THE EFFECTS OF FIRE ON VIRGIN NORTHERN MIXED GRASSLAND AT CUSTER BATTLEFIELD NATIONAL MONUMENT

Jane H. Bock
Carl E. Bock
E.P.O. Biology Department
University of Colorado
Boulder

Appleton-Whittell Research Ranch
National Audubon Society
Elgin, AZ 85611

and

Maureen O'Shea Stone
E.P.O. Biology Department
University of Colorado
Boulder

Preface

INTRODUCTION TO THE FINAL REPORT. This report describes our 3-year study on the effects of wildfire at Custer National Monument near Crow Agency, Montana. A wildfire of undetermined origin, which occurred on 10 August, 1983, burned 220 ha (approximately 90%) of the Monument (Figure 1). Although no data are available on fire intensity, the ambient conditions were remembered as hot, dry, and windy. An examination of photos shows that the fire killed virtually all above-ground vegetation.

Our work commenced in spring, 1984. Field work for this project was carried out in the springs and summers of 1984, 1985, and 1986. Our final report is divided into four parts. The first and longest section describes our study of the vegetation on the Battlefield and its response to fire. The second section is a manuscript (presently under review) which presents a study of the responses of birds to the fire. The third portion presents a history of the Battlefield's vegetation from the time of the Battle of the Little Bighorn until now. The fourth section presents our checklist of the vegetation of Custer National Monument, and our classification of the dominant grassland communities on the study area.

Abstract

SECTION I. The vegetation of the Custer Battlefield National Monument belongs to the Northern Mixed Grass Prairie. The most dramatic vegetation change as a result of the 1983 fire on the Battlefield was the elimination of big sagebrush

