THE EFFECTS OF FIRE ON

VIRGIN NORTHERN MIXED GRASSLAND

AT CUSTER BATTLEFIELD NATIONAL MONUMENT

FINAL REPORT

May, 1987

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PREFACE

INTRODUCTION TO THE FINAL REPORT.-This report describes our three 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 (see Figure 1, Section I). 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 (see Figures 2 and 3, Section I).

Our work commenced in spring, 1984. Field work for this project was carried out in the springs and summers of 1984, 1985, and 1986. This, 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 (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.

ACKNOWLEDGMENTS

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 Battleifeld 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.

THE EFFECTS OF FIRE ON NORTHERN MIXED GRASSLAND VEGETATION

AT CUSTER BATTLEFIELD NATIONAL MONUMENT

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Final Report: Section I
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INTRODUCTION TO THE EFFECTS OF FIRE ON BATTLEFIELD VEGETATION.-Custer Battlefield lies on the high plains of Bighorn County, in south-central Montana. Küchler (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 (See Section 3) supports the legitimacy of this approach.

METHODS

DATA COLLECTION.-Only two small sections of the Battlefield, comprising approximately 24 ha, were spared from the 1983 fire (Figs. 1, 2, and 3). In May, 1984 we established five 20 X 20-m plots on the unburned land (Fig. 4), along with 20 plots on the burned portion of the sites (Fig. 5). Just prior to the beginning of our study, Custer Battlefield had been mapped and staked into a grid at 100-m intervals with each grid intersection marked by a tagged steel bar. We used these permanent markers to establish the southeastern corners of each of our 20 X 20-m plots (Appendix I and Fig. 1). Ten of the twenty burned plots closely matched the five unburned plots in terms of elevation and topography; these are shown in Figure 1. The remaining ten burned plots included small swales with some

woody vegetation (*e.g.*, Rosa arkansana, Prunus virginiana, and Symphoricarpos occidentalis), and/or relatively steep slopes not found on any of the unburned portions of the Battlefield. The 20 burned plots did not differ substantially from one another in terms of general ground cover categories (*e.g.*, bare ground, graminoids, herbs), but there were important differences in species composition. Therefore, we used data from all burned plots for analyses of ground cover (Table 1), but for individual species comparisons we restricted our burned area data set to those ten plots most similar to the unburned sites (as in Tables 3 and 4).

Five sorts of data were collected on the plots between late May and early August of 1984 through 1986. 1) Five 20-m transects were set out across each plot, and ground cover sampled at 0.5-m intervals along the transects (n=200 points per plot). At each occupied point, the plant was identified to species and its height measured. Unoccupied points were categorized as either bare ground or litter. Data from all 25 plots were used to compare the frequencies of general ground cover categories on burned vs. unburned portions of the study area (Table 1).

2) Live above-ground vegetation was clipped from inside two $0.2m^2$ hoops inside each plot each year. The hoops were placed randomly inside plots by tossing the hoops over the shoulder from the permanent stake on each plot. If the hoop encompassed woody vegetation, it was thrown again until only

herbaceous material was enclosed. Clippings were oven-dried at 60°C for 72 hrs, and then weighed on an analytical balance to provide estimates of above-ground productivity (Table 2). (50 x 50 cm)

3) A 2500 cm^2 frame was set on the ground 20 times, at 2-m intervals around the perimeter of each plot. For each frame placement, all plant species rooted inside the frame were identified and recorded. Resulting data were used to estimate plant species frequencies, plus local plant species richness, on the topographically similar burned (n=10) vs. unburned plots (n=5). A total of 100 unburned and 200 burned frames were sampled each year (Table 3).

4) Plant height data were compared for the five unburned and ten most similar burned plots, using up to the first 50 individuals measured for each species per treatment per year (Table 4).

5) All shrubs were counted each year on all plots, to estimate woody plant densities (Table 5).

DATA ANALYSIS.-Chi-square contingency and goodness-of-fit, Mann-Whitney U, and t tests were applied to the data as appropriate, to look for differences between vegetation on burned vs. unburned areas (Sokal and Rohlf, 1981). Because of the large number of statistical comparisons involved in our analyses, the probability of Type-I error (falsely rejecting a null hypothesis) was high. Therefore, we have interpreted our results conservatively, attaching most

biological significance to those differences with very low probabilities of chance occurrence.

Chi-square contingency tests were used to look for independence of treatment and ground cover categories across combined burned vs. unburned plots (Table 1). Plant frequency data (Table 3) were analyzed in two ways. First, the numbers of occupied frames per plot were compared within-years between treatments using the Mann-Whitney U statistic. Second, total occupied frames per treatment were compared within-years using Chi-square goodness-of-fit tests, against null expectations of equal percentages of occupied frames under each treatment. The former method detected significant differences for plants that were consistently more common on all plots of one vs. the other treatment. The latter method was more sensitive to differences among relatively rare plants, missing from or scarce on many of the plots of either treatment, but perhaps strikingly more abundant on several plots of one treatment.

Shrub density data were analyzed in several ways, depending on whether a particular species occurred on the unburned plots, and/or how it appeared to be responding on the burn. Artemisia tridentata densities were compared between treatments within-years using the Mann-Whitney U statistic. We used Chi-square contingency statistic to test for independence of number of A. cana between years and treatments. Other locally common shrubs happened to be

missing from all unburned plots. For these we applied Chi-square goodness-of-fit tests to burned plot data, against null expectations of equal numbers for each year.

Finally, mean plant weights and heights (Tables 2 and 4) were compared across treatments within-years using the *t* statistic.

RESULTS

GROUND COVER.-Frequencies of general ground cover categories differed dramatically ($P < 0.001$) between burned and unburned portions of the Battlefield during each of the three post-fire years (Table 1). However, percent vegetated ground did not differ significantly in any of the years. Rather, bare ground was abundant and litter scarce on the burn relative to the control. This difference diminished with each year of post-fire succession, but it remained significant and substantial through 1986 (Table 1A). Vegetation cover increased on all plots over the three years, independent of fire.

While overall vegetation cover did not differ between burn and control, there were highly significant differences ($P < 0.001$) in graminoid vs. herb vs. shrub cover during all three post-fire years (Table 1B). Burned plots supported less shrub cover all three years. In 1984 and 1985 the burned plots included more herb cover than controls, while in 1986 grass cover was substantially higher on the burn.

ABOVE GROUND BIOMASS.-Non-woody clipping sample from burned plots averaged heavier than those from unburned areas in each post-fire year (Table 2). Although these differences are not statistically significant, they are consistent with the higher burned plot cover of graminoids and herbs revealed by the transect data (Table 1B). In retrospect, we should have increased numbers of samples for the biomass analysis. Spatial variability in plant abundance was high, and this variance masked what likely was a real difference in productivity on burned vs. unburned portions of the Battlefield.

PLANT FREQUENCIES.-Twenty-eight plant species were sufficiently common for meaningful analysis (Table 3). Given the 168 comparisons (28 spp. X three years X two statistical tests per comparison; see METHODS), we would expect about eight statistically significant differences at the $P < 0.05$ level and two such differences at the $P < 0.01$ level, purely by chance. There were 49 and 29 such differences respectively, among the actual data, indicating that plant frequencies differed substantially between the burned and unburned portions of the Battlefield. Recall that the burned plot data used in this analysis were taken only from those 10 burned plots topographically most similar to the unburned areas.

Certain herbs differed dramatically between treatment. Alyssum spp. appeared to be greatly stimulated by the fire for two post-burn years. Tragopogon dubius was much more

common on the burn in 1984, reduced on the burn in 1985, and equal on both treatments in 1986. Other less abundant herbs that may have been variously stimulated by fire include Gaura coccinea, Phacelia linearis, Psoralea spp., and Sphaeralcea coccinea.

Among the grasses, only Poa were substantially affected by the fire. Burning apparently reduced frequencies of the exotic Poa pratensis, while stimulating the native P. juncifolia. The dominant Agropyron dasystachium clearly was unaffected by fire (Table 3). Other graminoids either were too rare, or differed too little between treatments, for us to conclude that there were important fire effects.

Big sagebrush was the dominant shrub on the unburned portions of Custer Battlefield, but no individual was was found alive in the censuses of shrubs on the twenty burned plots or elsewhere on the burned portion of the Battlefield (Table 5). These data and photographic evidence (compare Figures 4 and 5), convince us that sage mortality was the single most dramatic result of the 1983 fire.

SPECIES RICHNESS.-Average plant species per frame (250 cm^2) was significantly higher on the burn in 1984 and 1985, but did not differ between treatments in 1986 (Table 3).

PLANT HEIGHTS.-Eight species were common enough on the transects for meaningful height analysis. By chance alone we would expect one or two significant differences among the 24 comparisons. There were seven significant differences in the actual data set (Table 4). However, most were not

striking, and we do not see the fire as having had any major impacts on plant height. The heights of Bromus japonicus plants appear to have been stimulated by the burn in the first post-fire growing season (1984), when Stipa comata and Andropogon dasystachium were retarded. These distinctions disappeared in subsequent years. On the other hand, Poa pratensis and Tragopogon dubius appear to be shorter on burned part of the Battlefield in 1985 and 1986.

SHRUB DENSITIES.-Artemisia tridentata was virtually obliterated by the fire, and it showed no signs of recovery or re-establishment through 1986 (Table 5). Artemisia cana appeared to be a more volatile species, on both the burned and unburned parts of the Battlefield. The fire seemed to stimulate seedling establishment in this species during the second and third post-fire growing seasons (Table 5). Prunus, Rosa, and Symphoricarpos densities were reduced during the first post-fire year, but they clearly had resprouted in very large numbers by 1985.

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 the strong relationships between grassland vegetation and the environmental factors, especially 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 (*ibid.*) 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, *ibid.*). 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 (see Section 3). 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 1976 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 5). 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 juncifolia, 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 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 (given in Appendix 1). 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 animals? and 2) Has the burn over the long time favored the native grasses of the Northern Mixed Grass Prairie ecosystem?

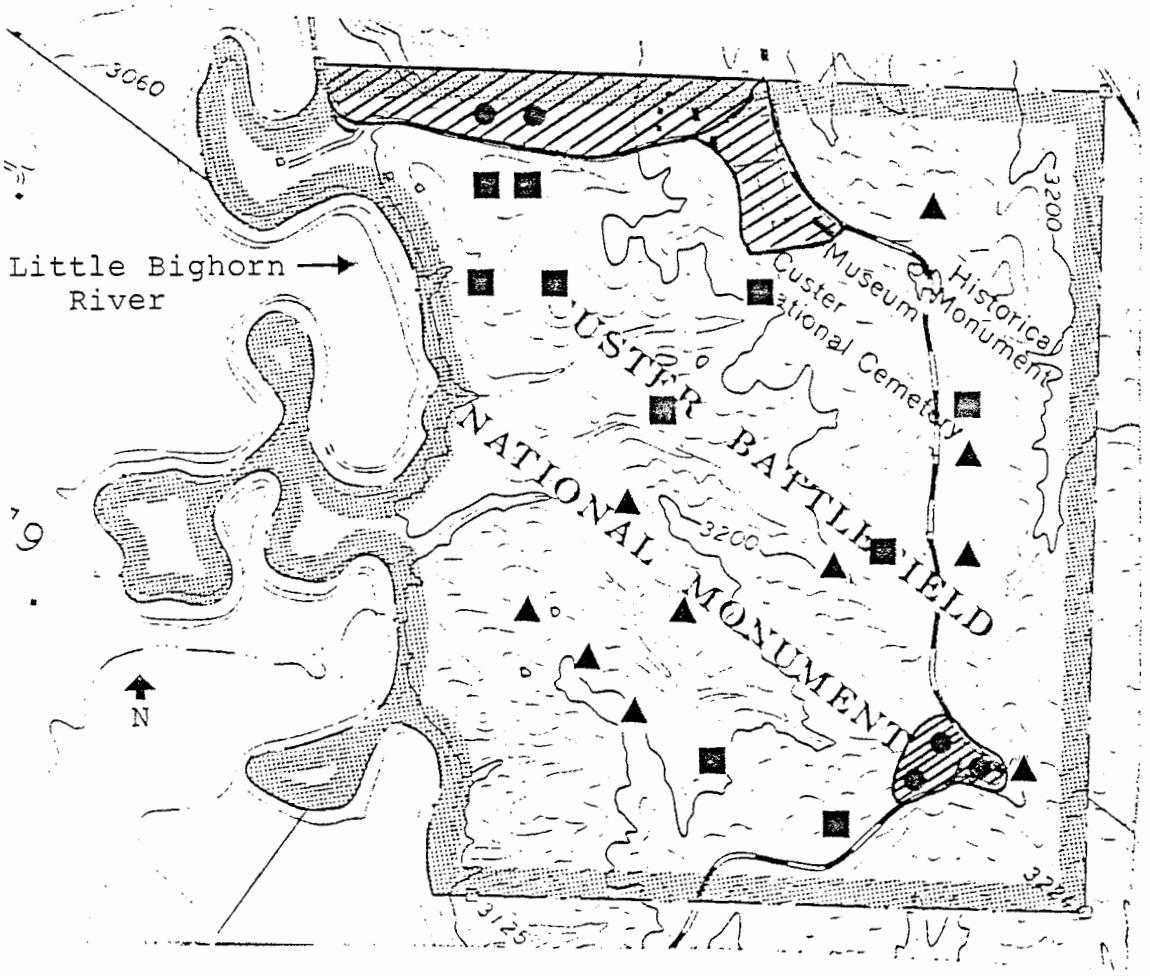


Figure 1. Map of the Custer battlefield. Areas shaded with diagonal lines were not burned in the 1983 fire. Scale: 1 cm = 154 m. Dots = unburned plots. Squares = 10 burned plots topographically similar to unburned plots. Triangles = burned plots in areas unlike unburned plots.



Figure 2. Overview of Custer Battlefield after fire, 11 August, 1983.

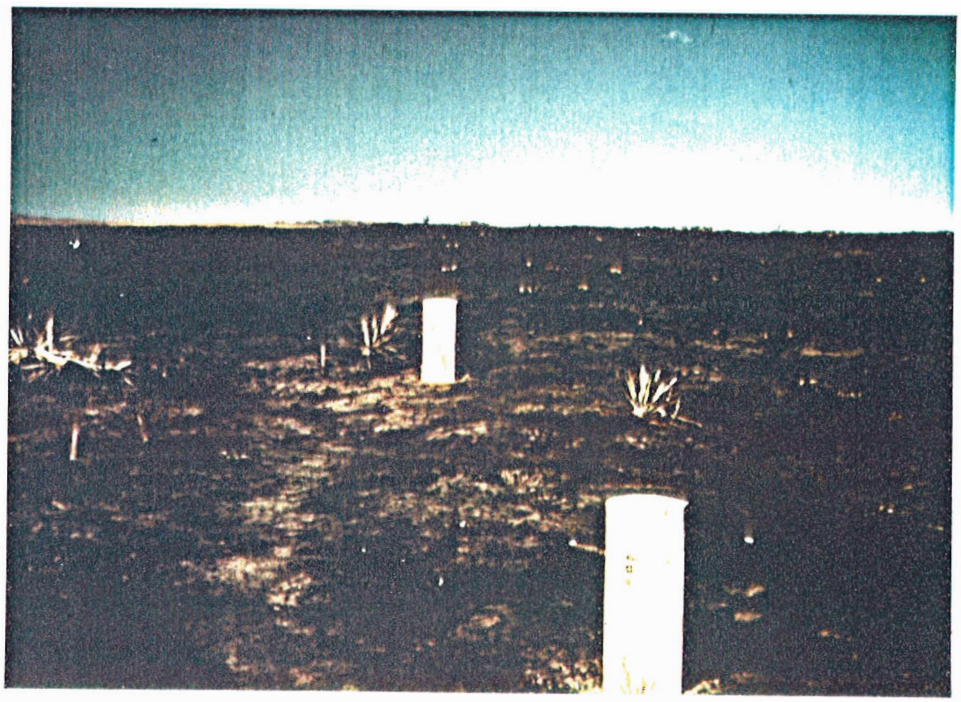


Figure 3. Close-up of burned area on Battlefield, 11 August 1983, showing total destruction of above-ground vegetation.



