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Timing of burning and mowing management of a bluestem prairie in eastern Nebraska.

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TIMING OF BURNING AND MOWING MANAGEMENT OF A BLUESTEM PRAIRIE IN EASTERN NEBRASKA

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THESIS ACCEPTANCE

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Abstract

This study evaluates the effects of time of mowing on species composition and inflorescence phenology in a bluestem prairie and contrasts mowing and burning treatments. Treatment areas in a native prairie, with a history of summer mowing, were burned and mowed in April and evaluated in June and August of the same year. While reflecting only a single year's treatment, this study indicated that summer mowing favors cool season grasses, such as porcupinegrass (*Stipa spartea*) and selects against warm season grasses such as big bluestem (*Andropogon gerardii*). Canopy coverage, biomass, and flowering stem numbers and height of porcupinegrass was consistently greater on summer mow plots than on spring burn and spring mow plots. In comparison, big bluestem was favored by spring burning and spring mowing. The effect of spring and summer mowing treatments on overall species composition is suggested in slight but consistent responses of cool and warm season forbs and grass species; spring mowing favors warm season species and summer mowing favors cool season species. Comparisons between spring mowing and spring burning treatments suggest first, that time of mowing is equally as important as time of burning, and second, that while not duplicating burning results, mowing in the spring seems to be a next-best alternative for maintaining bluestem prairie species diversity. Consideration of these differences with respect to time of burning and mowing is important in planning for the maintenance of native bluestem prairie ecosystems.

Introduction

Native bluestem prairie (Küchler 1964) once covered much of eastern Nebraska although it is presently substantially reduced in extent. In addition, fire, once a major environmental factor, has been largely excluded from the remaining prairie remnants; most are presently mowed for hay. The effects of spring fires on native bluestem prairie vegetation have been documented by many researchers (Aldous 1934, Curtis and Partch 1948 and 1950, Weaver and Rowland 1952, Dix and Butler 1954, Aikman 1955, Ehrenreich 1959, Kucera and Ehrenreich 1962, Ehrenreich and Aikman 1963, Hadley and Kieckhefer 1963, Kucera and Koelling 1964, Weaver 1965, Brown 1967, Hulbert 1969 and 1973, Old 1969, Kucera 1970, Christiansen 1972, Richards 1972, Owensby and Smith 1973, Hill and Platt 1975, Peet *et al* 1975, Bragg and Hulbert 1976, Adams and Anderson 1978, Rice and Parenti 1978). Extensive reviews have been conducted by Daubenmire (1968) and Vogl (1974). These studies suggest a variety of results including, an earlier initiation of spring growth, increased flowering for certain species, increased density of native species, and increased height of flowering stems. Burning also prevents invasion by woody plants, reduces the success of cool season species such as Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*), and prevents excessive litter accumulation.

Changes in the physical environment have also been observed as a result of spring burning (Aldous 1934, Weaver and Rowland 1952, Hulbert 1969, Old 1969, Rice and Parenti 1978). Among the many changes noted by these and other investigators are an increase in light intensity, soil temperature, soil nutrient levels, and a decrease in soil moisture. The increase in light intensity and resultant higher photosynthetic rates may account for greater number of flowering stems. Higher soil temperatures may also stimulate growth by increasing microbial release of nitrogen and phosphorus. These factors, in addition to the ready availability of water early in the growing season and lack of competition from cool season grasses, may account for an increase in production of native grasses (Old 1969, Peet et al 1975).

Mowing native prairie is a common practice in Nebraska and has been found to affect plant production and composition in native bluestem prairies elsewhere (Weaver and Rowland 1952, Hopkins 1954, Robocker and Miller 1955, Ehrenreich 1959, Ehrenreich and Aikman 1963, Hulbert 1969). Frequent mowing during a growing season has been reported to reduce net production, although spring mowing may increase big bluestem production if litter accumulation is substantial. Yield on mowed areas has been found to be comparable to that obtained from burned areas only when mowing is done at the end of the growing season after the dominant warm season grasses have flowered. Accumulated litter tends to reduce evaporation and increase rates of infiltration and soil moisture content.

Most bluestem prairie relicts in eastern Nebraska have a history of summer mowing, usually in July but also as late as September.

Rarely are these prairies burned. The long term effects of such mowing on vegetative composition and production, are not well documented. There is thus the possibility that mowing management, in combination with a cessation of burning, has altered the vegetative composition from that dominating before European settlement of the region. This possibility, in addition to the need to determine appropriate ecosystem maintenance procedures for small relict bluestem prairies, provided the impetus for this study. Specifically this study evaluates: (1) the degree to which differences in time of mowing are likely to favor changes in species composition and (2) the likelihood that mowing can replace burning as an ecosystem maintenance tool. Trends indicated as a result of a single year's treatment provide a limited but useful projection of long term effects.

