated by planted stands of smooth brome, an introduced forage species, with low densities of a few native species as secondary components. The goal of SBNM management is to have these sites covered by native grassland communities. Smooth brome is very competitive but will eventually diminish and possibly disappear from these sites and native species will increase. However, this process may take 20 to 40 years or more. It appears smooth brome is less sensitive to summer and fall burning than is cheatgrass. This is primarily due to its rhizomatous growth form (where the perennating meristematic tissue is a few inches belowground and protected from heat released from surface fires). A contributing factor is that at the times we burned there was, and

generally is, less fuel on the ground surface of the smooth brome sites than on the cheatgrass sites at AFBNM. The lack of litter on the ground and the fact that a greater proportion of the dead leaves and stems of smooth brome stay erect and above the soil surface results in less heat being eliminated near the ground surface than in the cheatgrass dominated community.

Although it may be worthwhile to attempt to accelerate succession of the smooth brome sites to a native community by annual summer burning it is likely this approach will not work. This approach could be used for a few years and the plant populations carefully monitored. If change does not occur or appears to be too slow another approach should be instituted. By one management practice or another the smooth brome population must be weakened considerably before substantive invasion, recolonization, and eventual domination of the site by native species will take place. This may be attempted by intensive grazing at critical times of the year, herbicides, plowing or disking or combinations of two or more of these factors.

It may also be necessary to introduce seeds of the major native species. Introduction and establishment of these plants may require mechanical treatments such as interseeding or disking followed by broadcast seeding and chaining or, ultimately, drill seeding. Rapid establishment of native species will be necessary to minimize the risk of the area becoming a thicket of exotic annuals following elimination of the smooth brome. Under no circumstances should the area be fertilized because this will favor exotic species.

VEGETATION MONITORING

The vegetation mosaic in both Monuments is a complex mixture of many different community types. It is therefore impractical and quite expensive to monitor long-term changes of all plant populations and all community types. Only the major communities in each Monument should be monitored.

We suggest continuation of monitoring of a portion of the permanently marked vegetation monitoring sites we established for our studies. These sites include one upland native grassland vegetation site at each Monument, an abandoned cropland site at AFBNM, and a smooth brome site at SBNM. Each of the study sites we established includes cells that were not burned but were monitored and served as controls for our burning experiments. Each cell has 30 permanently located 0.5 m² circular plots. These cells are replicated three times at each site (a total of 90 permanent plots per site) and could be monitored on a routine basis. Although annual monitoring of peak standing crop of current years production by the double-sampling weight-estimate method, using the same plant species and groups we used in our study, provides extremely valuable ecological information for interpreting long-term vegetation dynamics it is rather time-consuming and expensive to perform. We recommend monitoring peak standing crop of major plant species and ecological function groups of plants every three to five years.

Another limitation of utilizing production is that this parameter does not easily yield useful data for individual secondary species. This is because sample adequacy for determination of annual production of secondary species requires far larger samples than for dominant species.

The permanent production plots can also be used to monitor density and/or frequency of occurrence by individual species. These parameters provide information of lesser value than does production for dominant species but are satisfactory measures for documenting large order changes in abundance of secondary species at the species level. Although canopy cover is a useful parameter for measuring change in the more common secondary species and some dominant species it is a difficult parameter to estimate and use as an index of change for the less common secondary species. As with the use of biomass, the problem with this parameter for determining change in rarer species is sampling adequacy. Less common species require huge numbers of samples to attain levels of precision equivalent to those yielded by relatively small sample sizes for the more common species.

Boundaries between and areas occupied by the major community types (grasslands, riparian zones, woodlands, and possibly fundamentally different types of grasslands and woodlands) at both Monuments can be monitored by aerial photography. Periodic mapping of these types can be done by securing color aerial photographs from flights over the Monuments every five years or so. The flights should be done in the fall when the color distinctions between the vegetation types of main interest are the greatest. Immediately after each flight the color photos can be taken to the field and boundaries of the types carefully traced on the photos by field vegetation survey technicians. This imagery can then be transferred readily to Geographic Information System data bases for future comparisons and interpretations.