Figure 4. Unburned area of Custer Battlefield, where Control plots were established. Note sagebrush (arrow). Photo taken June, 1986.

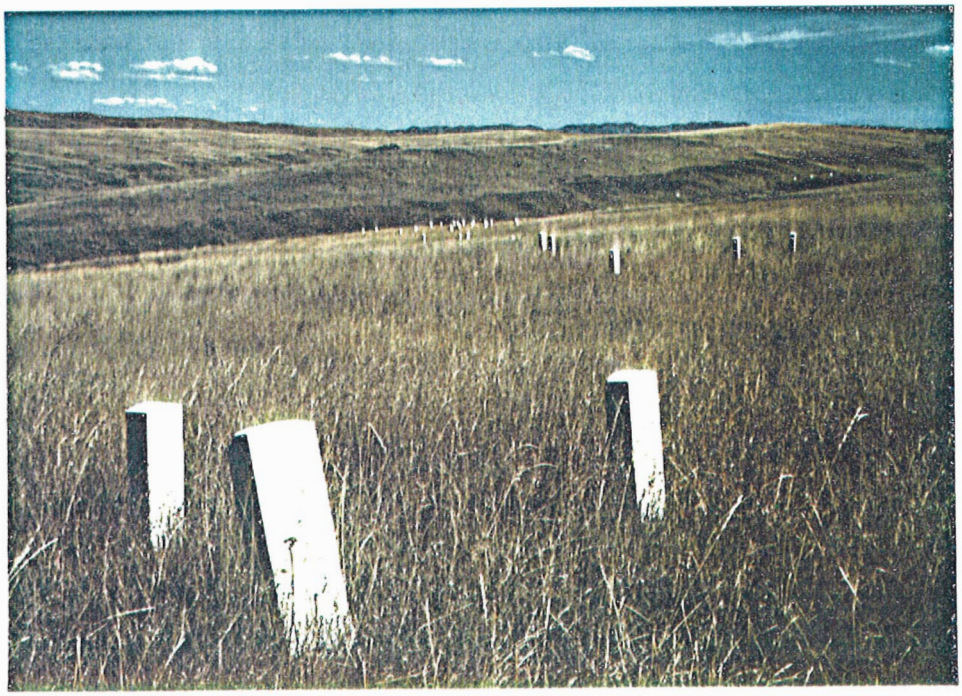


Figure 5. Burned area of Custer Battlefield, where Experimental plots were established. Contrast this with Fig. 4, and note absence of big sagebrush.



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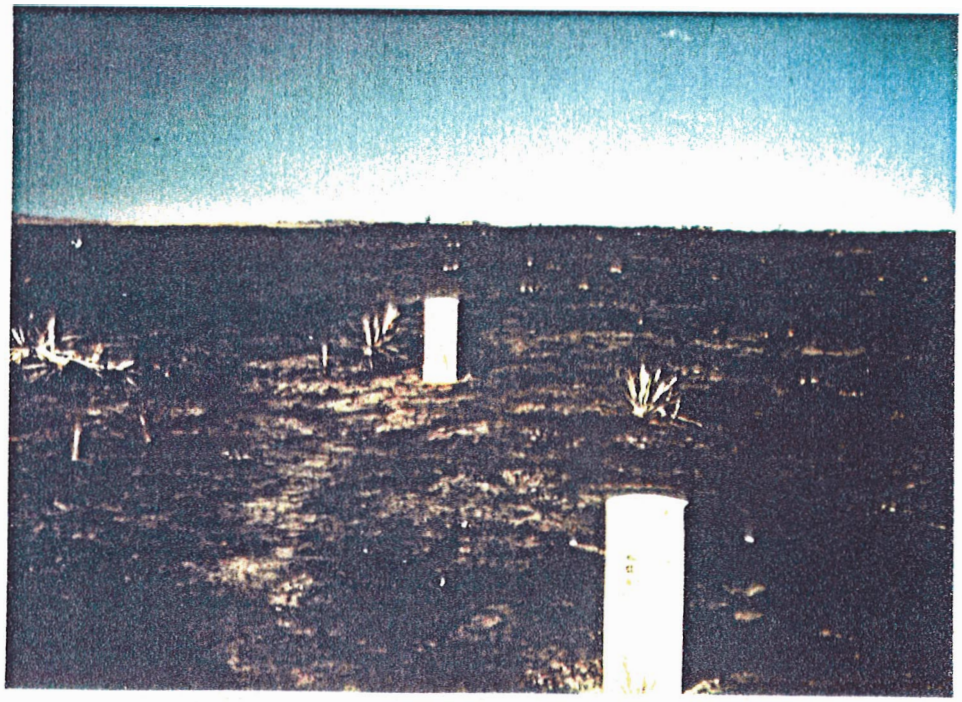


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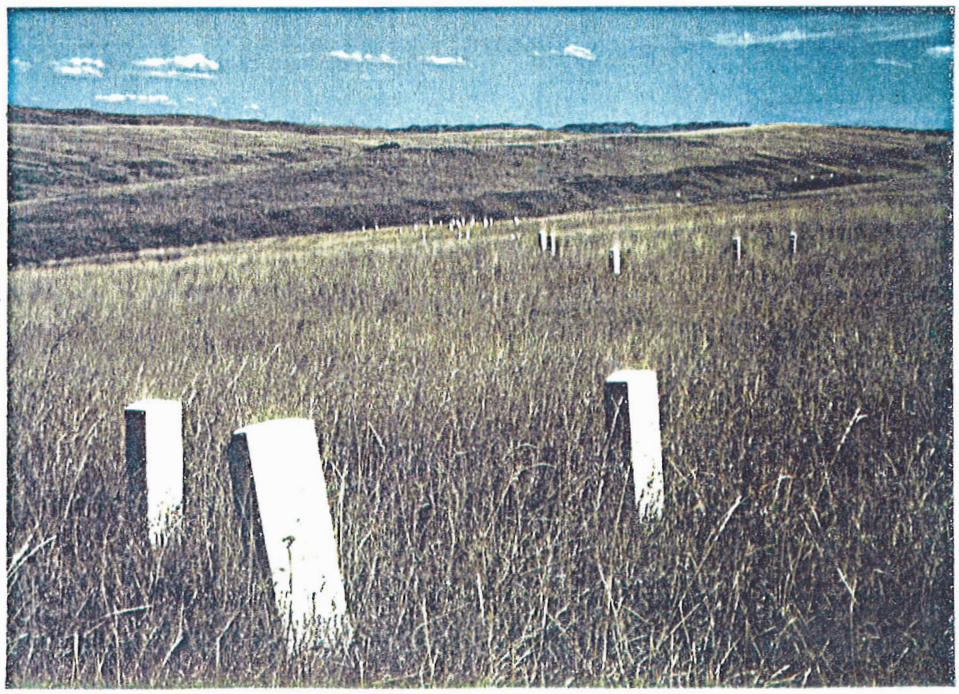


Figure 5. Burned area of Custer Battlefield, where Experimental plots were established. Contrast this with Fig. 4, and note absence of big sagebrush.

AVIAN HABITAT SELECTION FOLLOWING FIRE

IN A MONTANA SHRUBSTEPPE

Section II

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ABSTRACT - Partial fire-kill of sagebrush (Artemisia tridentata) has been shown to have only a minor impact on shrubsteppe breeding bird populations. A 1983 wildfire caused 100% sagebrush mortality at Custer Battlefield National Monument, converting an Artemisia shrubsteppe into a pure high plains grassland. We examined avian habitat selection in 1985-1986 on the burn and an adjacent unburned site. The burn supported a much lower variety and abundance of nesting birds than the unburned shrubsteppe. Lark buntings (Calamospiza melanocorys), lark sparrows (Chondestes grammacus), and Brewer's sparrows (Spizella breweri) selected patches of unburned habitat with higher than average sagebrush canopy, and they completely avoided the burn. Grasshopper sparrows (Ammodramus savannarum) also were significantly more abundant on the unburned site. Only western meadowlarks (Sturnella neglecta) were equally abundant in both areas, while no species preferred the burned grassland.

INTRODUCTION

The rolling grasslands of south central Montana lie in a transition zone between the northern great plains and sage-dominated shrubsteppe of the intermountain west (Küchler 1964). Big sagebrush (Artemisia tridentata) is common in parts of this region, related perhaps to historical patterns of grazing and fire suppression (Wright and Wright 1948). One such area is Custer Battlefield National Monument, near Crow Agency, Bighorn County, Montana. Most of this 310ha area has been protected from

livestock grazing since 1891, and today it supports unusually rich stands of annual and perennial grasses (Stubbendieck 1983). Photographic evidence shows that sagebrush also was common over most of the battlefield from the late 1800's through August 10, 1983. On that date a wildfire of undetermined origin combusted about 220ha of the site, causing virtual 100% mortality of these shrubs.

Birds of shrubsteppe habitats have been shown to be relatively insensitive to environmental perturbations (e.g. Best 1972, Castrale 1982, Wiens and Rotenberry 1985, Wiens et al. 1986). For example, prescribed fire in an Idaho shrubsteppe reduced sage cover, yet presumed sage-dependent birds responded neither predictably nor consistently to this habitat change (Peterson and Best, in press). It is for this reason that we were inspired to study the responses of breeding birds to the complete loss of sage cover at the Custer Battlefield. Objectives of the study were to compare abundances of breeding birds on burned vs. unburned portions of the monument, and to determine if these differences were consistent with habitat preferences shown by the species within either area and elsewhere in their ranges.

METHODS

The study area consisted mostly of rolling shrubsteppe. Dominant ground cover included perennial grasses in the genera Agropyron, Stipa, and Poa, plus the exotic annual grass Bromus japonicus. Artemisia tridentata was the only abundant upland

shrub. Scattered small stands of chokecherry (Prunus virginiana) and skunkbush (Rhus trilobata) occupied the bottoms of some swales and small ravines. These comprised most of what little woody vegetation remained following the fire.

Custer Battlefield includes two holdings: a 244 ha site where Colonel G.A. Custer and his troops were annihiliated by Cheyenne and Sioux on June 25, 1876, and a 66 ha site 4.5 km distant where forces under the command of Major M.A. Reno and Captain F.W. Benteen held out between 25 and 26 June. In 1985 and 1986, we compared the avifauna of the Reno-Benteen site with that of the burned portion of the Custer site.

Because we did not visit the study area prior to the 1983 fire, our conclusions must be based entirely upon post-burn data, and their strength depends upon the legitimacy of using the Reno-Benteen site as a model of the Custer site before the fire. We feel that this approach was valid for several reasons. First, an extensive photographic record from monument archives shows that, prior to burning, the Custer site supported stands of Artemisia tridentata comparable to those at the Reno-Benteen site, and the areas have had an otherwise similar land use history. Second, two small unburned patches of the Custer site continue to support sage, and to resemble the Reno-Benteen site in other vegetational characteristics (Bock and O'Shea-Stone 1985) , although they are too small for meaningful avifaunal analysis. Finally, the two sites are in no sense isolated, but are part of an extensive area of generally similar shrubsteppe. Intervening lands belong to members of the Crow Tribe, and differ

from the monument only insofar as they are grazed by cattle and horses. We observed all species of birds involved in this study on these grazed lands, during our trips between the Custer and Reno-Benteen study areas.

We examined avian habitat selection using a bird-centered vegetation sampling procedure (Larson and Bock 1986). Two 2.2 km transects were established, one in unburned shrubsteppe at the Reno-Benteen site, the other in totally burned grassland at the Custer site. We walked each transect four times, twice each in June of 1985 and 1986, marking the locations of all birds detected within 50 m on either side of the transects. Archaeologists had established survey grids at both sites in 1984. We selected 10 of these grid intersects in each of the two years, within each of the transect strips, to serve as randomly located points for comparison with those centered on the birds. We then measured shrub density by species in a 40 m^2 plot, plus percent coverage of shrubs, grasses, herbs, bare ground, or litter inside ten 0.25-m^2 frames placed in a standardized pattern < 10-m from each point.

Numbers of detections in the two treatment areas were compared using the Chi-square statistic, or, for those species found only at one site, using exact tests, assuming equal probability of detection at either site. Birds may have been more detectable at the Custer site because of the absence of shrubs. However, this possible bias would make our conclusions conservative, given that the only significant differences were among species detected more often in the unburned area (Table 1).

Vegetation characteristics of random and bird-centered plots were compared using the Mann-Whitney U statistic.

RESULTS

Total shrub cover differed dramatically and significantly between treatments (Table 1), due to fire-caused mortality of Artemisia tridentata at the Custer site. Sage density averaged 13.7 plants/40m^2 on random plots at the unburned site. We found only one sage plant that survived the fire. Those plants killed by the fire were burned away to < 5 cm of ground level. No re-sprouting or recruitment of big sagebrush had occurred through the end of the 1986 growing season. Grass and herb canopy was somewhat higher on the burn (Table 1), but this difference was only marginally significant ($0.05 < P < 0.10$).

Lark buntings (Calamospiza melanocorys), lark sparrows (Chondestes grammacus), and Brewer's sparrows (Spizella breweri) occupied patches of unburned habitat with significantly more shrub canopy than was available randomly in the unburned area (Table 1). This apparent selection of relatively shrubby unburned areas is consistent with the complete absence of these species from the burn. Lark sparrows also selected unburned sites with relatively little ground cover (Table 1). However, it is difficult to attribute their avoidance of the burn to any preference for open ground, since burn and control differed so little in this regard.

Grasshopper sparrows (Ammodramus savannarum) occupied both sites, but were detected significantly less often on the burn

(Table 1). In the unburned area, plots centered on grasshopper sparrows did not differ from random plots in terms of shrub canopy or total ground cover. On the burn, grasshopper sparrows may have selected sites with less ground cover and more shrubs than were randomly available, but the small sample size (i.e., scarcity of this species on the burn) makes these conclusions highly speculative. The western meadowlark (Sturnella neglecta) was the only common bird on the burn. Numbers of meadowlark detections did not differ significantly between treatments, nor did shrub canopy of meadowlark-centered plots differ significantly from random plots in either area. On the burn, meadowlarks were detected in areas with slightly (and significantly) less grass/herb cover than was randomly available.

DISCUSSION

Fire at the Custer Battlefield converted an Artemisia tridentata shrubsteppe into a high plains grassland. Birds responded to this change in ways generally consistent with habitat preferences described for the same species elsewhere in their ranges. Brewer's sparrows nest in shrubs, and have shown positive associations with shrub (especially sage) cover in a variety of sites (Wiens 1973, Rotenberry and Wiens 1980, Larson and Bock 1986). Partial kill of shrubs by fire or herbicides may not eliminate Brewer's sparrows from an area (Best 1972; Wiens and Rotenberry 1985; Wiens et al. 1986; Peterson and Best, in press). However, total kill and removal of standing dead twigs and branches apparently does so (Shroeder and Sturges 1975, Pyrah

and Jorgensen 1974, this study).

Lark sparrows were positively associated with shrub cover across a variety of sites in the northern Great Basin (Wiens and Rotenberry 1981), and with areas of relatively open ground and scattered mesquite (Prosopis juliflora) in southern Arizona (Bock and Webb 1984). Lark buntings are gregarious nesters, rather patchily distributed in time and space across central Canadian and U.S. grasslands, but generally associated with areas of "mixed shortgrasses and sagebrush" (Johnsgard 1979:465). Both lark sparrows and lark buntings seemed to prefer this sort of mixture of sagebrush and grass at the Custer Battlefield.

Grasshopper sparrows were positively associated with grass cover and vegetation height, but not necessarily with shrubs, across a wide variety of western U.S. steppe habitats (Rotenberry and Wiens 1980). However, Wiens (1973) found that grasshopper sparrows in shortgrass prairies were most numerous in areas with emergent vegetation that the birds used as song perches. The scarcity of such perches on the Custer burn seems to have made the area less suitable for grasshopper sparrows than nearby shrubsteppe, despite the lush grass cover (Table 1).