Study Site

The study was conducted at Hover Prairie, a 5 hectare, privately owned, native prairie located in eastern Sarpy County, Nebraska (Figs. 1, 2). The prairie, homesteaded in 1857 on a land grant from President James Buchanan, has never been tilled or used for cattle grazing; it has been mowed annually in late summer since at least 1900. Burning in recent times has been sporadic, occurring only when embers from passing trains have ignited the grasses. Porcupinegrass (*Stipa spartea*) and big bluestem (*Andropogon gerardii*) are the principal dominants. Soils are Judson and Monona silt loams, both of which are high to moderate in organic matter, slightly acidic, well-drained soils with a moderate degree of permeability and high water capacity (Bartlett 1975); the prairie slopes gently from east to west. Precipitation of the region averages 71 cm annually, but totaled 65 cm in 1978. An average of 78% of the annual precipitation falls during the growing season. Average temperatures range from $-12^{\circ}C$ in January to $24^{\circ}C$ in July; extremes range from $-25^{\circ}C$ in January to $38^{\circ}C$ in July (U.S. Department of Commerce 1978).

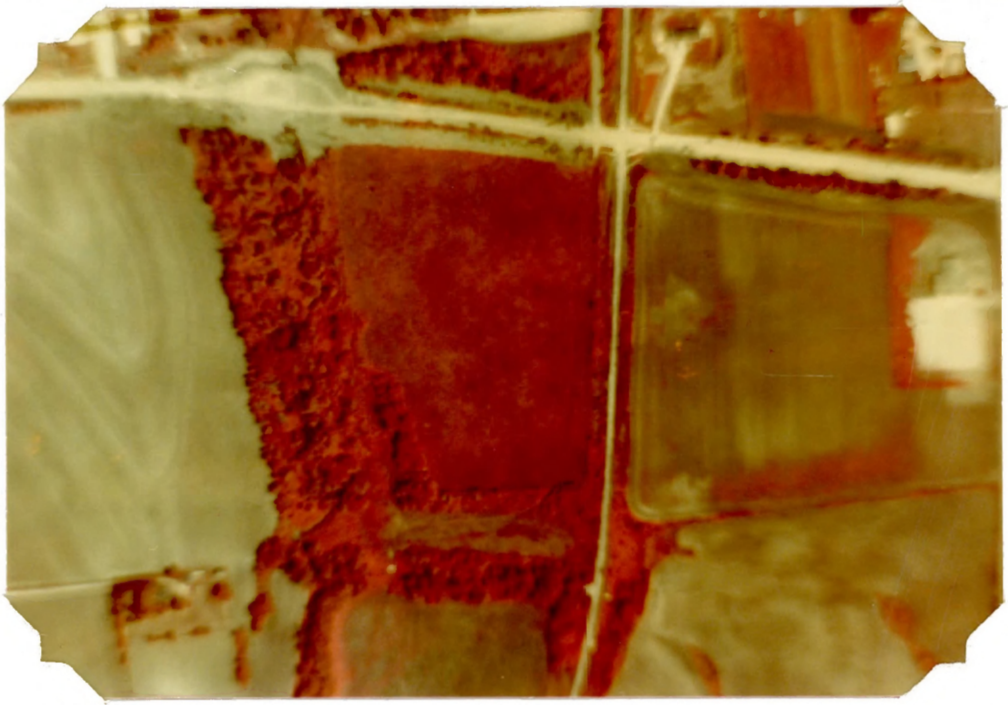

Fig. 1. Infrared aerial photograph of Hover Prairie; June 1976. (Remote Sensing Applications Laboratory, University of Nebraska at Omaha).

Fig. 2. Photograph of Hover Prairie looking from northeast to scuthwest; June 1978.

Methods and Materials

In April 1978, three locations within the study site were selected on the basis of having a representative composition of native vegetation and little or no smooth brome (Bromus inermis). At each location 3, 100 m^2 (10 x 10 meter) treatment plots were permanently marked (Fig. 3) and on 26 April, one plot was burned and one was mowed and the vegetation removed. These plots represent spring burn and spring mow treatments respectively. The third plot, established as a control, actually represents a long period of late summer mowing and hence is referred to as summer mow treatment in this study. At the time of burning and mowing, porcupinegrass was actively growing although a complete burn was obtained.

Summer fires may have occurred during midsummer (Bragg, unpublished) but late April burning has historically been used as a range management practice. April burning treatments, therefore, were used in this study to permit comparisons with other bluestem prairie burning studies. Mowing at the same time as burning was designed to evaluate similarities between these two treatments. In addition, spring mowing versus summer mowing allowed a comparison of mowing management at two times of the growing season. Differences between these treatment times is important because of the differences in phenology of the warm and cool season species.