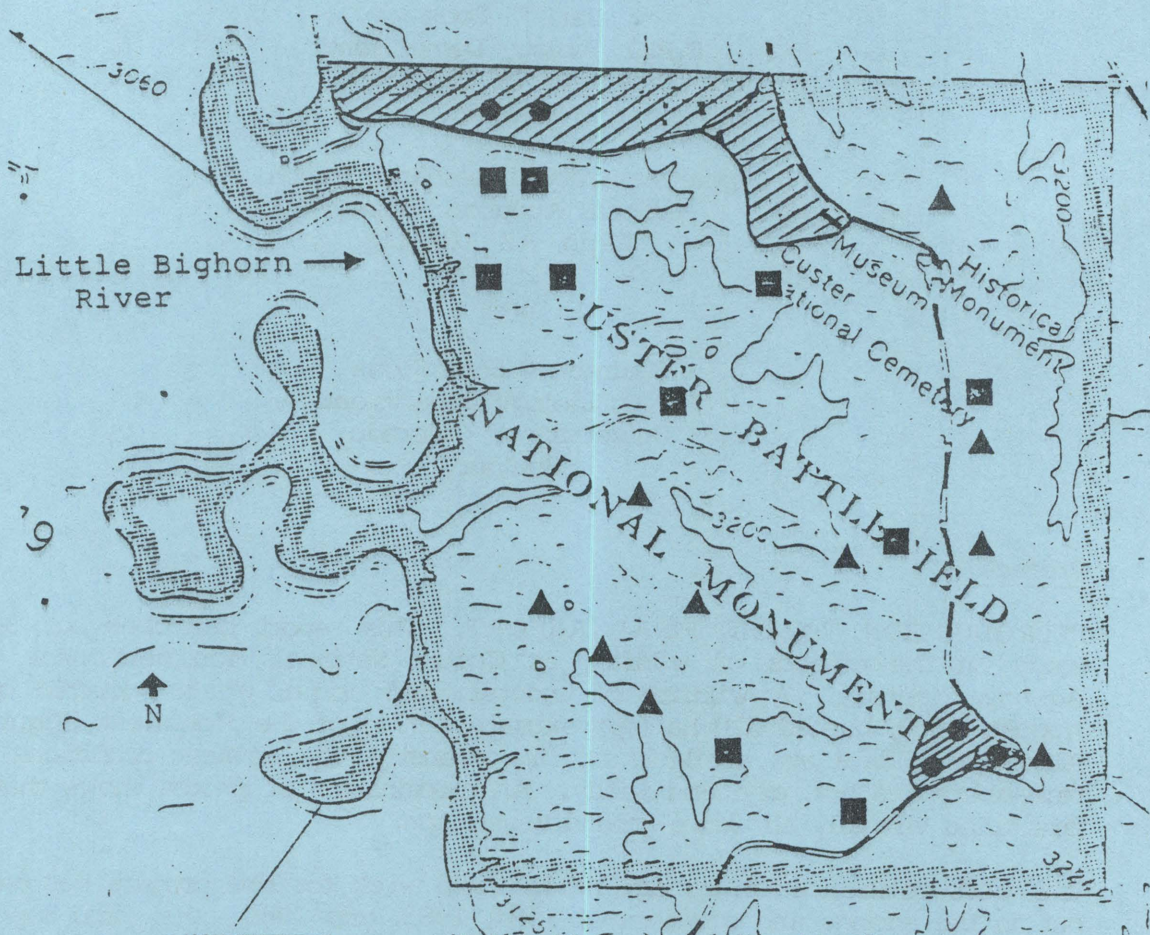

Figure 1. Map of the Custer battlefield. Areas shaded with diagonal lines were not burned in the 1983 fire. Scale: 1 cm = 154 m. Dots = unburned plots. Squares = 10 burned plots topographically similar to unburned plots. Triangles = burned plots in areas unlike unburned plots.

(Artemisia tridentata) on the burned site. Also, the litter layer covering the soil was reduced and had not returned to unburned depths by the 1986 growing season. The grasses and herbs showed no permanent changes which could be attributed to the fire, nor was productivity altered significantly. Our findings enforce the hypothesis that wildfires are a natural, non-destructive event in western North American grasslands including the Northern Mixed Grass Prairie.

SECTION II. Loss of sagebrush cover at the Custer Battlefield apparently reduced both the variety and abundance of breeding birds. Only western meadowlarks bred at high densities on the Battlefield in 1985 and 1986. Lark sparrows, grasshopper sparrows, and lark buntings all were significantly more common on sage-covered areas of the nearby Reno-Benteen site than they were on burned portions of the Battlefield.

SECTION III. We investigated the general characteristics of the Battlefield vegetation, from the time of the Battle of the Little Bighorn (1876) to the present, by means of written records describing certain incidents in the Battle and, more importantly, from the photographic records of the Battlefield. This photographic record commences shortly after the Battle. We conclude that the Battlefield supported shrub-steppe vegetation (a combination of sagebrush and grassland vegetation) from (before) 1876 until the 1983 fire, when it became a grassland.

SECTION IV. We collected 130 species of plants from our study sites. We quantified the vegetation by topographic associations into three a priori groups, 1) level ground plants, 2) well-drained steep slope plants, and 3) small ravine plants. Using Cluster Analysis we grouped the 31 common species into three assemblages, and found agreement with our intuitive assemblages, although almost all species occurred in two or more habitats. We suggest that the National Park Service stress the natural, as well as the historic, values of Custer Battlefield National Monument.

Acknowledgements

We are grateful for this opportunity to thank some of the many people who facilitated our work at the Battlefield. Ken Diem introduced us to this work and showed unflagging interest in it. The Superintendent at Custer, James V. Court, and the Historian, Neil Mangum, were helpful in innumerable ways. Neil Mangum made the preparation of Section III of the report possible by loaning us negatives from the Battlefield archives. Their cooperation and encouragement were essential, as was the help of other Monument personnel. Robert Cross, photographer, prepared prints from the Battlefield negatives in such a way that the features of the vegetation were distinctive.

We were extremely fortunate in our field assistants for the three summers of work: Roger Amerman, Jacqueline Old Coyote, Dan Stone, and Curtis Yarlett, thank you for your unfailing friendship and help. And special thanks go to Jill and Putt Thompson, and to Bill Yellowtail, who introduced us to the great Crow Nation and made us feel at home.

Introduction

Custer Battlefield lies on the high plains of Bighorn County, in south-central Montana. Kuchler (1964) placed it in the transitional area between relatively pure grasslands to the northeast, and sage-dominated shrub steppe of inter-mountain basins to the southwest. He called it the Bouteloua-Stipa-Agropyron Vegetation Type (Type 64). We have chosen to identify it as Northern Mixed Grass Prairie, the International Biological Program designation (Risser et al., 1981).

The Battlefield's historic value is well appreciated. On June 25, 1876, Colonel G. A. Custer and his troops were annihilated by assembled members of the Cheyenne and Sioux nations. Because of this, the site has been afforded a level of protection unlike its surrounding area which is used largely as rangeland for cattle and horse grazing, or is plowed and planted to winter wheat. Grazing livestock have been excluded from the Battlefield since 1891, when the Battlefield was fenced. However, horses were used in reenactments for several decades after the Battle; these reenactments ceased several years ago. Because of this protection from grazing, the Battlefield represents an unusually pristine example of the grasslands of southeastern Montana (Steubbendieck, 1983).