Western meadowlarks are perhaps the most adaptable of all North American grassland birds (e.g., Rotenberry and Wiens 1980). Our results are entirely consistent with this general pattern, since this was the only species equally abundant on both study sites, and the only common breeding bird on the Custer burn.

While birds responded predictably to conversion of

shrubsteppe to grassland at the Custer Battlefield, we do not use our results to argue for the existence of shrubsteppe vs. grassland bird "communities" here. Postulation of such communities is neither necessary nor sufficient to explain our findings. First, several species supposedly characteristic of Artemisia-dominated steppe environments did not occur at all on the battlefield, at least in 1985 and 1986. Second, those species we did find were not always present in comparable numbers in both years.

Sage sparrows (Amphispiza belli) and sage thrashers (Oreoscoptes montanus) frequently are abundant in areas with high sage densities (Wiens and Rotenberry 1981), while horned larks (Eremophila alpestris) and vesper sparrows (Pooecetes gramineus) have increased in other shrubsteppe habitats following reduction of shrub cover (Castrale 1982; Wiens and Rotenberry 1985; Peterson and Best,in press). The absence of sage sparrows and sage thrashers at the battlefield perhaps can be explained by the relatively low density of sage present, even on the unburned area. The unusually heavy grass cover at both sites certainly could explain the absence of horned larks. Our failure to find vesper sparrows is difficult to understand, especially since Best (1972) found it to be the second most abundant breeding bird in a Montana shrubsteppe about 150 km northwest of our study area.

Brewer's sparrows were reasonably abundant on our unburned area in 1985, and showed a clear preference for areas of high shrub cover. However, we found none of them in 1986, either on the transects or elsewhere in the vicinity of the battlefield. Similarly, lark sparrows were scarce in 1985 (one detection

only), but fairly common in 1986. Such patterns could be due to changes in resources or habitat characteristics at the battlefield that we did not preceive, but it seems more likely that they were the result of events affecting survivorship or reproduction of these species in other places and times.

Results of this and similar studies provide considerable insight into the habitat preferences or requirements of individual bird species, and these enable us to predict where certain birds are likely not to occur. It is less probable that we can use these data to predict exactly where a species will occur, or in what numbers. Our results do suggest that at least some scattered shrubs are an essential component of nesting habitat for many birds breeding in the high plains grassland of southeastern Montana.

ACKNOWLEDGMENTS

We thank Roger Amerman, Maureen O'Shea-Stone, and Curtis Yarlot for field assistance. The Superintendent and staff of Custer Battlefield National Monument kindly made available their facilities. This project was supported by the U.S. Deptartment of the Interior, National Park Service - University of Wyoming Research Center (Contract No. CX 1200-4-A034).

TABLE 1. Numbers of detections and characteristics of random and bird-centered plots on unburned vs. burned sites at Custer Battlefield National Monument, 1985-1986.

Treatment (site)	Plot type	n	Shrub canopy (%) $\bar{X}$ (range)	Grass-herb canopy (%) $\bar{X}$ (range)
Unburned (Reno-Benteen)				
	Random	20	4.9(0-33)[b]	37.2(18-56)
	Western Meadowlark	19	6.7(0-19)	34.5(19-55)
	Grasshopper Sparrow	19[a]	5.4(0-11)	33.1(16-53)
	Lark Bunting	12[a]	9.5(0-33)[c]	37.3(25-46)
	Lark Sparrow	9[a]	9.2(1-16)[c]	26.4(20-36)[c]
	Brewer's Sparrow	7[a]	13.7(6-33)[c]	43.3(24-76)
Burned (Custer)				
	Random	20	0.2(0-2)	43.8(25-59)
	Western Meadowlark	26	0.6(0-12)	37.4(17-56)[c]
	Grasshopper Sparrow	5	1.4(0-6)	32.6(26-43)[c]
	Lark Bunting	0		
	Lark Sparrow	0		
	Brewer's Sparrow	0		

[a] Number of detections significantly different between treatments (Chi-square or exact tests, $P < 0.05$

[b] Significantly different from random plots on burn (Mann-Whitney U, $P < 0.01$).

[c] Significantly different from random plots within-treatment (Mann-Whitney U, $P < 0.05$).

A PHOTOGRAPHIC HISTORY OF THE VEGETATION

OF

CUSTER BATTLEFIELD NATIONAL MONUMENT

CROW AGENCY, MONTANA

NPS Contract No. CX-1200-4-A034

Section III

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At Custer Battlefield, the visitors and staff alike tend to be occupied with details of the Battle of the Little Bighorn. It is not surprising that, in this environment, we biologists became curious about the vegetation that was in place on the Battlefield on June 25, 1876, because no formal description from that time exists. We also were interested in the history of the vegetation between 1876 and today.

Although the vegetation at the Battle scene was not described purposefully, clues about its nature can be obtained from recorded observations by Indian participants in the Battle and by military visitors to the site immediately after the Battle. We assume warriors always have been influenced by their environment, and we believe the participants in the Battle of the Little Bighorn were no exception. George Armstrong Custer, the hero and/or fool of the Battle, was especially concerned with natural features of the sites of his military experiences, as we can see by his journals. He wrote frequently of the wildflowers and general aspects of places he visited in the West. Had he survived, we most likely would have a clear and detailed description of the vegetation on the Battlefield.

We can piece together from various sources the character of the vegetation on the Custer Battlefield and the Reno-Benteen site on June 25, 1876; by means of scattered references. A great ingathering of Sioux and Cheyenne people had taken place in the vicinity of the

Battle scene, just prior to June 25. The Oglala Sioux boy, Black Elk (Neihardt, pp 106-109), set the scene prior to the Battle.

> The Indians were camped on the west side of the Little Bighorn River. The river was running high due to the summer runoff from melting snow in the Bighorn mountains to the west. "Many people were in the water now and many of the women were out west of the village digging turnips."

These turnips, known locally as Indian turnips (Psoralea esculenta), possess an edible root. They grow on the Battlefield to this day (see Section IV). Black Elk also noted there was copious forage for their horses in the area.

> "On the westward side of us were lower hills, and there we grazed our ponies and guarded them (a duty of Black Elk's). There were so many they could not be counted."

> Another source, Stewart's valuable history (1955), assembled numerous observations about the Battlefield. He discussed the terrain of the Battlefield that day (p. 43), "The terrain was admirable for concealment, the broken country cut by many small gullies and dotted with tiny hummocks and ridges, its patches of sagebrush and grass much taller than now (1955, see Fig. 15 for what the Battlefield looked like at Stewart's writing), affording perfect cover for the Indians but making the terrain little suited to the formations necessary for

the successful maneuvering of cavalry." Further on, he cites comments from Edna L. Waldo, "'Coulees intervened, trees and shrubbery masked the Indians retreat (?) along the riverbank below; tall, heavy sagebrush, since cropped by sheep, covered the battlefield at a height that would conceal a lurking savage.'" Stewart concludes, "All of which gives weight to the contention that the topography of the country in the vicinity of the hostile village had more to do with Custer's defeat than any other factor. Many warriors were concealed behind the ridge along which the Custer command was riding, so that when the time came to spring the trap the soldiers would be attacked from all directions."

These sketchy descriptions suggest that the Battlefield at the time of the Battle was covered with full grown mixed grasses interspersed with big sagebrush. The earliest photos of Last Stand Hill support the notion that big sagebrush was present (see Figs. 1,2,3, and 6). However, these photos show little well developed growth of grasses. The activites of the Battle itself, subsequent burial details, and mounted visitors are likely to have reduced the grass cover considerably. These activites would have been much less detrimental to tough big sagebrush.

We also have a record of the big sagebrush and grassy vegetation at the Reno encampment site. In a letter, dated April 5, 1933, from T. Goldin to A.W.

Johnson, Goldin states that while climbing up Reno Hill, "I noticed his (Lt. Donald McIntosh) lariet was dragging on the ground, once in a while catching in the tall grass or sage brush." Stewart also commented on the appearance of Reno Hill (p. 409), "Little protection was afforded (to Reno's troops) on that saucer-like hilltop, even the sparse sagebrush being useless for anything other than concealment (see Figs. 3 and 4 for early views of the Reno site)."

The area along the Little Bighorn afforded more cover according to several sources.

Black Elk said (Neihardt, pp. 131-132), "Beneath the hill (Medicine Tail Coulee?), right on the west side of the Greasy Grass (Little Bighorn River), were some bullberry bushes (Shepherdia argenta, still growing along the Little Bighorn today, see Section IV), and there was a big boy by the name of Round Fool who was running around the bushes. We boys asked him what he was doing that for, and he said, 'There is a Wasichu (non-Indian person) in that bush.' And there was." Plenty Coups tells of his friend who helped some of Reno's troops hide down by the River (Linderman, 1930, p. 176), "It was Half-yellow-face and White-swan who led many of that other chief's (Reno) men into a safe place among the bushes. And it was they who, when at last night came, showed these soldiers where they could creep away and cross the Little Bighorn to reach

the chief who was on the hills with the rest of his men. Half-yellow-face and White-swan, who was badly shot, stayed in those bushes with the wounded white soldiers until The-other-one (General Terry) came and relieved them all, two days after Son-of-the-morning-star (Custer) had been wiped out." Goldin in a letter to A.W. Johnson, described the banks of the Little Bighorn in this way (Oct. 20, 1928), "At the time of the fight the entire bottom was covered with a growth of high sage brush, clumps of bullberry bushes, and rank high grass."

For a knowledge of the Battlefield's appearance we can use a few written descriptions in addition to the photographic record.

One peculiar vegetation note comes from the correspondence between Walter C. Camp and Jacob Galbaraith. Galbraith on Dec. 18, 1911, wrote, "The locations of the bodies of the killed under the immediate command of Custer were traceable by the appearance of the grass. The moldering bones fertilized the soil; they lay not far beneath the surface of the ground, and during the long dry summer of that year (1890) patches of grass, green by contrasts with the generally sunbaked landscape marked the places where the corpses (since removed and buried elsewhere) were. These streaks of green were about the length of decaying skeletons." Camp replies on Dec.

22, 1911, "Some years ago Col, now Brig. Gen., W.W. Robinson, Jr., told me that when he visited the site of the Custer battlefield in 1881, the rank growth of vegetation due to the increased fertility of the soil where the bodies had lain, was quite noticealbe. Your statement that the same thing was the means of identifying the locations of the graves when the markers were put up is equally interesting, as a matter of history." The markers referred to can be seen in Figs. 5 and 6.

The general picture we have of the Battlefield on the day of the Battle is of a grassland-big sagebrush, shrub-steppe. In this part of the U.S., this type of vegetation is most often associated with heavy grazing by large herbivores and an absence of fire (see Discussion in Section I). There are indirect comments about the Little Bighorn region which suggest the source of grazing which encouraged the big sagebrush growth. General Gibbon scouted the region close to the Battle site shortly before it occurred and remarked on the enormous buffalo herds present (Stewart, 1955, p. 113). Also, interviews with members of the Cheyenne, Sioux, and Crow tribes suggest that the country along the Little Bighorn had long been a gathering place for Indians and their horses for many summers prior to 1876. This was due to the predictable presence of much good grass and large bison herds (Stewart, *ibid.*). The grazing by horses and bison, plus the disturbance associated with

camping, likely was suffficient to encourage the invasion of the Northern Mixed Grass Prairie by big sagebrush. This vegetation remained in place from the time of the Battle until 1983 due to the absence of wildfire from the Battlefield.

However, intervening years saw changes in vegetation. Most dramatic was the destruction of vegetation cover, especially evident in the 1931 photos (Figs. 12, and 13). We assume this degradation was due to a combination of drought and reenactments of the Battle (see Figs. 7, 9, 10, and 11). By the 1950's (Figs. 14 and 15) and especially the 1960's (Figs. 16 and 17), the grass cover became much heavier. By this time, the reenactments on site had ceased and stricter policing was carried out on the Battlefield, *e.g.* automobiles and carriages no longer were driven on the site (see Fig. 10).

The greatest changes in the vegetation of the Battlefield in the last half century were due to the August 10, 1983, wildfire which destroyed approximately 90% of the above-ground vegetation of the Battlefield (Fig. 21) and caused the dramatic demise of big sagebrush (compare Figs. 18A and 18B, Figs. 19A and 19B, and Figs. 20A and 20B).

Today, the Battlefield presents a beautiful view of rare, intact Northern Mixed Grass Prairie (Fig. 22). On the morning of June 25, 1876, it likely looked more like the shrub-steppe shown in Figures 16, 17, 18A, 19A, and 20B. By sundown, a remnant of grassland with scattered big sagebrush

sentinels (like those depicted in Figure 8, Memorial Day, 1920) bore quiet witness to the bloody events of the day.

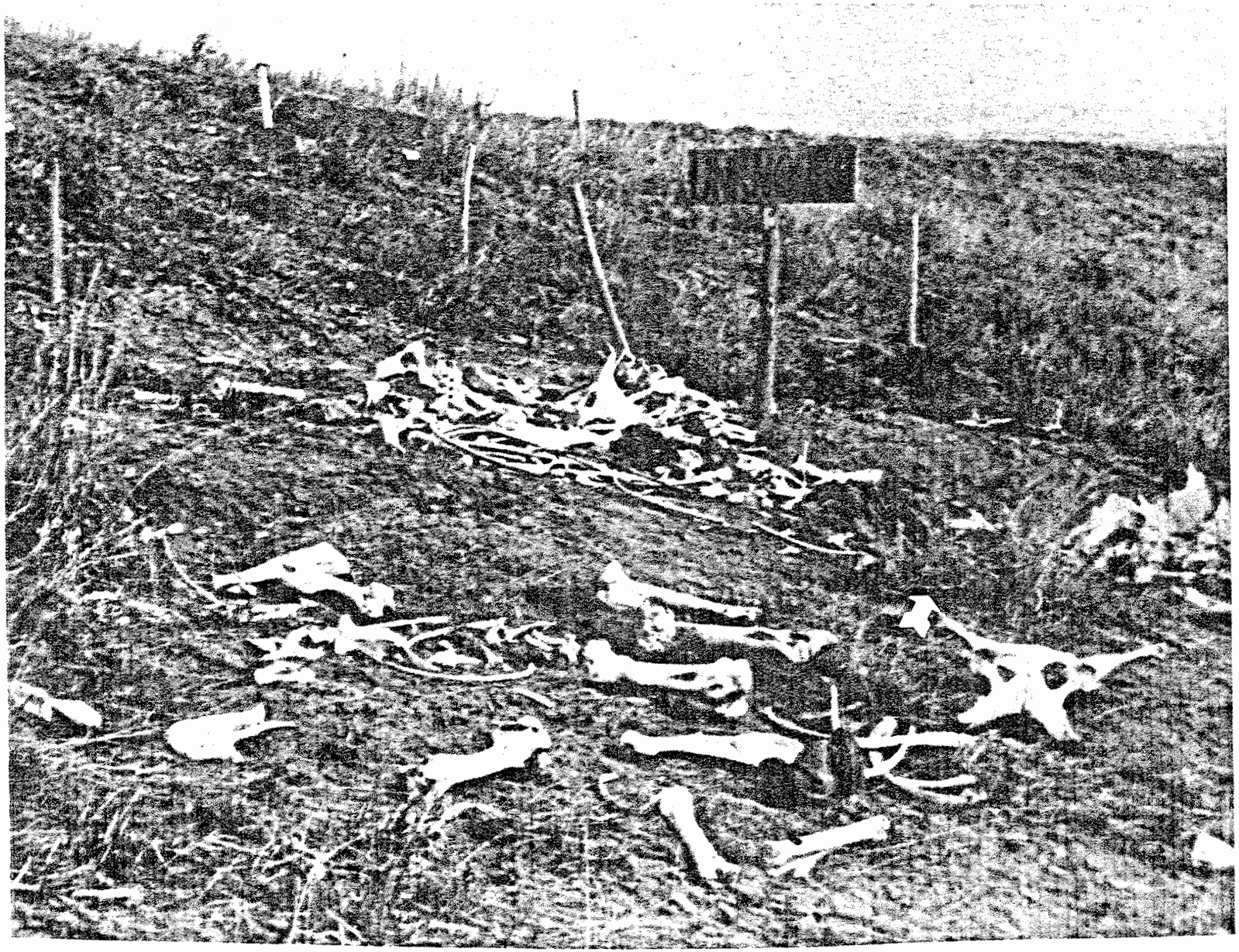


Figure 1. 1879. Last Stand Hill. The horse bones are scattered among big sagebrush (arrow) and prairie plants. The sparse vegetation may have been due in part to battle activities.