Analysis of the vegetation was timed to coincide with the flowering times of the two grasses that dominate Hover Prairie, porcu-

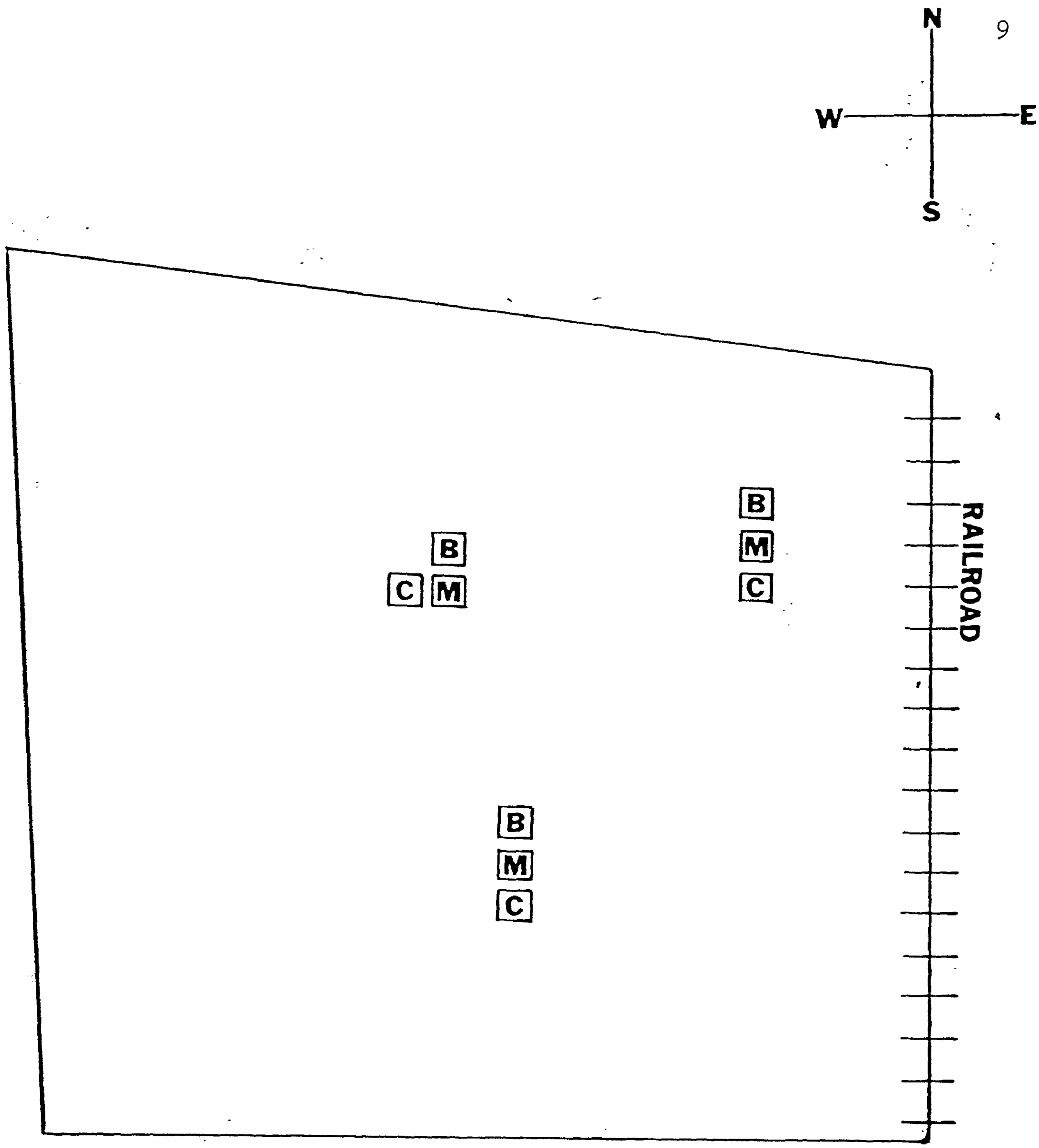

Fig. 3. Location of treatment plots within study site. Site location: Sect. 28 T14N R13E. B = spring burn in April 1978, M = spring mow in April 1978, C = control (summer mow).