Since the permanent monitoring sites established in our study are on a limited number of community types it is desirable for the NPS to establish additional study sites in other community types at each monument. The same parameters and design should be used. The methodology we used will work for monitoring change in all herbaceous community types and in understories of riparian and woodland communities. Additional measures need to be incorporated to document change in the woody overstories of riparian and woodland types.

Although several methods have potential for monitoring change in the arborescent component of these communities we suggest the use of permanently located line intercept transects. This procedure records canopy cover and geographic location of the major woody plants along 100 meter tapes that are placed between permanent markers in each community type. The measurements are straight forward in that they consist of linear measurements of the interval of the tape covered by the canopies of woody plants. Data can be easily recorded by species. We suggest a minimum of three transects per community type. Belt transects that record both canopy cover and woody plant density are also a possibility. Belt transects provide more information but require more effort and time to read.

In the woody plant communities the line intercept transects for woody components and permanent plots for monitoring the herbaceous components should be located together. Each of the three transects should have permanently marked endpoints. Thirty herbaceous monitoring plots can be equally spaced along the transect and also marked with a permanent low profile iron stake. This will make it convenient to find each herbaceous monitoring point. Care must be taken when reading the line intercepts so that the vegetation in the herbaceous monitoring plots

is not damaged by the feet of the individuals taking the measurements.

The data reduction and summarization routines in ~~VEGECALC~~ are robust enough to process all the data generated by the methods suggested in this report. The manual that accompanies the software is also written in a straight forward fashion and should be easy for resource specialists and technicians to use following a brief orientation and training period. The vegetation monitoring protocol formulated for SB and AFB National Monuments must, obviously, be compatible with the fiscal and human resources available to prepare and execute a plan of work. Therefore, an exact monitoring plan can only be prepared when available resources are known. ~~The most critical monitoring to be done is that in support of the intensively managed former croplands where the management goal is to convert the existing vegetation to native upper seral communities.~~ Vegetation monitoring information is important in evaluating past management actions and making adjustments in management plans that govern future management decisions and actions. Key sites in these communities should be monitored at least every two years with more superficial field notes taken on the sites each year. The remaining communities should be monitored every three to five years. ~~Large inter-annual variations are characteristic of the type of native grasslands that occur in both Monuments. Therefore, the periodic monitoring of these grasslands should be conducted throughout both Monuments in the same year.~~

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THE FIRE HISTORY OF SCOTTS BLUFF NATIONAL MONUMENT

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Abstract. Determination of presettlement fire return interval, seasonal occurrence of fire, and estimation of fire intensity is difficult in grassland ecosystems, which lack woody plants to carry fire scars. A review of published scientific literature, historical journals, diaries, narratives, letters, military records, eye witness accounts, and National Park Service fire records was conducted to reconstruct a fire history for Scotts Bluff National Monument (SBNM). Fire history prior to 1935 was determined for the general land area west of the confluence of the North Platte and South Platte rivers to Fort Laramie Wyoming, north to the Black Hills and south to the Kansas border. For the period after 1935, the review concentrated specifically on SBNM. The presettlement fire return interval was estimated at 15-30 years, and fires occurred primarily in the dry season—late summer and early fall. In contrast, the postsettlement fire return interval was greater than 50 years, and fires occurred in the spring. Fire intensities were greater in presettlement fires. Prescription burning for management of natural areas should probably mimic presettlement fire characteristics in order to have the same ecological influences on community composition.

INTRODUCTION

Grasslands of the Great Plains developed and were maintained by seasonal periods of aridity that created flammable fine fuels in sufficient quantities to propel natural and man-made fires through grassland ecosystems (Albertson and Weaver 1945, Stewart 1953, Kucera 1981, Axelrod 1985). Fire is, therefore, an important force in the regulation and maintenance of species composition in grassland ecosystems (Daubenmire 1968, Vogel 1974).