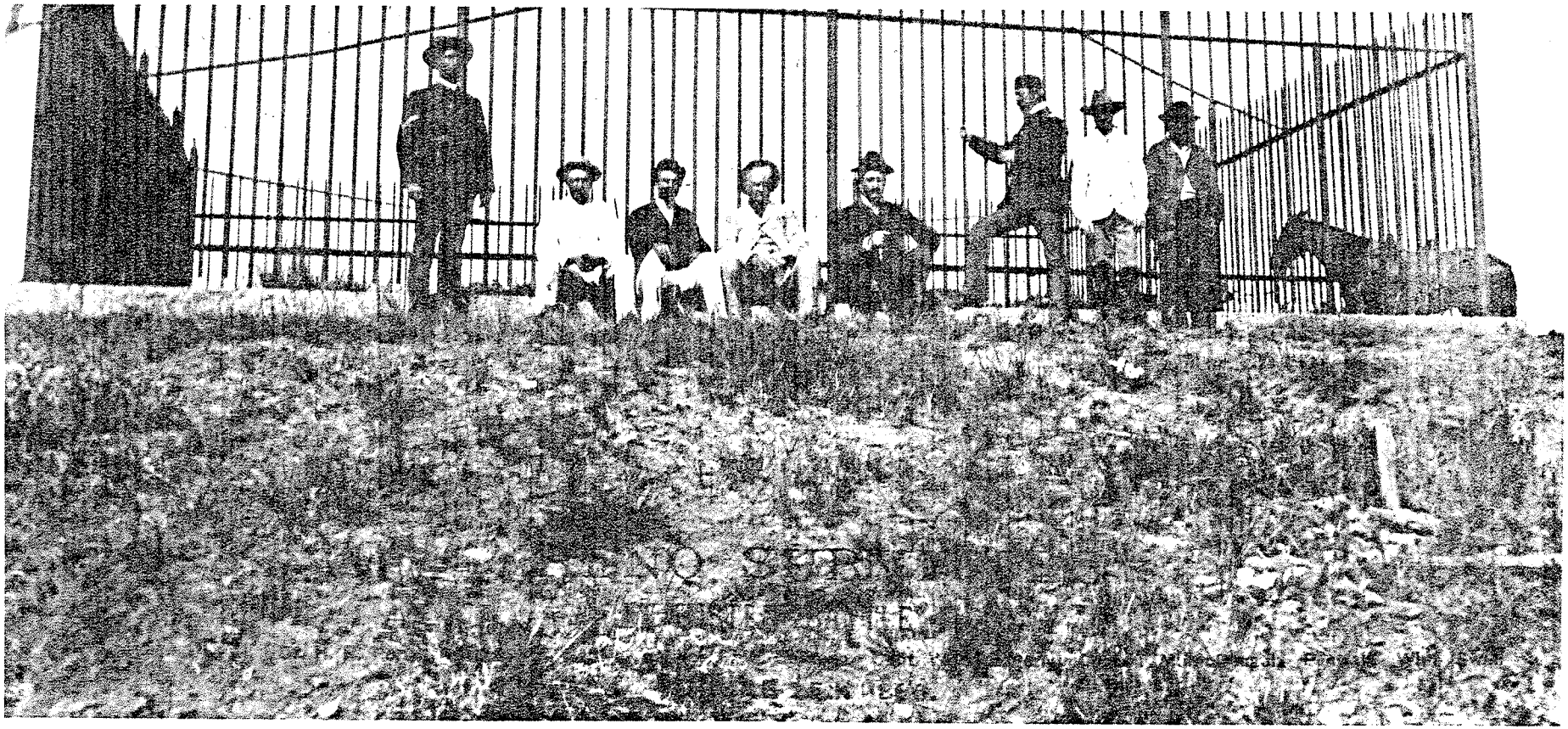


Figure 2. 1886. Last Stand Hill. Some survivors of Reno's and Benteen's units gather on 10th anniversary of the Battle. D.F. Barry photo.

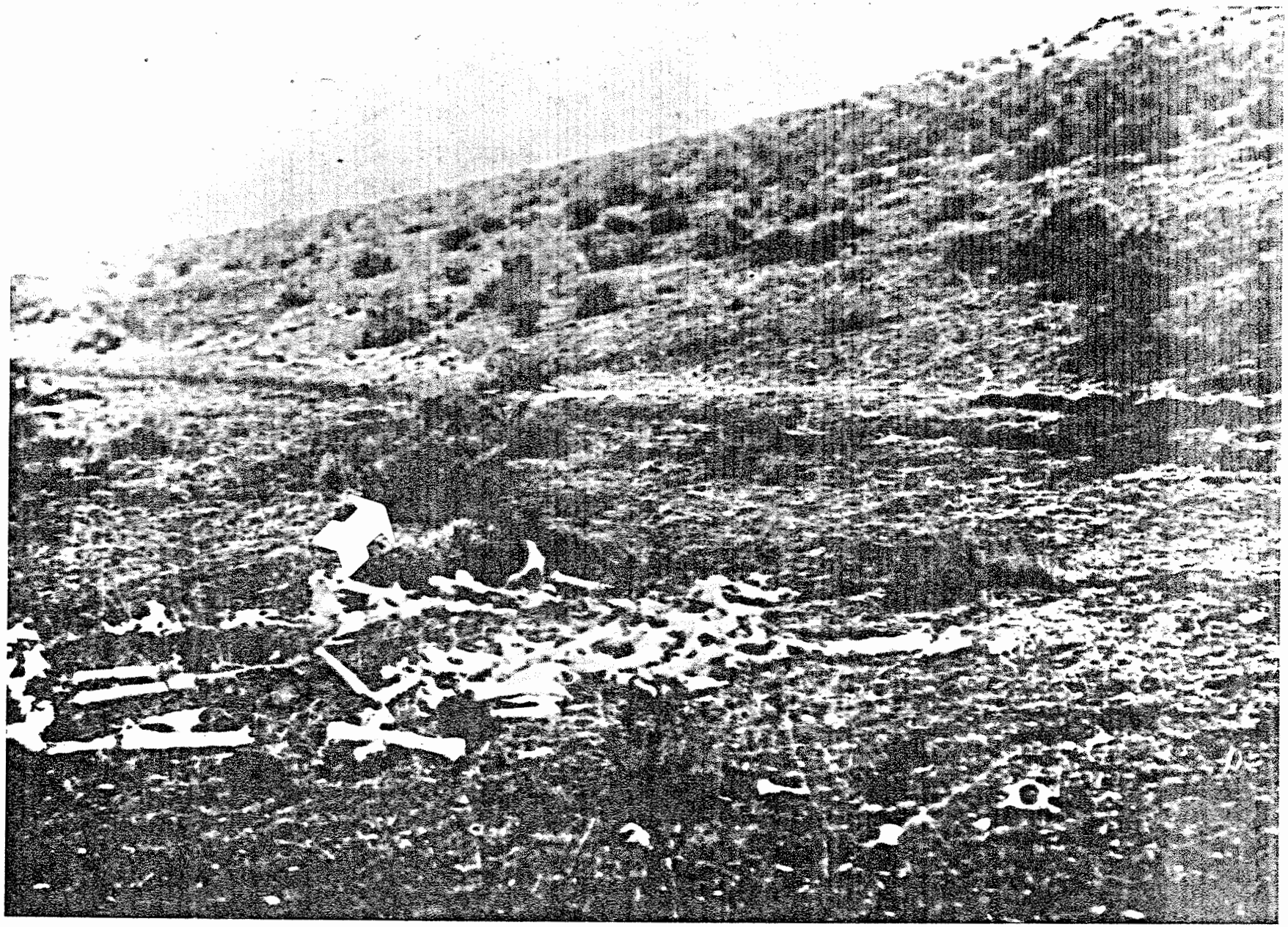


Figure 3. Probably 1886. Reno's encampment area, showing horse bones and big sagebrush (arrow).

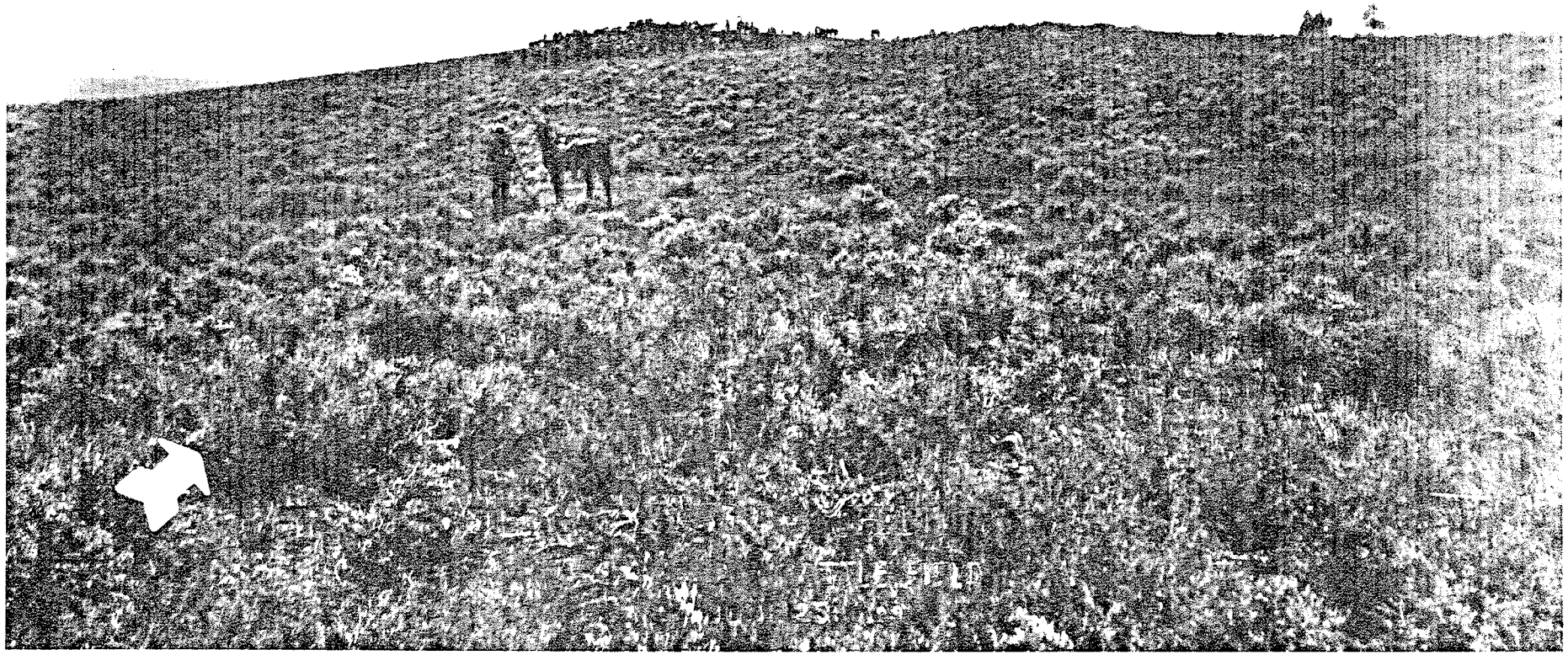


Figure 4. June 25, 1886. Reno-Benteen site on 10th anniversary of Battle. Note big sagebrush (arrow). This area looks much the same today (1987).



Figure 5. 1894: Distant view looking out over Battlefield. Note big sagebrush (arrow).

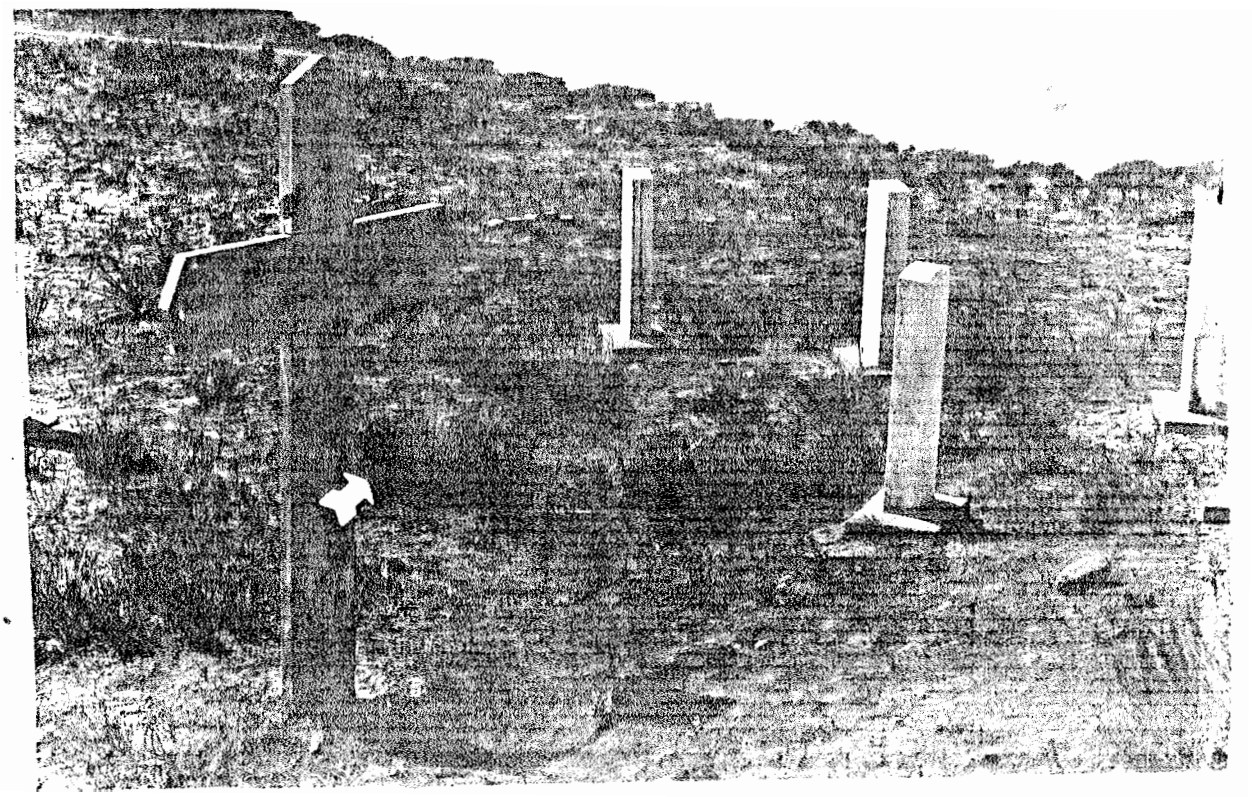


Figure 6. 1894: Last Stand Hill. Close-up view of place where Custer died. Scattered sagebrush are clearly visible (arrow).