pinegrass, a cool season species which was evaluated from 16 to 18 June, and big bluestem, a warm season species which was evaluated from 16 to 19 August 1978. Evaluations were started when anthesis was visually estimated to be at its peak. In each of the nine treatment plots, 5, 0.5 m^2 (1.0 x 0.5 m) microplots were systematically located. Canopy coverage of each species and percent-of-total-biomass of principal species was estimated within each microplot. In addition, the number and height of flowering stems of porcupinegrass was measured in June and big bluestem in August. Canopy coverage and biomass were selected because they are measures of species productivity. Flowering stems and flowering stem heights were selected as measures of energy spent for reproduction. Canopy coverage for all species was estimated using the following categories: 0-5% coverage, 5-25%, 25-50%, 50-75%, 75-95%, and greater than 95% (Daubenmire 1959). Midpoint values of each category were used for analysis. Flowering stem heights were measured from ground to tip of the highest part of each inflorescence. After canopy coverage and biomass estimation, the vegetation was clipped, separated into grasses and forbs, and ovendried at 30°C for 48 hours. Identification of all species was verified at the University of Nebraska at Omaha Herbarium (OMA).

Results and Discussion

Species Composition

While reflecting the effects of only a single year's treatment, this study indicated that summer mowing favors cool season species, such as porcupinegrass, and selects against warm season species such as big bluestem (Table I, Fig. 4). In both June and August evaluations, canopy coverage of porcupinegrass averaged higher with summer mowing than with either spring burning or spring mowing. Kentucky bluegrass, another cool season species, averaged lower in coverage in burned plots, although it did not appear to be adversely affected by either spring or summer mowing treatments. Big bluestem coverage, on the other hand, averaged lower in summer mow treatments than spring burned or spring mowed areas; this trend was reflected in both June and August evaluations. Responses of little bluestem (*Andropogon scoparius*) and sideoats grama (*Bouteloua curtipendula*), both midheight, warm season grasses, appeared to be similar to that for big bluestem. Dominant forbs were not significantly affected by the various treatments although slight but consistent trends in canopy coverage indicated that whorled milkweed (*Asclepias verticillata*) and flowering spurge (*Euphorbia corollata*) increased with spring burning; this response is similar to that indicated by data on warm season grasses. Biomass data reflect results similar to those obtained from canopy coverage (Appendix Table III).

TABLE I. Average percent canopy coverage ± SE for mowed and burned treatment areas. Only species with frequency values greater than 20% are included.[1] tr = <0.5%.

SPECIES[2]	JUNE EVALUATION			AUGUST EVALUATION		
	SPRING BURN	SPRING MOW	SUMMER MOW	SPRING BURN	SPRING MOW	SUMMER MOW
GRASSES:						
Big bluestem (*Andropogon gerardii*)	11 ± 2	10 ± 1	2 ± tr	84 ± 3	75 ± 5	35 ± 4
Indian grass (*Sorghastrum nutans*)	tr	tr	tr	8 ± 2	7 ± 2	1 ± tr
Junegrass (*Koeleria pyramidata*)	1 ± tr	1 ± tr	1 ± tr	tr	1 ± tr	1 ± tr
Kentucky bluegrass (*Poa pratensis*)	1 ± tr	2 ± tr	2 ± tr	tr	2 ± tr	2 ± tr
Little bluestem (*Andropogon scoparius*)	tr	tr	0	1 ± tr	tr	0
Porcupinegrass (*Stipa spartea*)	86 ± 2	87 ± 1	98 ± 0	5 ± 1	15 ± 4	60 ± 4

TABLE I. Average percent canopy coverage ± SE for mowed and burned treatment areas. (Continued)

	JUNE EVALUATION			AUGUST EVALUATION		
SPECIES	SPRING BURN	SPRING MOW	SUMMER MOW	SPRING BURN	SPRING MOW	SUMMER MOW
Sideoats grama (*Bouteloua curtipendula*)	tr	tr	tr	2 ± 1	1 ± tr	1 ± tr
Small panic grass (*Panicum oligosanthes*)	1 ± tr	1 ± tr	2 ± tr	2 ± tr	1 ± tr	1 ± tr
FORBS:						
Daisy fleabane (*Erigeron strigosus*)	1 ± tr	1 ± tr	tr	tr	0	0
False sunflower (*Heliopsis helianthoides*)	0	0	0	1 ± tr	1 ± tr	1 ± tr
Flowering spurge (*Euphorbia corollata*)	3 ± 1	2 ± tr	2 ± tr	3 ± 1	7 ± 2	2 ± tr
Goatsbeard (*Tragopogon dubius*)	tr	1 ± tr	1 ± tr	tr	0	0

TABLE I. Average percent canopy coverage ± SE for mowed and burned treatment areas. (Continued)