The 1983 wildfire provided a unique opportunity for studying post-fire responses of a high plains ecosystem protected from livestock grazing. A major limitation to this study is that it did not begin until the growing season following the fire, and no quantitative data about pre-fire vegetation were available from the Battlefield. Therefore, we are unable to make statements about pre-burn conditions on the burned grassland. We selected our controls from the 10% of the Battlefield which was untouched by the 1983 fire, and used these unburned areas as a model for what the pre-burn vegetation may have been. Our research design compares the burned vs. the unburned areas. Photographic evidence supports the legitimacy of this approach.

Discussion and Conclusions*

Custer Battlefield had not burned in many years; the last fire was at least as long ago as 1910 (pers. comm. J. Court, CBNM Superintendent). The 1983 fire burned primarily on the National Park lands rather than on adjacent rangelands. Perhaps the recent decades of livestock exclosure, which allowed a heavy grass and litter cover to build up on Custer Battlefield, provided an appropriate heavy fuel load to react with the hot ambient temperature and winds to produce the dramatic fire in 1983.

Fire at the Custer Battlefield, because of the virtual 100% mortality of big sagebrush (Artemisia tridentata), converted what appeared to be a shrub-steppe ecosystem into a grassland. Many workers have pointed out the strong relationships between grassland vegetation and environmental factors, especially

* Constraints of space, limit presentation to this portion of Section I of the Final Report of this project.

grazing and fire (e.g., Barbour et al., 1986; Bock and Bock, 1984; Risser et al. 1981; French, 1979; Wright and Wright, 1948). A. tridentata shows extreme sensitivity to fire (e.g., Wright and Bailey, 1982; Beardall and Sylvester, 1976; Blaisdell, 1953; and Pickford, 1932). When fire occurs in sagebrush-grassland habitats the fires most commonly are patchy, rather than broad scale (Beardall and Sylvester, ibid., for Nevada; Petersen, in press, for Idaho). Beardall and Sylvester (1976) suggest the patchiness is due often to insufficient fuel loads to sustain fires in sagebrush areas, although the sagebrush plants themselves contain many volatile compounds and burn readily once ignited (Wright and Wright, 1948). What results are mosaics comprised of shrubby areas and open areas of grassland-herb vegetation. This was true for the Battlefield fire. Even though sage has now disappeared from 90% of the Battlefield, plenteous seed reservoirs from living A. tridentata plants exist in the 10% of the Battlefield which did not burn, as well as on adjacent rangelands. Whether big sagebrush will recolonize the burned area of the Battlefield is a question of considerable ecological interest and importance.

We found no sign of regrowth of Artemisia tridentata during the three years of our study; although our photographic record from 1879 to the time of the fire in 1983 shows more or less continuous presence of big sagebrush until the 1983 fire. There are few data on the rate of re-establishment of big sagebrush on burns. In Idaho, the process appears to be complete after approximately 30 years (Harniss and Murray, 1973). Recovery can be affected by 1) the completeness of the burn, 2) rains subsequent to the fire (Wright and Bailey, 1982), and 3) seed production (Johnson and Payne, 1968). We assume the appropriate environmental conditions have not yet been present for big sagebrush's reestablishment since the burn.

The relationship between overgrazing and big sagebrush cannot be discounted. Generally, range managers view overgrazing has occurred when the animal productivity on land is lower than it would be if grazing were reduced (Crawley, 1983). If the overgrazing ceases after a short time, the grassland may restore itself to its original condition. However, if the overgrazing persists over a long period of time, the very nature of the community may change. For example, a grassland may slowly change into a persistent shrub-steppe (Kenney et al., 1986; Bock et al., 1984; Hastings and Turner, 1965; and Humphrey, 1958). When overgrazing occurs in grasslands such as that found at Custer Battlefield, whether by native grazers (e.g. Bison) or by domestic animals (e.g. cattle, horses, or sheep), the invasion of Artemisia tridentata is facilitated (Crawley, 1983, p. 300). We believe the annual presence of horses and perhaps of bison as well for decades before the Battle in 1876 may have facilitated the invasion of this Northern Mixed Grass Prairie by big sagebrush. The 1983 fire, which cleared the Battlefield of big sagebrush, offers an opportunity to study patterns of Artemesia tridentata invasion in the absence of large domestic or native grazing animals.