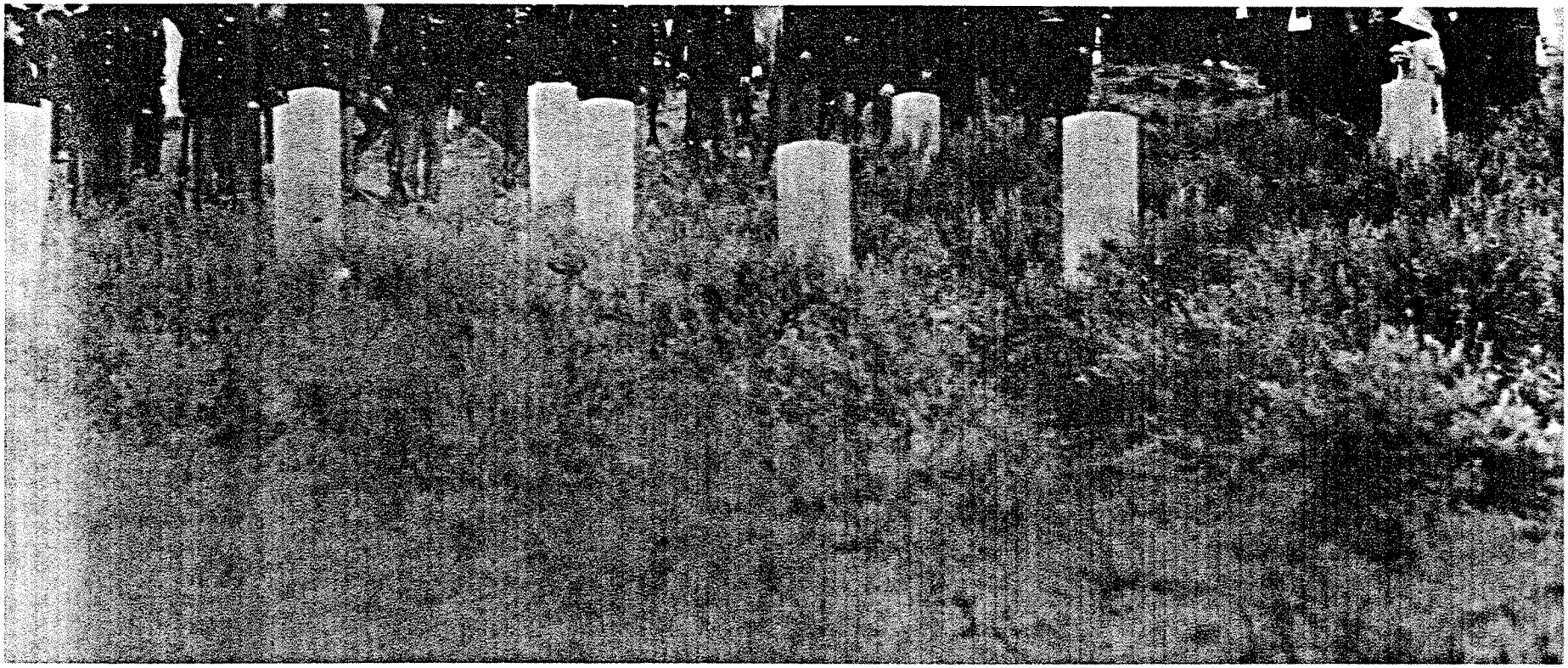


Figure 7. June 25, 1916: 40th anniversary of the Battle. Dense stand of big sagebrush among markers on Last Stand Hill.

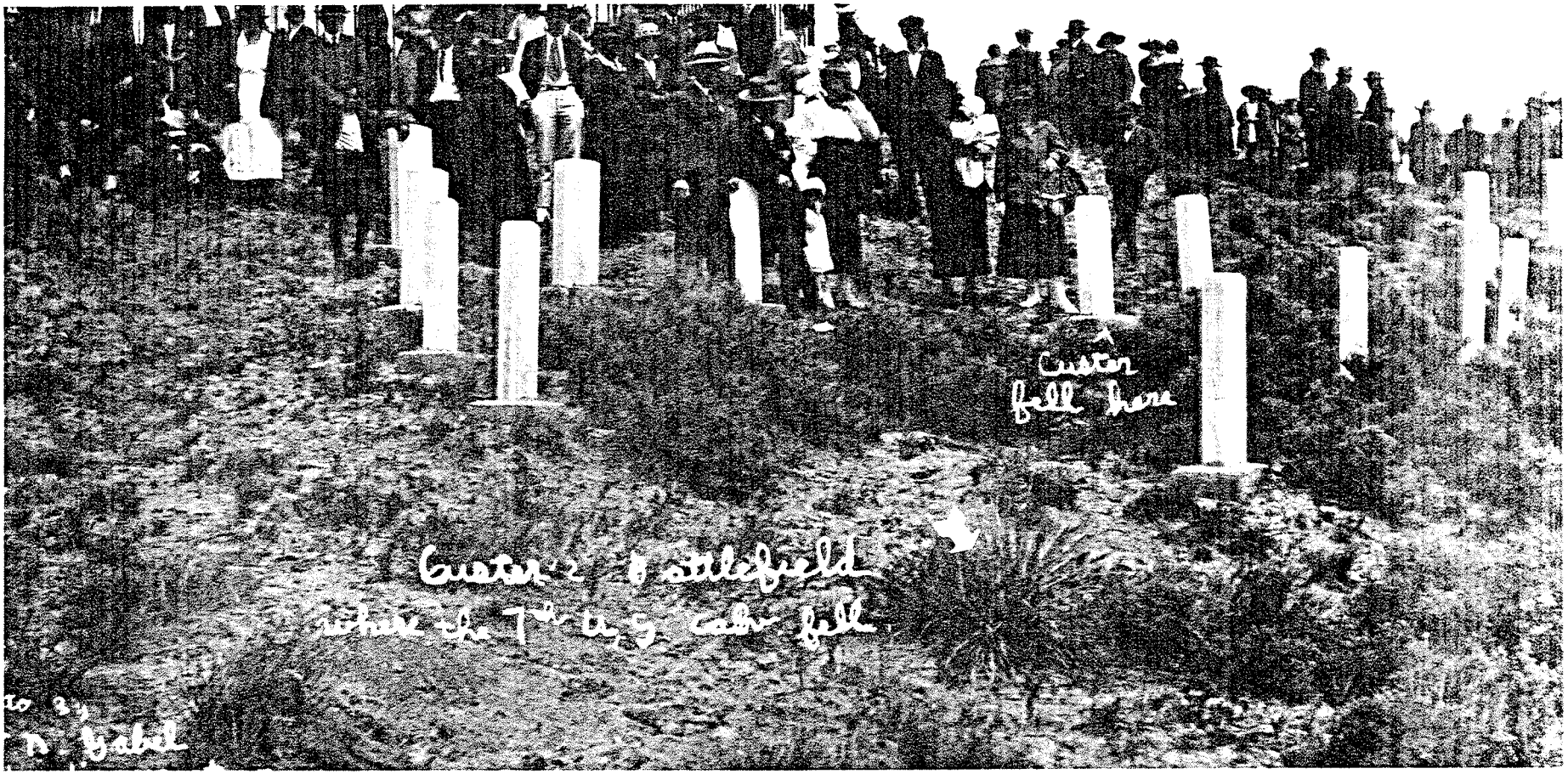


Figure 8. Memorial Day, May 30, 1920. Last Stand Hill with Yucca (arrow) and big sagebrush growing among markers.

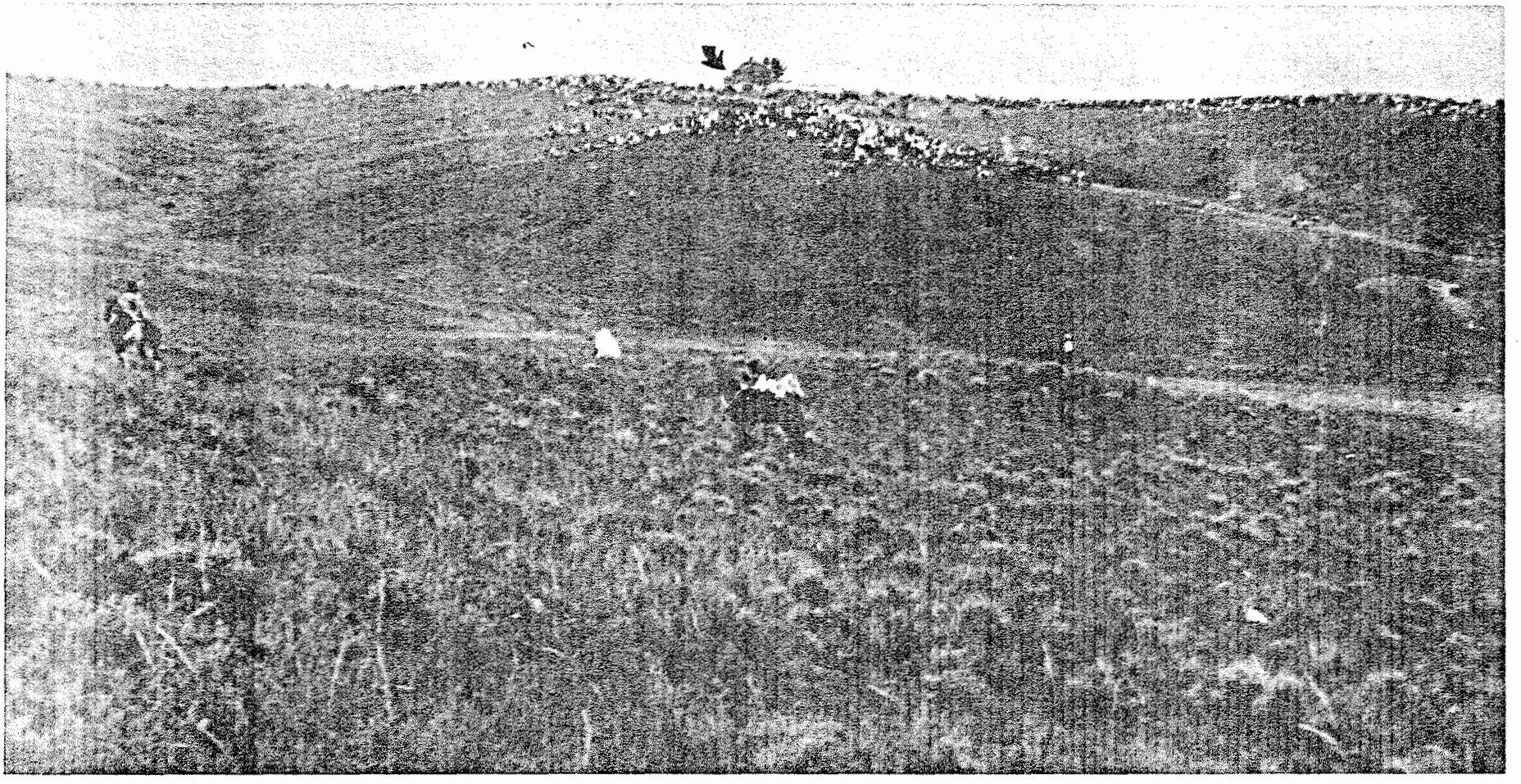


Figure 9. June 25, 1921. Reenactment of the Battle on its 45th anniversary. Stone House is visible in the background (arrow). Scattered big sagebrush are evident in the foreground.

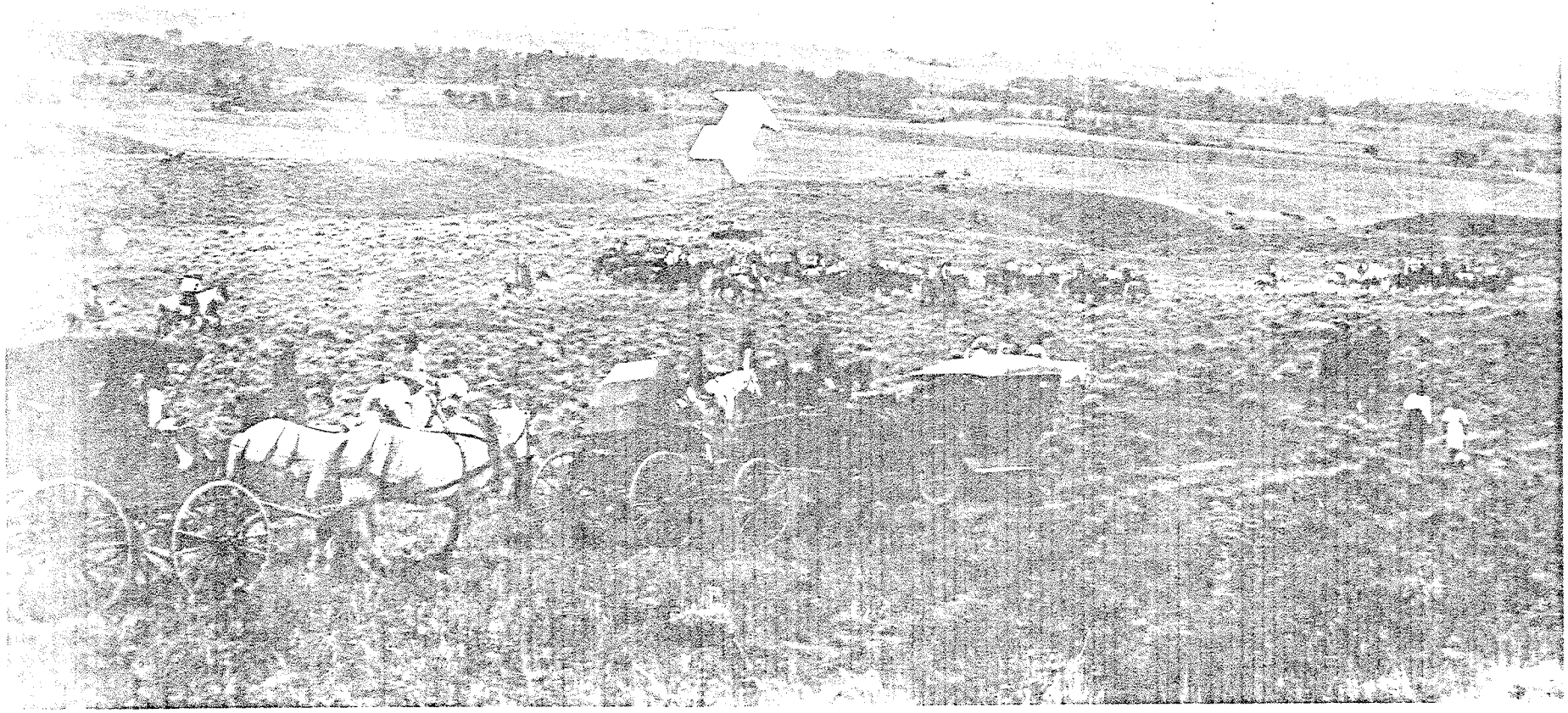


Figure 10. June 25, 1921. Gathering of visitors with various modes of transportation on the Battlefield. Below Last Stand Hill. The Little Bighorn River is outlined by trees in the distance (arrow).



Figure 11. June 25, 1926: 50th anniversary. Participant in peace ceremony, resting among big sagebrush (arrow) and grasses on Last Stand Hill.