	JUNE EVALUATION			AUGUST EVALUATION		
SPECIES	SPRING BURN	SPRING MOW	SUMMER MOW	SPRING BURN	SPRING MOW	SUMMER MOW
Horseweed (*Conyza canadensis*)	0	0	0	0	2 ± tr	1 ± tr
Plantain (*Plantago spp.*)	2 ± tr	2 ± tr	2 ± tr	0	tr	tr
Whorled milkweed (*Asclepias verticillata*)	3 ± 1	3 ± 1	1 ± tr	5 ± 2	1 ± tr	2 ± tr
OTHER SPECIES:						
Lead plant (*Amorpha canescens*)	5 ± 1	4 ± 1	2 ± tr	2 ± tr	2 ± tr	3 ± 1
Mead's sedge (*Carex meadii*)	tr	1 ± tr	1 ± tr	tr	0	0

[1] Appendix Table I lists all species found in the various treatment plots. Appendix Table II lists species not observed in treatment plots but present at Hover Prairie.

[2] Scientific and common names from McGregor and Barkley 1977.

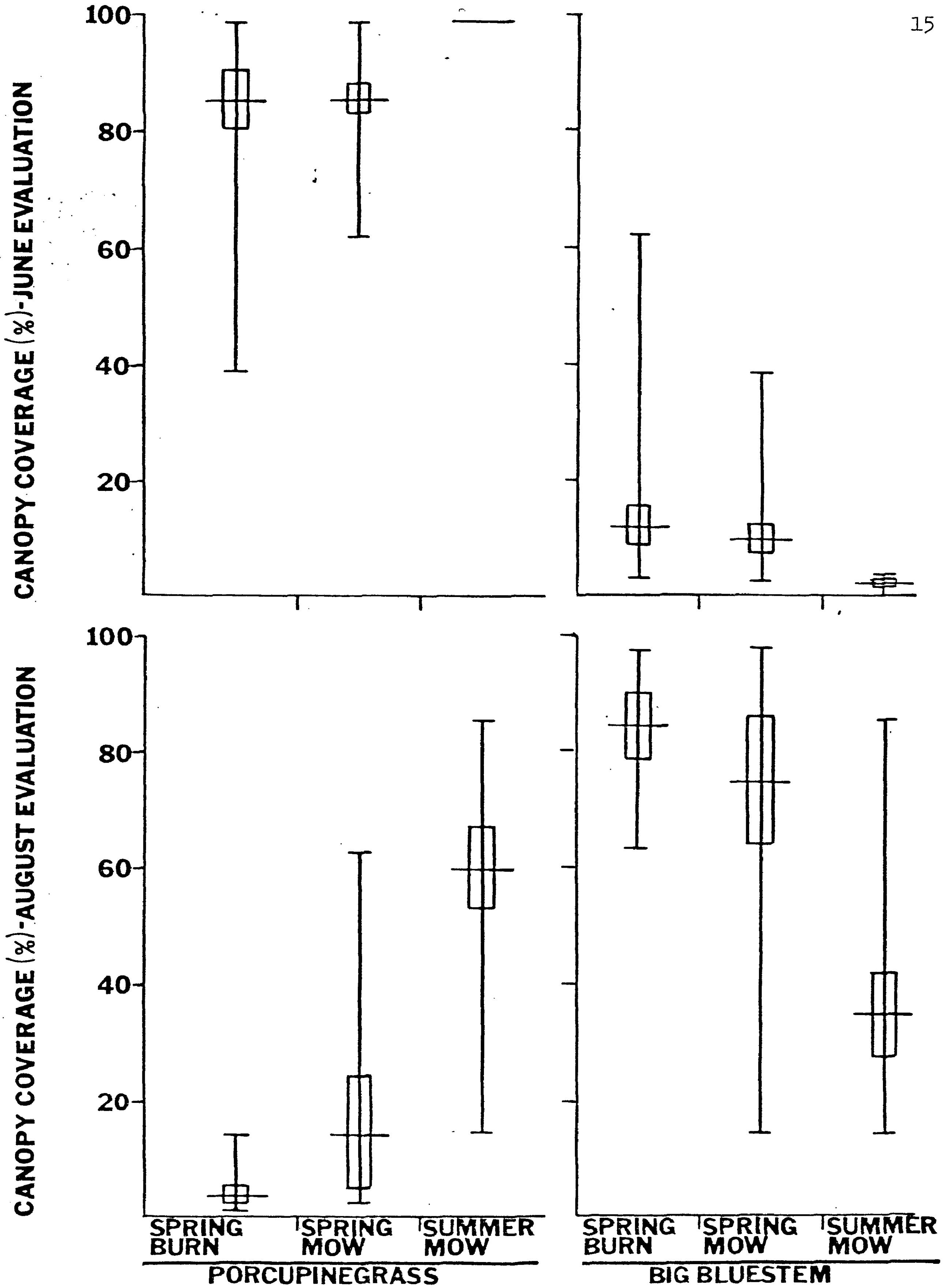

Fig. 4. Canopy coverage of porcupinegrass and big bluestem at June and August evaluation times. Vertical line of dice-gram connects maximum and minimum values. Horizontal line represents mean value and bar represents 95% confidence intervals; $\bar{x} \pm t_{0.05}$ SE.