The vegetation of Scotts Bluff National Monument (SBNM) has probably undergone change in species composition over the past 200 years because of alterations in the fire return interval, in seasonal occurrence of fires, and in fire intensity. These factors have been found to influence the floristic composition of the northern mixed prairie (Shantz 1947, Dix 1960, Wright and Bailey 1982, Bock and Bock 1984, Smith et al. 1985, Muhlbachler 1986, Steinauer and Bragg 1987). Invasions of grasslands by fire-sensitive woody plant species have been associated with lengthened wildfire return intervals (Kucera 1981). Harrison (1980) and Steinauer and Bragg (1987) observed the invasion of ponderosa pine (*Pinus ponderosa* L.) in Sandhills prairie south of the Niobrara River in north-central Nebraska. Fisher et al. (1986) concluded that woody plants have invaded sites historically occupied by grassland or savanna ecosystems at Devil's Tower National Monument in northeastern Wyoming. More subtle changes in herbaceous species composition on grasslands also occur as a result of alterations in fire return interval, season of fire occurrence, and fire intensity (Dix 1960, Conrad and Poulton 1966, Daubenmire 1968, Wright and Bailey 1982).

Because of a lack of trees to carry fire scars, there are few reliable published summaries of natural fire attributes in the northern mixed prairie (Wright and Bailey 1982). Further, the fire accounts which do exist are often incomplete and contain limited information regarding exact time, location, size of fires, and estimated fire intensity. However, defensible estimations of presettlement fire return intervals, seasonality, and fire intensity can be inferred from the combined use of historical references and recently published fire history literature.

The objectives of this research were to determine fire return intervals, seasonal occurrence of fires, and relative intensity of fires prior to and following settlement of SBNM.

METHODS

The fire history of SBNM was reconstructed by reviewing published literature, historical records, and National Park Service (NPS) TF-1202 fire records for SBNM. For the period prior to 1935, the review of historical records and published literature was conducted for the land area situated west of the confluence of the North and South Platte rivers to Fort Laramie Wyoming, north to the Black Hills and south to the Kansas border. Literature from this period was reviewed on a regional basis because few fire records specifically referred to SBNM. For the period following 1935, the fire history review concentrated specifically on SBNM because of the existence of NPS fire records.

Records from the Henderson collection of Oregon Trail Records (University of Wyoming Archives Collection), the Wyoming State Historical Society (Cheyenne, Wyoming), and the Cook collection (SBNM Nebraska) were searched. For the period prior to 1935, 759 historical records were reviewed including journals, diaries, narratives, letters, military records, and eyewitness accounts. The source, location, date, size, cause, and observer of each fire was recorded and stored in a Data Base Three Plus format. A copy of the data base is located at the SBNM library. In addition, we reviewed recently published literature pertaining to presettlement fire return intervals for the region.

Postsettlement fire return intervals for SBNM were determined by comparing the boundaries and dates of all fires that occurred on the Monument on a system of overlay maps. Intervals were calculated as the lengths of time between fires occurring at the same points in space. The park, thus, consists of a mosaic of different fire return intervals.

RESULTS

The majority of western pine forests have fire return intervals ranging from sixty to several hundred years (Weaver 1951, Wagener 1961, Houston 1973, Hall 1976, Arno 1978, Romme and Knight 1982). In contrast, fires were far more common in grasslands. Wright and Bailey (1982) concluded that a natural fire return interval as low as five years was probable for grassland ecosystems having level to rolling topography. However, where more topographic variety exists, like SBNM, the fire return interval was suggested to range between 20 and 30 years (Wright and Bailey 1982).

Fire return intervals have been evaluated for several sites near SBNM. Steinauer and Bragg (1987) reported that fire return intervals in the Nebraska Sandhills (100 km northeast of SBNM) had lengthened from 3.5 years between 1851 and 1900 to 8.5 years between 1901 and 1950. Using dendrochronology techniques, Shilts et al. (1980) estimated fire return intervals in grasslands of Wind Cave National Park (90 km north of SBNM) for the time period between 1820 and 1910 to be 13 to 21 years. Perhaps the most detailed work done to date estimating presettlement fire history in the northern mixed prairie is that by Fisher et al. (1986). Based on fire scar research at Devil's Tower National Monument (185 km northwest of SBNM), they concluded that between 1600 and 1770 the fire return interval was 27 years, from 1770 to 1900, the fire return interval was 14 years, and after 1900 the fire return interval lengthened to 42 years. We conclude that fire return intervals in

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The northern mixed prairie prior to 1935 were about five years on smooth and gently rolling topography and 15 to 30 years on topographically diverse areas like SBNM.

NPS fire records from 1935 to the present indicate that the average fire return interval is greater than 50 years on SBNM (Table 1). At present, more than 45% of the Monument has not burned since 1935, and less than 10% of the park has a fire return interval of 27 years or less.