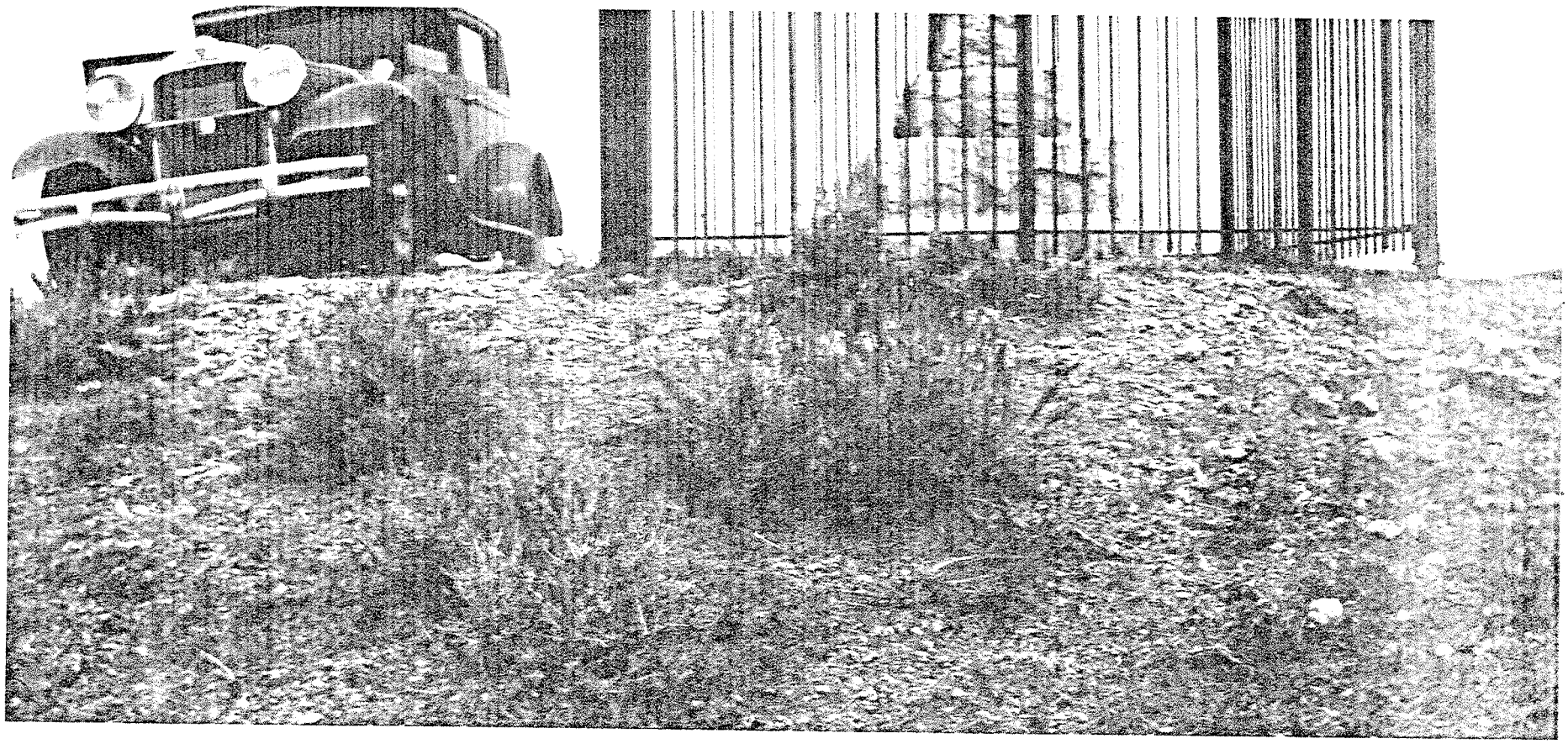


Figure 12. 1931: Top of Last Stand Hill, showing extreme disturbance of vegetation. Big sagebrush dominates the scene.

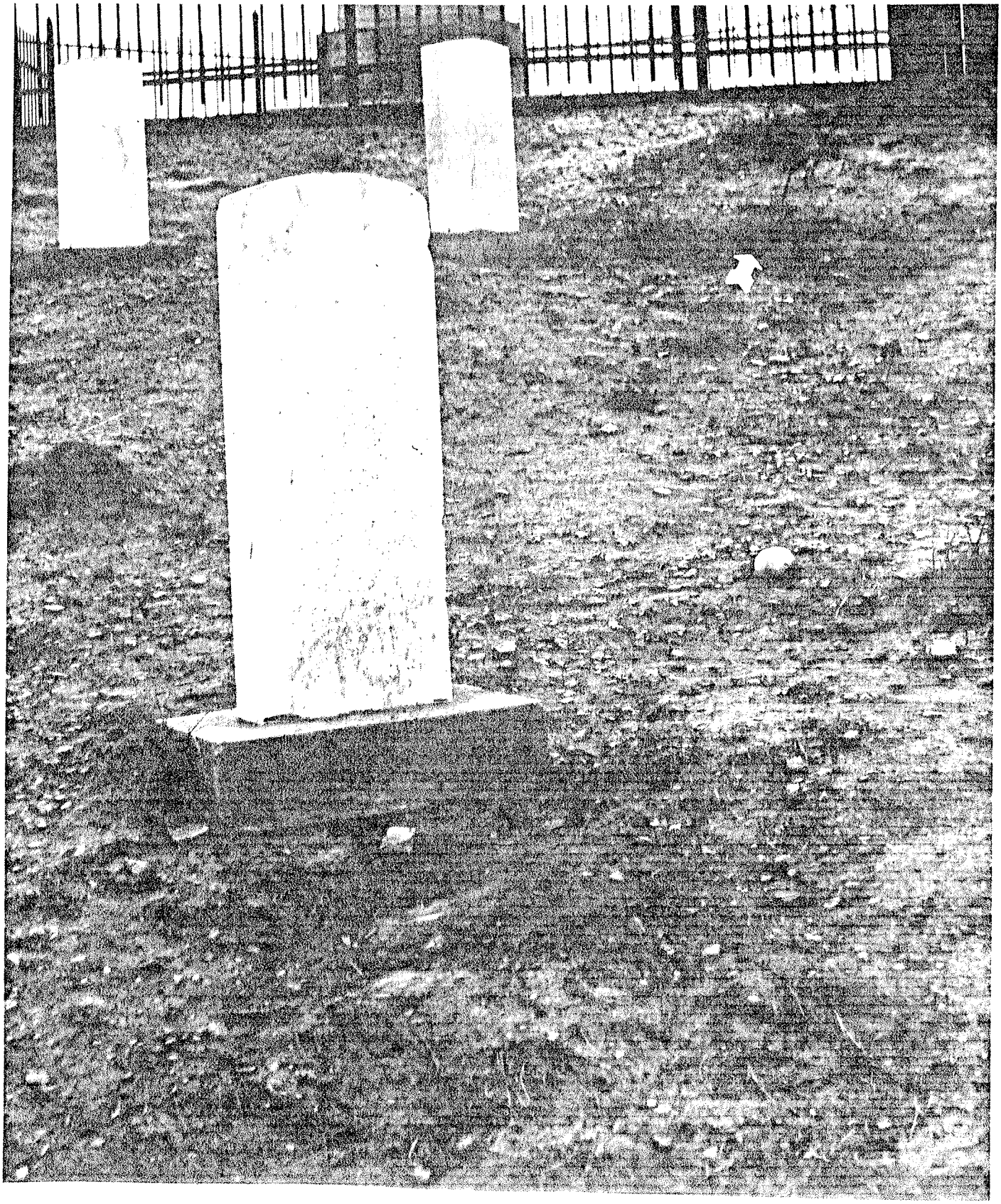


Figure 13. 1931. Slope of Last Stand Hill, showing wholesale destruction of vegetation. A few big sagebrush survive (arrow) near the top of the picture.

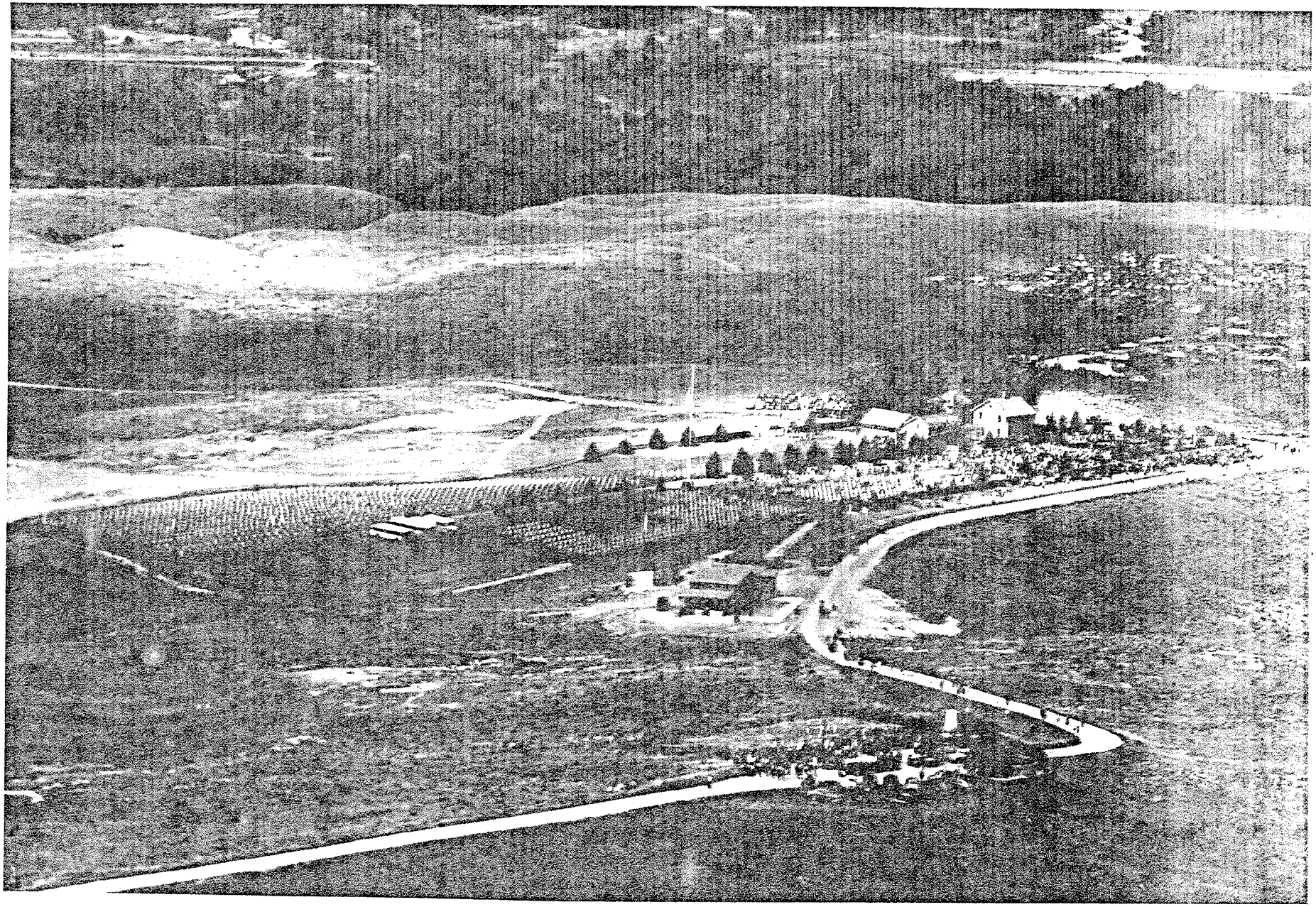


Figure 14. June 25, 1951: 75th anniversary of the Battle. Note visitors' cars, indicating increasing visitor numbers in modern times.

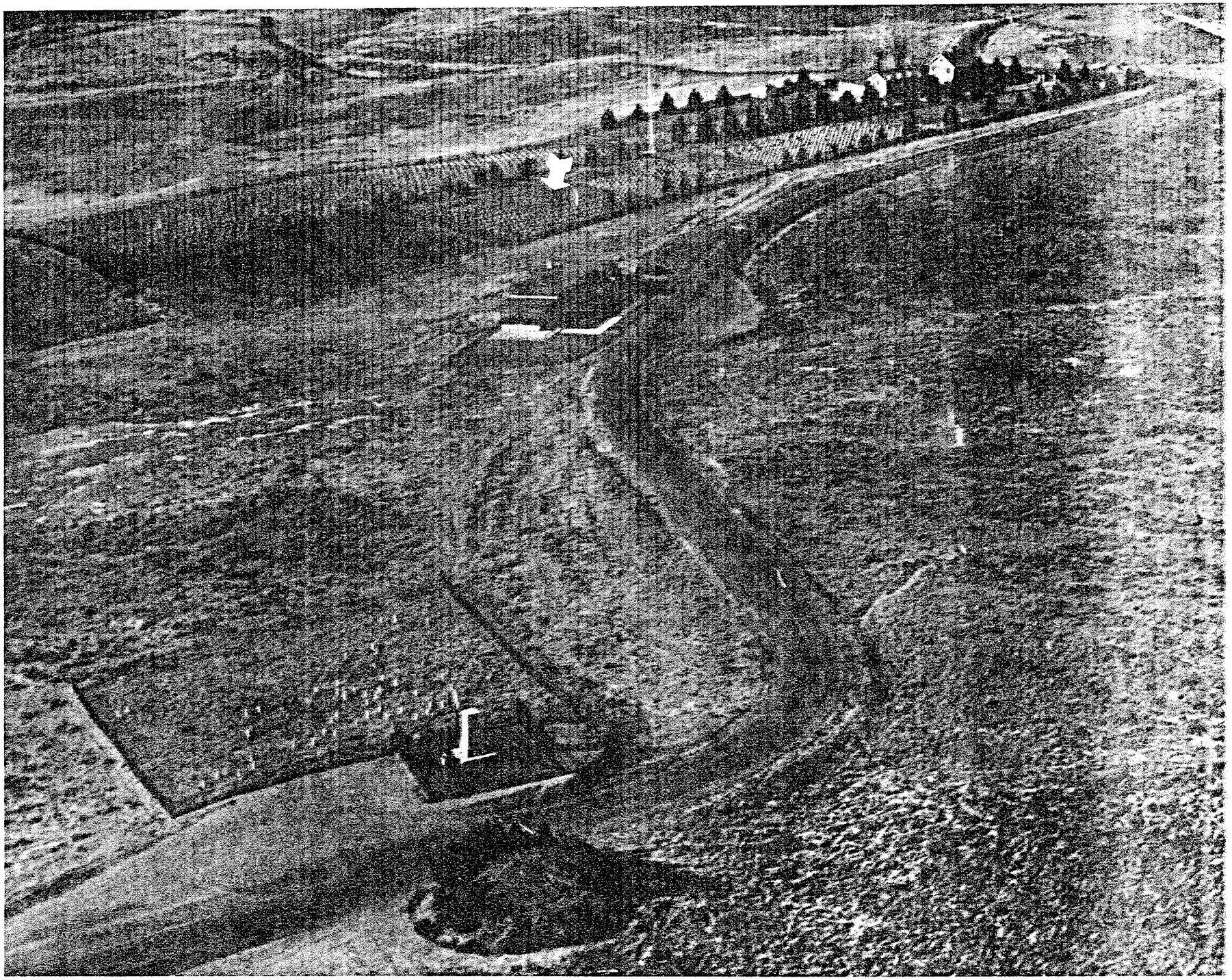


Figure 15. A 1954 aerial view of the Battlefield, differing little from Fig. 14. Big sagebrush is scattered over the site. Bluegrass sod (arrow) is visible on military cemetery.



Figure 16. 1965. Battlefield view with shrubsteppe vegetation. This view is indicative of the condition of the Battlefield's vegetation prior to the 1983 fire. Vegetation has recovered from the effects of annual Battle reenactments. Compare this photo with those from earlier decades.

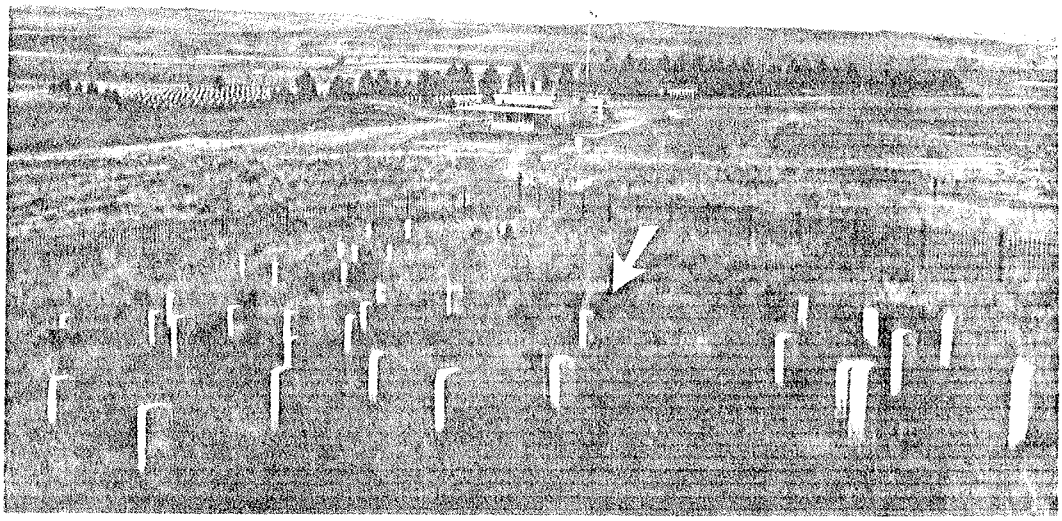


Figure 17. 1965. Last Stand Hill, looking towards the Visitors' Center. Big sagebrush (arrow) is interspersed with vigorous Northern Mixed Grass Prairie plants.