Flower Stem Density and Height

The number and height of flowering stems reflect trends similar to those shown by canopy coverage and biomass data with summer mowing increasing the height and number of inflorescences of cool season species and spring mowing or burning similarly affecting warm season species. Porcupinegrass inflorescences, evaluated in June, were significantly greater in numbers in summer mow plots than in spring burn and spring mow plots (Fig. 5). Similarly, porcupinegrass stem height averaged higher with summer mowing (Table II, Fig. 5). The number and height of flowering stems of big bluestem, evaluated in August, were significantly greater as a consequence of spring burning than with summer mowing; spring mowing was intermediate with more flowering stems than summer mowing but less than spring burning. The effect of fire stimulation on big bluestem production has been reported previously (Curtis and Partch 1950, Dix and Butler 1954, Ehrenreich and Aikman 1963, Hadley and Kieckhefer 1963, Hulbert 1969). Flowering stems of Indian grass (Sorghastrum nutans) similarly averaged considerably fewer with summer mowing than with either spring burning or mowing. An increase in the number of flowering stems may indicate the adaptation of a species to sexual reproduction in a fire-affected environment. The effect of increased height may also give a species a reproductive advantage with respect to seed dispersal or pollination. The critical factors of increased light intensity and resultant increase in soil temperature and soil nutrient levels may also play a role in explaining