Other vegetation changes from the 1983 Custer burn were less dramatic than that for Artemesia tridentata and probably will be of shorter duration. Other shrubs were set back for one year, but they resprouted to pre-burn densities or higher by the second year (Table 2). This result agrees with observations on other western grasslands (Bock and Bock, 1984; Bock et al., 1976; Risser et al., 1981; and Kozlowski and Ahlgren, 1974). The native grassland species of our study have coexisted with fire over past millennia. Those species which were readily killed by prairie wildfires have long since vanished from the grassland. The most dramatic effect of the fire we measured, aside from the disappearance of A. tridentata, was the removal of the litter layer from the soil (Table 1). By the end of the study the litter layer on the burn remained significantly smaller than that of the control plots. This difference is likely to persist for many years. However, the native grasses and associated herbaceous dicots showed no persistent change following the burn (Table 3). (A note of caution must be added here because we lack pre-burn data for the burned plots.)

When the frequencies of the native vs. exotic grasses are studied, the following pattern emerges (Table 3). The native species Agropyron spicatum (bluebunch wheatgrass), the Bouteloua s (grama grasses), Koelaria macrantha (June grass), Poa jucifolia, Stipa comata (needle and thread), and Stipa viridula (green needlegrass) all showed significant increases during at least one post-fire growing season in comparison with their unburned counterparts. This was also true for the common native sedge, Carex filifolia. One native grass, Agropyron dasystachium (thickspike wheatgrass), showed no differences in occurrence between the burned and unburned plots. The two common exotic grasses on the study sites, Bromus japonicus (Japanese brome) and Poa pratensis (Kentucky bluegrass) did significantly better on the unburned plots than on the burned ones in (at least) the third post-fire growing season. We tentatively conclude that the 1983 Custer fire favored the native grasses over their introduced counterparts. Similarly, the native herbs, Alyssums, Gaura, Phacelia, Psoralea, and Sphaeralcea, did better on the burned plots in at least one post-fire season, with one exception, Collomia. Two exotic herbs, Melilotus and Lactuca, were less successful on the burned sites in the third post-fire year (1986); although Lactuca did better on the burn in 1985. Tragopogon initially responded very positively to the burn, but did better in the second year on the unburned site, and in the third year, there was no distinction between sites. The remaining herbs, four natives (Calochortus, Commandra, Phlox, and Vicia) and one exotic (Taraxacum) showed no significant response to the fire. Taken together, these data further substantiate our hypothesis that fire is a natural and non-destructive feature of the western American grasslands.

We found that the August, 1983, fire on the Custer Battlefield National Monument did not cause any major changes in the natural vegetation of this Northern Mixed Grass Prairie, although it caused the pre-burn shrub-steppe grassland to develop towards a true grassland. The most dramatic result of the fire was the removal of big sagebrush, Artemisia tridentata, from the burned area. The burn tended to favor the native herbaceous dicots and caused no significant overall changes in native grasses.

We sincerely hope our study will serve as a basis for ongoing monitoring through time of our field sites. Two important questions can be examined by monitoring: 1) What is the pattern of colonization of big sagebrush in the northern grasslands in the presence of a viable seed source (the living plants on the unburned portion of the Battlefield), but in the absence of large grazing

Table 1. Ground cover as percent of points sampled, burned vs. unburned portions of the Custer National Battlefield. N = 4,000 points on 20 plots, burned; n = 1,000 points on 5 plots, unburned. Chi-square values calculated using actual number of data points.

	1984		1985		1986	
Category	Burned	Unburned	Burned	Unburned	Burned	Unburned
Vegetated	64.2	65.7	74.6	76.0	82.5	86.5
Litter	1.0	29.1*	5.2	19.8*	6.2	11.4*
Bare ground	34.8*	5.2	20.2*	4.2	11.3*	2.1
X^2 (<u>P</u>)	1199.7(<0.001)		347.0(<0.001)		100.5(<0.001)	
Graminoids	47.1	54.0	51.5	49.3	49.2	43.6
Herbs	14.2*	5.5	19.3*	14.8	29.3	32.7
Shrubs	2.9	6.2*	3.8	11.9*	4.0	10.2*
X^2 (<u>P</u>)	80.2(<0.001)		105.2(<0.001)		64.8(<0.001)	

* significantly different from other treatment within-year (Mann-Whitney <u>U</u>, <u>P</u><0.05), comparing mean cover values for 20 burned vs. 5 unburned plots.