Figure 18A. Probably in the 1970's. Postcard view of Last Stand Hill enclosure. Note big sagebrush clumps (arrow).



Figure 18B. Copies Fig. 18A, but taken in 1985. View of Last Stand Hill. Note absence of big sagebrush after the fire.



Figure 19A. Probably 1970's. Postcard view of Last Stand Hill covered with big sagebrush.



Figure 19B. 1986. Post-fire view of Last Stand Hill, duplicating view in Fig. 19A, and showing fire-induced changes in vegetation.

Figure 20A. Probably 1970's. Postcard view of Battlefield showing shrubsteppe vegetation.

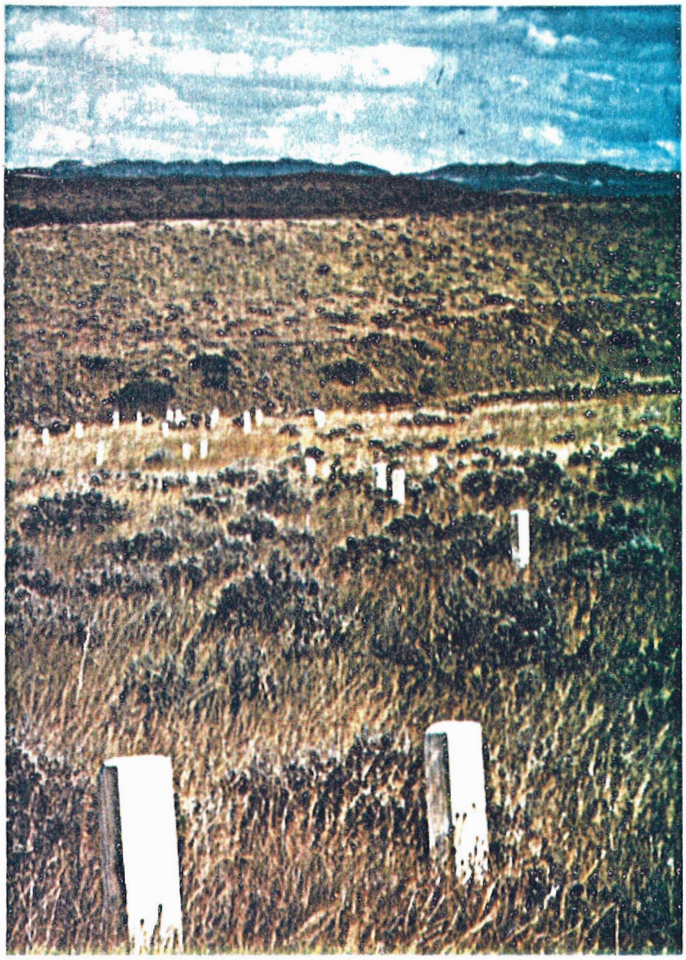


Figure 20B. 1986. Duplicate view of Fig. 20A, showing Northern Mixed Grass Prairie on the Battlefield



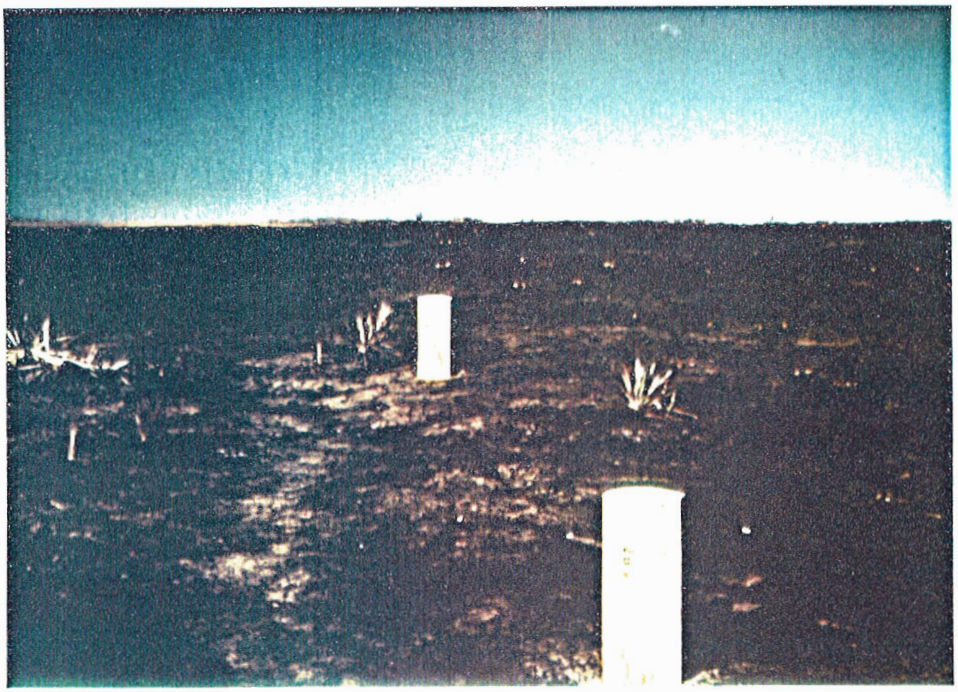


Figure 21. 1983. Battlefield view immediately after fire.



Figure 22. June, 1986. Custer Battlefield as it appears today, a rare example of intact Northern Mixed Grass Prairie.

VEGETATION OF

CUSTER BATTLEFIELD

NATIONAL MONUMENT

Section IV

NPS Contract No. CX-1200-4-A034

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INTRODUCTION.-Lewis and Clark were the first known visitors to make a written record of their impressions of the vegetation in the general vicinity of what is now called Custer Battlefield National Monument. In 1806 they described the "short grass" in the area around what they named Pompey's Pillar in honor of Sacajawea's baby boy. Pompey's Pillar is approximately 56 km northwest from the Battlefield. In modern terms, Coupland (1961) described this grassland as an extension of the Canadian grasslands, calling it part of the Stipa-Bouteloua-Agropyron Faciation in the Mixed Prairie Association. Similarly, Kuchler (1964) referred to this grassland as the Bouteloua-Stipa-Agropyron Vegetation Type (Type 64). In his monumental treatment of the world's floristic regions, Taktajan (1986) places this grassland within the North American Prairies Province as Mixed-grass Prairie. In their recent plant ecology text, Barbour *et al.* (1986) refer to this area as a Mixed Grassland as well. After careful consideration, we have chosen to refer to this area as Northern Mixed Grass Prairie, an appellation from the recent IBP grassland work (Risser *et al.*, 1981). We favor this name because we believe the IBP evaluation of the region distinguished this grassland from others nearby.

The flora of the Custer Battlefield had not been studied in a comprehensive manner prior to our work. As part of our analysis of post-fire vegetation changes, we

compiled a checklist of plants on or near our research plots on the Battlefield (Table 1). In addition, we examined general habitat relationships among the more abundant species. Our field work was restricted to grass and shrubland habitats, specifically excluding the riparian vegetation along the Little Bighorn River.

METHODS.-Plants were collected throughout the duration of the study, between May, 1984, and July, 1986. Identifications were based upon keys in several regional floras including Dorn (1984), VanBruggen (1976), and Weber (1976). Voucher specimens have been placed in the Herbarium of Montana State University, Bozeman, Montana, where our identifications are being verified.

Plant species frequencies were recorded for 25 plots scattered across burned and unburned portions of the Battlefield (see Section I for details). A 250 cm^2 frame was placed 20 times at 2-m intervals around the perimeter of each plot. Frequencies for each species were computed as the percentage of occupied frames per plot.

Frequency data were analyzed in two ways, in an attempt to describe habitat relationships among the common species. First, the 25 plots (20 burned, 5 unburned) were grouped *a priori* into what appeared to us to be three basic and distinguishable topographic states. Twelve plots (four unburned) were relatively level (slope= or < 5%) and poorly drained. Nine plots (one unburned) were well-drained and on

relatively steep slopes. Four plots (all burned) included small ravines. We then calculated a mean frequency for each of Battlefield's 31 most common species in each of these three habitats (Table 2).

Second, these same 31 species were grouped using Cluster Analysis, based upon their frequencies on the 25 plots. In this method, the matrix of raw frequency data (species X plots) was used to generate a matrix of product-moment correlation coefficients comparing each pair of species. These data in turn were subjected to single-linkage cluster analysis using the computer program NT-SYS (Rohlf *et al.*, 1972; Sneath and Sokal, 1973).

We examined the similarity between the burned plots and their controls for the three years of the study in terms of general ground cover (litter, bare ground, and vegetation), vegetation categories (grasses, herbs, and shrubs), and plant frequencies (the most common species on the study plots; see Section 1). For these calculations we used the index of similarity (Table 3).

$$S = 2W / A + B$$

Where A = sum of values on burned plots,

B = sum of values on unburned plots,

and W = sum of minimum values (burned or unburned) for each category in the comparison.

RESULTS.-We collected 130 species of vascular plants on upland (non-riparian) parts of the Custer Battlefield (Table

1). Dominant species on level uplands included in descending order: Agropyron dasystachium, Tragopogon dubius, Alyssum spp., Bromus japonicus, Vicia americana, Collomia linearis, and Poa juncifolia (Table 2).

Species with highest frequencies on well-drained slopes were Alyssum spp., Agropyron spicatum, Bromus japonicus, Agropyron dasystachium, Phlox hoodii, Koeleria macrantha, and Commandra umbellata.

Two woody species, Rosa arkansana and Symphoricarpos occidentalis, characterized ravines, along with occasional patches of Prunus virginiana. However, the numerically dominant ravine species were those common in the other habitats: Alyssum spp., Bromus japonicus, Agropyron dasystachium, Tragopogon dubius, and Agropyron spicatum (Table 2).

Cluster analysis (Figure 1) revealed three groupings of species, generally consistent with the habitat analysis shown in Table 2. However, correlations between species pairs, or between groups of species, were relatively low. This reflects the fact that many species were rather widely distributed across the Battlefield, and/or had distinctive patterns of local abundance.

Similarities between burned and unburned areas of the Battlefield ranged from 70 to 91%, depending upon year and ground cover, vegetation type, or species being compared.

DISCUSSION.-Risser *et al.*(1981) stated that there were approximately 50 species in the southern Montana grassland (p. 50). We assume that this statement was based upon their observations for the International Biological Program, many of which were made near Colstrip, which must have a more impoverished flora. The collection of 130 species we made at the Battlefield was not exhaustive. It neglected the riparian corridor, an integral part of western grasslands.

Wright and Wright many years ago pointed out (1948, p. 449), "The grassland vegetation of south central Montana is of considerable ecological interest because it lies in the tension zone between the bunch grass prairies of the Northwest and the short grass prairie of the Great Plains." Since the 1983 fire, big sagebrush (Artemisia tridentata) no longer is a dominant feature of the Custer Battlefield (Table 2). Even on the unburned plot with maximum sage density, it occurred with only a 30% frequency inside our sampling frames. Before the burn, as in 1986, dominant vegetation in upland parts of the Battlefield consisted of 1) the native perennial grasses Agropyron dasystachium, A. spicatum, and Poa juncifolia, 2) the exotic annual grass, Bromus japonicus, and 3) the herbs, Alyssum spp., Tragopogon dubius, Vicia americana, Collomia linearis, and Phlox hoodii (Table 2).

Earlier workers also made lists of important taxa for this region. Wright and Wright (1948), who worked primarily in cemeteries, stated that ungrazed sites near the

Battlefield were dominated by Agropyron spicatum, Carex filifolia, Bouteloua gracilis, Koeleria cristata, Stipa comata, and Artemisia tridentata. These data, which were collected from a Hardin, Montana, cemetery which since has been planted to Kentucky bluegrass, agree very well with our findings. George Hewlitt, Research Entomologist at Montana State University (pers. comm.) made vegetation lists from a small site on Custer Battlefield and compiled vegetation averages for his transects in 1981 and 1982. His data cannot be directly compared with ours because he did not repeat his samples on the same places, nor are the sites permanently marked. His findings are in nearly perfect agreement with those reported by Stubbendieck (1983), who did not describe his data collecting procedures. They found the most common single species on the Battlefield to be Agropyron spicatum. Other important species they cited (and which agree with our findings) were Stipa comata, S. viridula, Koeleria (macrantha), Poa (juncifolia), and Artemisia tridentata. Species which they noted but we did not encounter included Calamovilfa longifolia (prairie sandreed), Festuca idahoensis (Idaho fescue), and Crataegus spp.. Singh *et al.* (1983) noted at Colstrip the dominant species to be Agropyron smithii (our A. spicatum), Stipa comata, Bouteloua gracilis (present but uncommon on our sites), Koeleria cristatum (our K. macrantha), Poa secunda (our P. juncifolia), and Bromus japonicum.

Our brief review of literature (Section I) supports the hypothesis that sage abundance is related both to the absence of fire and livestock grazing. We found neither Bouteloua nor Stipa were abundant relative to Agropyron on the Battlefield, as other workers in the vicinity had reported (*e.g.*, Wright and Wright, 1948; Hewlitt, pers. comm., and Stubbendieck, 1983). The reasons for this discrepancy are not obvious. Perhaps we have an explanation for blue grama's relatvie rarity. We interpreted Archer's findings (1984) to indicate that Bouteloua gracilis, blue grama, may be a successional species in some cases in northern grasslands. In North Dakota, Brand and Goetz (1986) found the grama grasses were replaced by Carex in a successional pattern. Since Carex filifolia is more common than the gramas on our sites, it may be that it has replaced the gramas to some extent. The success on the Battlefield of exotics (*e.g.*, Poa pratensis and Bromus japonicus) deserves mention. The most obvious source for the Poa is the Military cemetery at the Battlefield which is sodded and maintained in this species. Bromus japonicus has been introduced in many parts of the high prairie east of the Great Basin by several federal agencies interested in improving and maintaining grazing lands (R. Klukas, Wind Cave National Park, pers. comm.). We assume it has invaded (or been introduced) into the vicinity of the Battlefield subsequent to Wright and Wright's careful 1948 study, because they do not note its occurrence.

Cluster analysis grouped 31 common species into three assemblages (Figure 1) that in 28 cases were consistent with their relative frequencies in the three habitats we recognized *a priori* (Table 2). Therefore, we are confident of the reality of these three non-riparian habitat types at the Battlefield: 1) level uplands, 2) slopes, and 3) ravines. However, most species occurred in all three habitats, and some species had high and/or nearly equal frequencies in each. Only the woody plants had relatively narrow distributions on the Battlefield, and they were nowhere dominant. With the exception of the narrow ravines, the overriding impression one gets of the Battlefield, especially on the area of the 1983 burn, is of vegetation uniformity. This caveat aside, there are some species which rather clearly prefer either level uplands or slopes. Agropyron spicatum, Carex filifolia, and Phlox hoodii arguably are the best indicators of sloping well-drained uplands. Tragopogon dubius, Vicia americana, and Collomia linearis are more common on level ground.

Now, it is useful to look at how the 1983 fire, which destroyed the above-ground vegetation on 90% of the Battlefield, affected the plant communities present. Our Index of Similarity (Table 3) shows that the patterns of ground cover (bare ground vs. litter vs. vegetation) on the burned and unburned study plots were only 70% similar during the first post-fire growing season. This was due primarily to the reduction in litter by the fire on the burned plots.

However, by the third post-fire season, the burned and unburned plots had become more than 90% similar. Most ecologists feel that sites which are 90% similar can be considered identical for ecological purposes. By the third post-fire season this was also the case for general vegetation categories (grasses vs. herbs vs. shrubs), where we found 91% agreement between unburned and burned areas. When occurrences of the 31 most common species werecompared for the unburned and burned sites, a 75-80% agreement is reached. How long it will take to obtain 90% agreement here, we do not know. Perhaps such an agreement will never be reached, although fire research elsewhere convinces us that such agreement is likely to be achieved within a few more years (Bock *et al.*, 1976). Overall, similarity data (Table 3) further support our contention that fire is not destructive to the native flora in the Northern Mixed Grass Prairie ecosystem.