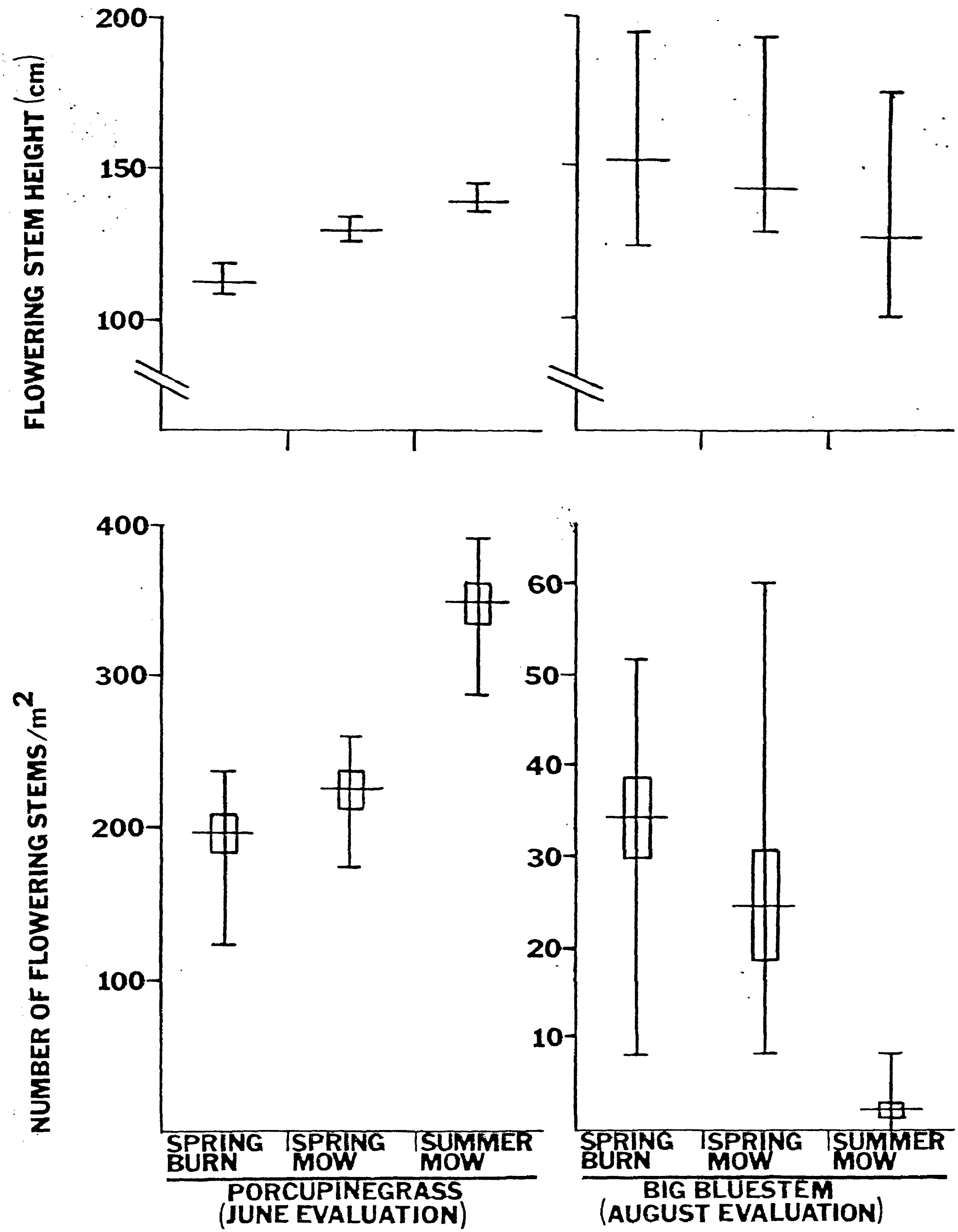

Fig. 5. Response of porcupinegrass and big bluestem flowering stem height and number to Spring and Summer burning and mowing treatments.

TABLE II. Number of Flowering Stems for Grass Species.

SPECIES	Number/m^2 ± SE		
	Spring Burn	Spring Mow	Summer Mow
<u>June Evaluation</u>			
Porcupinegrass	199 ± 5	225 ± 5	346 ± 7
<u>August Evaluation</u>			
Big bluestem	34 ± 2	24 ± 3	3 ± 1
Indian grass	7 ± 2	5 ± 1	1 ± tr
Little bluestem	2 ± 1	0.4 ± tr	0
Sideouts grama	2 ± 1	3 ± 1	1 ± tr
Canada wildrye	0.1 ± tr	0.1 ± tr	1 ± tr
Junegrass	0.1 ± tr	0.4 ± tr	1 ± tr

the greater abundance and height of flower stems.

Mowing and Burning Management

Generally, spring burning and mowing were found to approximate each other closely with respect to canopy coverage, biomass, flowering stems and height of flowering stems. The role played by energy stored in plants is undoubtedly of importance in explaining the similar results obtained. Cool season species that are burned or mowed in spring have expended much of their energy and must draw on remaining reserves. The result is likely to be a decrease in productivity and reproduction as noted in this and other studies (Aldous 1934, Curtis and Partch 1948, Robocker and Miller 1955, Ehrenreich and Aikman 1963, Hadley and Kieckhefer 1963). Warm season species that are mowed before flowering respond with similar decreases in productivity and reproduction.

The overall results of this study represent the effects of a single year's treatment although they also suggest some long term effects on species composition. Spring mowing appears to have effects similar to spring burning on warm and cool season species composition. Spring mowing, however, was found to be sufficiently different that it should not be considered a replacement but rather a second alternative type of management in those instances where spring burning is not practical. Hover Prairie, for example is located in an urban setting. The stringent conditions under which burning can be done safely as well as problems with smoke emitted in residential areas provides a strong argument in favor of mowing as an alternate means of maintaining such prairies. The effects of such mowing on vegetative diversity and productivity over many years, however, have yet to be evaluated.

By implication, this study further suggests that summer mowing may approximate the effects of burning. This is an important consideration since summer fires may have been relatively common before settlement, thus the common practice of summer mowing of most small prairies in eastern Nebraska may have maintained the pristine community composition. As with spring mowing, however, the long term results need careful evaluation before such conclusions are warranted.

It is apparent from these data that the time of burning and mowing has the potential to affect profoundly the composition of native prairies. While burning was a natural force in removing litter and altering soil temperature and moisture, this study indicates that mowing may approximate some of the same results of burning if applied at the same time of the year. Further evaluations on long term changes in nutrient content, light intensity, soil moisture relations, and soil temperatures on mowed as compared to burned areas are still needed to understand more fully the dynamics of bluestem prairie ecosystems.

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APPENDIX

Appendix Table I. Average percent canopy coverage ± SE for mowed and burned treatment areas. All species identified are included. tr = <0.05%.

	JUNE EVALUATION			AUGUST EVALUATION		
SPECIES	SPRING BURN	SPRING MOW	SUMMER MOW	SPRING BURN	SPRING MOW	SUMMER MOW
GRASSES:						
Big bluestem (*Andropogon gerardii*)	11 ± 2	10 ± 1	2 ± tr	84 ± 3	75 ± 5	35 ± 4
Canada wildrye (*Elymus canadensis*)	0	0	0	tr	tr	1 ± 1
Indian grass (*Sorghastrum nutans*)	tr	tr	tr	8 ± 2	7 ± 2	1 ± tr
Japanese brome (*Bromus japonicus*)	0	0	0	tr	2 ± tr	tr
Junegrass (*Koeleria pyramidata*)	1 ± tr	1 ± tr	1 ± tr	tr	1 ± tr	1 ± tr