Table 1. Fire return intervals for Scotts Bluff National Monument from presettlement to present time.

Time period	Average interval (years)	% Park area burned
Pre-1935	15.0-30.0	100
1935-1969	14.0	<1
	34.0	19
	Unburned	81
1970-1990	6.6	1
	10.0	4
	20.0	41
	Unburned	54

Since settlement, the fire season has shifted from late summer to early spring (Figure 1). Over 70% of the fires sighted in the SBNM region between 1824 and 1934 were recorded between July and November with most occurring in July and August. Between 1935 and 1969, a slight decline in late summer fires was observed, and from 1970 to 1990, a dramatic shift from late summer to spring fires (March-June) occurred.

Pioneer travel in western Nebraska was mainly in the spring because wagon trains passed through the region early in the year in an attempt to reach and pass through the western mountains before the onset of winter conditions. Of the 759 pre-1935 historical records examined in our investigation, only 85 records were from summer (July-September) travelers in the SBNM region, whereas 61 records were from spring travelers. Even with such a strong bias toward travel and increased observation opportunities during spring, spring fires were rarely observed.

Spring and early summer fires are generally less intense than late summer and fall fires (Wright and Bailey 1982). This is due to higher soil water content, higher fuel moisture, lower soil temperatures, lower ambient air temperatures, and higher relative humidity. Overall, the shift to spring-season fires resulted in less intense fires.

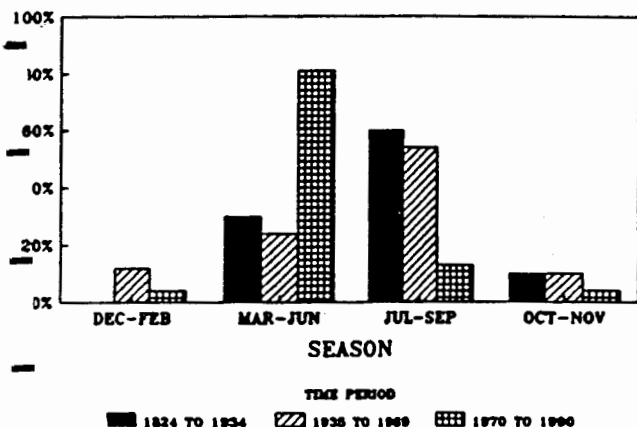


Figure 1. Change in seasonal occurrence of fires for Scotts Bluff National Monument, 1824-1990. Based on observations of 10 fires 1824-1934, 26 in 1935-1969, and 46 in 1970-1990.

DISCUSSION

Following settlement, the fire return interval for SBNM lengthened to 54 years or longer for more than 90% of the SBNM land area. This is attributed to European settlement and the advent of accidental and intentional fire suppression. The increase is similar to changes reported for other grassland areas following settlement (Shilts et al. 1980, Wright and Bailey 1982, Fisher et al. 1986, Steinauer and Bragg 1987).

The shift from late summer to spring fires was somewhat unexpected. Between 1935 and 1969 managers attempted to suppress all fires within Monument boundaries. The dramatic shift from dry to wet season fire between 1970 and 1990 resulted from the introduction of prescription burning and the suppression of all wildfires. Current NPS prescribed fire management policy for SBNM permits managers to conduct prescribed burns in the spring. The rationale is that spring burns are easy to control, revegetate quickly, and leave a mosaic of burned and unburned areas.

The NPS is mandated by Congress to manage the vegetation of SBNM to resemble presettlement species composition and diversity. Because fire is a significant force in structuring plant communities, management techniques that lengthen the interval between fires, shift fires from summer to early spring, and/or reduce fire intensity by prescribing cooler fires may result in species composition shifts toward fire intolerant and potentially undesirable non-native vegetation.

Prescribed burning programs for this and other grassland areas where fire is used to restore or maintain historical balance among species must consider the ecological impact of changing fire return intervals, season of burning, and fire intensity. The reintroduction of fire at the natural fire return interval but during the wrong season of year or at the wrong intensity may not result in restoration or maintenance of the native plant community. Unless evidence to the contrary is found, we recommend a prescription that mimics the presettlement fire history—high intensity summer fires on a return interval of 5 to 30 years.

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