Table 2. Average number of shrubs per $400m^2$ plot on burned (n = 20) vs. unburned (n = 5) portions of the Custer National Battlefield.

Species	Treatment	1984	1985	1986
Artemisia tridentata[a]	burned	0.2	0.2	0
	unburned	144.2	167.3	172.0
Artemisia cana[b]	burned	0.2	147.7	143.5
	unburned	7.2	79.4	48.4
Prunus virginiana[c]	burned	1.7	15.9	26.2
	unburned	0	0	0
Rhus trilobata	burned	0.2	0.6	0.7
	unburned	0.4	0.4	0.4
Rosa arkansana[c]	burned	0.5	83.9	23.9
	unburned	0	0	0
Sarcobatus vermiculatus	burned	0.3	2.1	1.5
	unburned	0.4	0.4	0.4
Symphoricarpos occidentalis[c]	burned	1.0	470.9	262.8
	unburned	0	0	0

[a] $\underline{P}<0.001$, Mann-Whitney *U* tests comparing abundances per plot between treatments within years.

[b] $\underline{P}<0.001$, Chi-square contingency test for independence of treatments and years, based on total shrubs per treatment per year.

[c] $P<0.001$, Chi-square goodness-of-fit tests of total shrubs per year on burned plots.

Table 3. Percent of $0.25m^2$ frames occupied by various plant species on burned vs. unburned portions of the Custer National Battlefield, 1984-1986. N = 100 frames on 5 unburned plots; n = 200 frames on 10 burned plots with generally similar physical locations.

Species	Treatment	1984	1985	1986
Achillea millefolium	burned	20	21	19
	unburned	18	21	22
Agropyron dasystachyum	burned	83	86	89
	unburned	82	85	91
Agropyron spicatum	burned	36	33[a]	39
	unburned	28	17	32
Alyssum spp.	burned	92**b	64**b	83
	unburned	58	14	74
Artemisia cana	burned	8	4	3
	unburned	6	7	6
Artemisia tridentata	burned	0	0	0
	unburned	23**b	28**b	24**b
Bouteloua spp.	burned	5	11[a]	16
	unburned	3	4	14
Bromus japonicus	burned	92	87	73*
	unburned	93	90	89
Calochortus nuttallii	burned	5	2	7
	unburned	2	0	1
Carex filifolium	burned	12	11[a]	13[a]
	unburned	5	4	5
Collomia linearis	burned	0	12	41
	unburned	0	14	60[a]
Commandra umbellata	burned	17	11	12
	unburned	14	12	15
Gaura coccinea	burned	3	13[a]	17[a]
	unburned	2	3	6

Table 3. continued

Species	Treatment	1984	1985	1986
Koelaria macrantha	burned	16	13[*b]	21
	unburned	8	1	16
Lactuca serriola	burned	17	35[b]	18
	unburned	12	16	32[a]
Melilotus officinalis	burned	20	15	12
	unburned	17	24	25[b]
Opuntia polyacantha	burned	7	2	2
	unburned	7	6	5
Phacelia linearis	burned	23[*b]	0	24[*b]
	unburned	0	0	1
Phlox hoodii	burned	20	20	20
	unburned	15	14	19
Poa pratensis	burned	12	2	11
	unburned	20	16[*b]	36[b]
Poa juncifolia	burned	49[*b]	23[**b]	71[*b]
	unburned	18	3	16
Psoralea spp.	burned	10	3	10[*b]
	unburned	6	0	0
Sphaeralcea coccinea	burned	17[b]	18[b]	15[a]
	unburned	5	8	5
Stipa comata	burned	11	12[b]	21
	unburned	17	2	15
Stipa viridula	burned	3	4[a]	7[*a]
	unburned	1	0	0
Taraxicum officinale	burned	0	7	13
	unburned	0	11	19
Tragopogon dubius	burned	70[**b]	36	74
	unburned	38	60[*b]	80
Vicia americana	burned	21	42	48
	unburned	26	41	58

Table 3. continued

Species	Treatment	1984	1985	1986
No. spp./frame	burned	6.78**	5.88*	8.22
	unburned	5.30	5.06	7.92

* average number of occupied frames significantly higher per plot than other treatment (n = 5 unburned and 10 burned plots; Mann-Whitney U test, $P<0.05$(

** as above, $P<0.01$.

a total occupied frames significantly higher than other treatment (Chi-square goodness-of-fit test, $P<0.05$).

b as above, $P<0.01$.

animals? and 2) Has the burn over the long time favored the native grasses of the Northern Mixed Grass Prairie ecosystem?

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