We wish to conclude with an evaluation of the ecological significance of the natural grassland at the Custer Battlefield National Monument. Steubbendieck said (1983, p. I-133), "The prairie, as a whole, at the Custer Battlefield National Monument is in good to excellent condition. It is in much better condition that *(sic)* than the surrounding ranchland." We are in general agreement with the statement, although we would like to see certain changes in emphasis in management aimed especially at protecting the grassland. Since the Battle reenactments

have ceased on the site, the last threat from damage by large, domestic herbivores has been removed. However, there is an ongoing impact from visitors to the Battlefield, especially in places not visible from the Visitors' Center. For example, the grassy slopes just south of Deep Ravine, which hold the best stands of grama grasses, receive considerable impact from visitors who do not stay on the clearly marked trails. Second, in the recent exciting archaeological exploration of the Battlefield for Battle artifacts, the eager amateurs were not fully informed of the natural values of the Battlefield, nor of their importance to the long-term well being of the Monument. Therefore, we make the following suggestions for policy modification at the Monument in order to maintain this rare example of intact Northern Mixed Grass Prairie:

1) Put more signs on the remote trails which say "Stay on Paths."

2) Have an educational program about the prairie for the Monument visitors so that they can appreciate the natural as well as the historic values of the Custer Battlefield.

3. Place special emphasis on protective management of the natural assets of the Battlefield for the next few years. The effectiveness of the protective policy can be monitored by revisiting our permanent study sites on the Battlefield (see Section I, Figure 1 and Appendix I.)

Custer Battlefield National Monument offers a unique opportunity to combine activities the National Park Service does better than any other public land agency, to educate about America's exciting history and to preserve and educate about its unmatched natural beauty. Teaching an appreciation of the ecological value of the prairie at Custer Battlefield will present an exciting challenge for the National Park Service.

Table 1. Vegetation Checklist of Flora of Custer Battlefield National Monument.

Yucca glauca	Yucca	Agavaceae
Rhus trilobata	Skunkbrush	Anacardiaceae
Musineon divaricatum		Apiaceae
Toxicodendron rydbergii	Poison Ivy	Apocynaceae
Asclepias speciosa	Showy Milkweed	Asclepidaceae
Achillea millefolium	Yarrow	Asteraceae
Antennaria corymbosa	Pussytoes	Asteraceae
Antennaria parvifolia	Pussytoes	Asteraceae
Arnica sororia		Asteraceae
Artemisia cana	Sweet Sage	Asteraceae
Artemisia frigida	Pasture Sage	Asteraceae
Artemisia filifolia	Silver Wormwood	Asteraceae
Artemisia tridentata	Big Sagebrush	Asteraceae
Aster scopulorum		Asteraceae
Centaura repens	Star Thistle	Asteraceae
Cirsium arvense	Canada Thistle	Asteraceae
Cirsium undulatum	Wavy-leaved Thistle	Asteraceae
Crepis occidentalis	W. Hawksbeard	Asteraceae
Echinacea angustifolia	Purple Coneflower	Asteraceae
Erigeron bellidiastrum	Daisy Fleabane	Asteraceae
Erigeron ochroleucus		Asteraceae
Grindelia squarrosa	Gumweed	Asteraceae
Haplopappus langinosus		Asteraceae
Helianthus sp.	Sunflower	Asteraceae

Heterotheca villosa	Golden Aster	Asteraceae
Lactuca serriola	Prickly Lettuce	Asteraceae
Lygodesmia juncea	Skeleton Plant	Asteraceae
Machaeranthera pinnatifida		Asteraceae
Microseris nutans	False Dandelion	Asteraceae
Ratibida columnifera	Coneflower	Asteraceae
Senecio plattensis	Groundsel	Asteraceae
Solidago nemoralis	Goldenrod	Asteraceae
Taraxicum officinale	Common Dandelion	Asteraceae
Tragopogon dubius	Salsify	Asteraceae
Lappula redowski	Beggers Tick	Boraginaceae
Lithospermum incisum	Cleft Gromwell	Boraginaceae
Alyssum alyssoides	Alyssum	Brassicaceae
Alyssum desertorum	Alyssum	Brassicaceae
Draba brachycarpa		Brassicaceae
Erysimum asperum	W. Wallflower	Brassicaceae
Lepidium perfoliatum	Clasping Peppergrass	Brassicaceae
Lesquerella ludoviciana	Bladderpod	Brassicaceae
Sisymbrium altissimum	Tumbling Mustard	Brassicaceae
Thlaspi arvense	Pennycress	Brassicaceae
Coryphantha missouriensis	Puncushion Cactus	Cactaceae
Opuntia polyacantha	Prickly Pear	Cactaceae
Lonicera tatarica	Honeysuckle	Caprifoliaceae
Symphoricarpos occidentalis	Snowberry	Caprifoliaceae
Seratoides lanata	Winterfat	Chenopodiaceae
Sarcobatus vermiculatus	Greasewood	Chenopodiaceae
Tradescantia bractata	Spiderwort	Commelinaceae

Carex filifolium		Cyperaceae
Scirpus acutus	Bullrush	Cyperaceae
Eleagnus commutata	Silverberry	Eleagnaceae
Shepherdia argentea	Buffaloberry	Eleagnaceae
Euphorbia robusta		Euphorbiaceae
Astragalus aboriginum	Indian Milk Vetch	Fabaceae
Astragalus agrestis		Fabaceae
Astragalus atropubescens		Fabaceae
Astragalus crassicarpus		Fabaceae
Astragalus drummondii		Fabaceae
Astragalus hyalinus		Fabaceae
Glycyrriza lepidota	Wild Licorice	Fabaceae
Lupinus argenteous	Lupine	Fabaceae
Medicago sativa	Alfalfa	Fabaceae
Melilotus officinalis	Yellow Sweet Clover	Fabaceae
Oxytropis sericea	White Locoweed	Fabaceae
Petalostemon candidum	Wt. Prairie Clover	Fabaceae
Petalostemon purpureum	Pl. Prairie Clover	Fabaceae
Psoralea argophylla		Fabaceae
Psoralea esculenta	Prairie Turnip	Fabaceae
Psoralea tenuiflora		Fabaceae
Thermopsis rhombifolia	Golden Banner	Fabaceae
Vicia americana	American Vetch	Fabaceae
Ribes aureum	Wild Current	Grossulariaceae
Phacelia linearis		Hydrophyllaceae
Hypericum perforatum	St. Johns Wort	Hydrophyllaceae
Allium textile	Wild Onion	Liliaceae
Calochortus nuttallii	Mariposa lily	Liliaceae

Leucocrinum montanum	Sand Lily	Liliaceae
Smilacina stellata		Liliaceae
Zigadenus venenosus	Death Camas	Liliaceae
Linum perenne	Blue Flax	Linaceae
Linum sulcatum	Yellow Flax	Linaceae
Sphaeralcea coccinea	Scarlet Mallow	Malvaceae
Fraxinus pennsylvanica	Green Ash	Oleaceae
Epilobium sp.		Onagraceae
Gaura coccinea	Scarlet Gaura	Onagraceae
Oenothera laciniata		Onagraceae
Oenothera albicaulis	Evening Primrose	Onagraceae
Plantago patagonica		Plantaginaceae
Agrostis hyemalis	Ticklegrass	Poaceae
Agropyron dasystachyum	Thickspike Wh.grass	Poaceae
Agropyron desortorum	Crested Wheatgrass	Poaceae
Agropyron repens	Quackgrass	Poaceae
Agropyron smithii	W. Wheatgrass	Poaceae
Agropyron spicatum	Bluebunch Wh.grass	Poaceae
Aristida purpurea	Purple Three-Awn	Poaceae
Bouteloua curtipendula	Side Oats Grama	Poaceae
Bouteloua gracilis	Blue Grama	Poaceae
Bromus inermis	Smooth Brome	Poaceae
Bromus japonicus	Japanese Brome	Poaceae
Bromus tectorum	Cheat Grass	Poaceae
Calamagrostis inexpansa	Northern Reedgrass	Poaceae
Calamovilfa longifolia	Prairie Sandreed	Poaceae
Hordeum jubatum	Foxtail Barley	Poaceae

Koeleria macrantha	Junegrass	Poaceae
Poa compressa	Canada Bluegrass	Poaceae
Poa juncifolia		Poaceae
Poa pratensis	Kentucky Bluegrass	Poaceae
Stipa comata	Needle&Thread Grass	Poaceae
Stipa viridula	Green Needlegrass	Poaceae
Triticum aestivum	Wheat	Poaceae
Collomia linearis		Polemoniaceae
Phlox hoodii	Phlox	Polemoniaceae
Eriogonum pauciflorum		Polygonaceae
Rumex crispus	Curly Dock	Polygonaceae
Delphinium nuttallianum	Larkspur	Ranunculaceae
Prunus virginiana	Chokecherry	Rosaceae
Rosa arkansana	Wild Rose	Rosaceae
Galium aparine	Cleavers	Rubiaceae
Galium cotusum	Smooth Galium	Rubiaceae
Populus deltoides	Plains Cottonwood	Salicaceae
Comandra umbellata	Bastard Toadflax	Santalaceae
Castilleja angustifolia	Indian Paintbrush	Scrophlariaceae
Orthocarpus luteus	Owls Clover	Scrophulariaceae
Penstemon albidus	Penstemon	Scrophulariaceae
Penstemon eriantherus		Scrophulariaceae
Penstemon nitidus		Scrophulariacea
Typha latifolia	Cat Tail	Typhaceae
Viola nuttalli	Nuttalls Violet	Violaceae

Table 2. Frequency of 31 common plant species at Custer Battlefield National Monument, expressed as percent of 250cm^2 frames occupied. Data are from 25 plots, grouped into three habitat types: 1) level uplands (n = 12 plots, 20 frames per plot), 2) slopes (n = 9 plots, 20 frames per plot), and 3) ravines (n = 4 plots, 20 frames per plot).

	Frequency (%)		
Species[1]	Level Uplands	Slopes	Ravines
Achillea millefolium	29.5*	21.0	25.0
Sphaeralcea coccinea	16.0*	9.5	14.0
Poa juncifolia	54.5*	37.0	21.5
Gaura coccinea	15.0*	12.0	14.0
Agropyron dasystachyum	94.0*	61.5	75.0
Tragopogon dubius	87.0*	36.0	49.0
Vicia americana	64.0*	31.0	30.0
Bromus japonicus	78.5	69.0	85.0*
Artemisia tridentata	4.5*	1.5	0
Taraxicum officinale	18.5*	6.0	2.5
Collomia linearis	62.0*	8.0	26.5
Lactuca serriola	26.5*	9.0	10.0
Poa pratensis	23.0	3.5	30.0*
Agropyron spicatum	25.5	74.0*	46.5
Phlox hoodii	16.5	45.0*	29.0
Commandra umbellata	6.5	37.0*	19.0
Koelaria macrantha	17.0	44.5*	15.0

Table 2, cont'd.

Species	Level Uplands	Slopes	Ravines
Bouteloua curtipendula	2.5	16.0*	7.5
B. gracilis	6.0	15.5*	2.5
Carex filifolium	3.5	29.0*	11.5
Phacelia linearis	11.5	29.5*	24.0
Psoralea spp.	4.5	11.0	15.0*
Calochortus nuttallii	5.0	11.0*	4.0
Stipa comata	18.0	18.5*	2.5
Alyssum spp.	78.5	89.0*	85.0
Opuntia polycantha	3.0	3.5*	1.5
Melilotus officinalis	11.0	15.5*	15.0
Artemisia cana	2.5	4.0	15.0*
Stipa viridula	3.5	6.5	11.5*
Symphoricarpos occidentalis	0	0	24.0*
Rosa arkansana	0	1.5	11.5*

[1]Species are presented in same order as in dendrogram (Fig. 1), with horizontal lines separating groups of species comprising its major stems.

*indicates habitat where species occurred with highest frequency.

Table 3. Percent similarity between burned and unburned portions of Custer Battlefield.

Comparison	Year 1984	1985	1986
Ground cover[1]	70.4	84.0	90.8
Vegetation categories[2]	85.5	90.2	91.0
Plant species frequencies[3]	80.6	75.3	80.7

[1]Data from Section 1, Table 1A.

[2]Data from Section 1, Table 1B.

[3]Data from Section 1, Table 3.

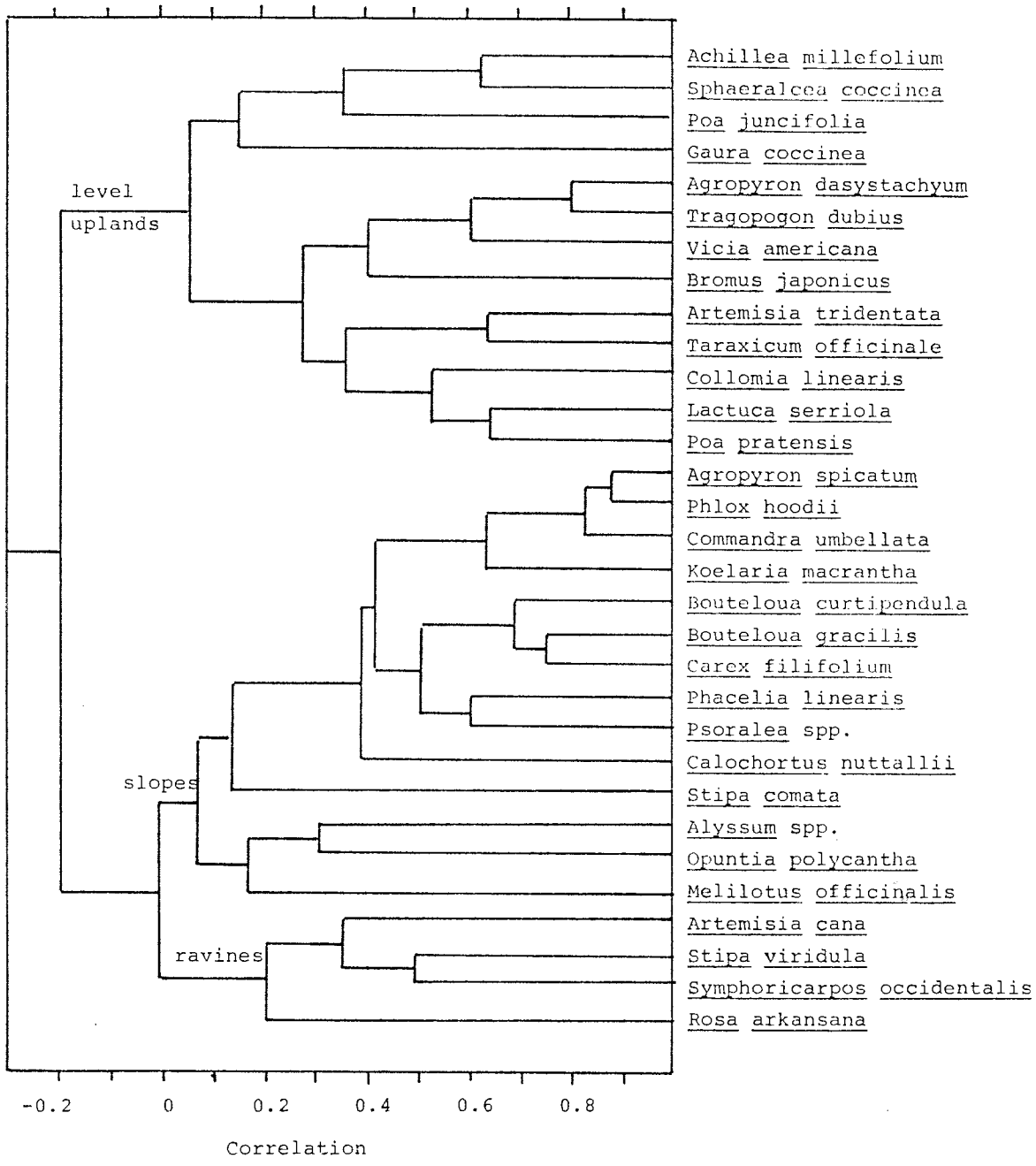


Figure 1. Cluster analysis of 31 common plant species at the Custer National Battlefield, based on their abundances on 25 study plots. Cophenetic correlation = 0.765.

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