Appendix Table I. Average percent canopy coverage $\pm$ SE for mowed and burned treatment areas. (Continued)

	JUNE EVALUATION			AUGUST EVALUATION		
SPECIES	SPRING BURN	SPRING MOW	SUMMER MOW	SPRING BURN	SPRING MOW	SUMMER MOW
Kentucky bluegrass (_Poa pratensis_)	1 $\pm$ tr	2 $\pm$ tr	2 $\pm$ tr	tr	2 $\pm$ tr	2 $\pm$ tr
Little bluestem (_Andropogon scoparius_)	tr	tr	0	1 $\pm$ tr	tr	0
Porcupinegrass (_Stipa spartea_)	86 $\pm$ 2	87 $\pm$ 1	98 $\pm$ 0	5 $\pm$ 1	15 $\pm$ 4	60 $\pm$ 4
Sideoats grama (_Bouteloua curtipendula_)	tr	tr	tr	2 $\pm$ 1	1 $\pm$ tr	1 $\pm$ tr
Small panic grass (_Panicum oligosanthes_)	1 $\pm$ tr	1 $\pm$ tr	2 $\pm$ tr	2 $\pm$ tr	1 $\pm$ tr	1 $\pm$ tr
FORBS:						
Canada goldenrod (_Solidago canadensis_)	0	0	0	0	0	1 $\pm$ tr

Appendix Table I. Average percent canopy coverage ± SE for mowed and burned treatment areas. (Continued)

	JUNE EVALUATION			AUGUST EVALUATION		
SPECIES	SPRING BURN	SPRING MOW	SUMMER MOW	SPRING BURN	SPRING MOW	SUMMER MOW
Daisy fleabane (_Erigeron strigosus_)	1 ± tr	1 ± tr	tr	tr	0	0
False boneset (_Kuhnia eupatorioides_)	0	0	0	0	0	1 ± 1
False sunflower (_Heliopsis helianthoides_)	0	0	0	1 ± tr	1 ± tr	1 ± tr
Finger coreopsis (_Coreopsis palmata_)	0	tr	0	0	0	0
Flowering spurge (_Euphorbia corollata_)	3 ± 1	2 ± tr	2 ± tr	3 ± 1	7 ± 2	2 ± tr
Goatsbeard (_Tragopogon dubius_)	tr	1 ± tr	1 ± tr	tr	0	0
Horseweed (_Conyza canadensis_)	0	0	0	0	2 ± tr	1 ± tr

Appendix Table I. Average percent canopy coverage $\pm$ SE for mowed and burned treatment areas. (Continued)

	JUNE EVALUATION			AUGUST EVALUATION		
SPECIES	SPRING BURN	SPRING MOW	SUMMER MOW	SPRING BURN	SPRING MOW	SUMMER MOW
Peppergrass (*Lepidium densiflorum*)	0	0	tr	0	0	0
Plantain (*Plantago spp.*)	2 $\pm$ tr	2 $\pm$ tr	2 $\pm$ tr	0	tr	tr
Purple coneflower (*Echinacea angustifolia*)	0	tr	0	0	0	0
Tall cinquefoil (*Potentilla arguta*)	tr	0	tr	0	0	0
White aster (*Aster ericoides*)	0	0	0	1 $\pm$ tr	tr	tr
Whorled milkweed (*Asclepias verticillata*)	3 $\pm$ 1	3 $\pm$ 1	1 $\pm$ tr	5 $\pm$ 2	1 $\pm$ tr	2 $\pm$ tr
Yarrow (*Achillea millefolium*)	0	0	tr	0	tr	0

Appendix Table I. Average percent canopy coverage ± SE for mowed and burned treatment areas. (Continued)

	JUNE EVALUATION			AUGUST EVALUATION		
SPECIES	SPRING BURN	SPRING MOW	SUMMER MOW	SPRING BURN	SPRING MOW	SUMMER MOW
Yellow wood sorrel (*Oxalis stricta*)	1 ± tr	tr	tr	tr	tr	0
OTHER SPECIES:						
Lead plant (*Amorpha canescens*)	5 ± 1	4 ± 1	2 ± tr	2 ± tr	2 ± tr	3 ± 1
Mead's sedge (*Carex meadii*)	tr	1 ± tr	2 ± tr	tr	0	0
Moss (*Leptodictyum trichopodium*)	tr	0	tr	0	0	0
Moss (*Weissia controversa*)	0	tr	0	0	tr	0
Scouring rush (*Equisetum hyemale*)	tr	0	1 ± tr	0	0	1 ± tr

Appendix Table II. Species identified at Hover Prairie that were not observed in treatment plots.

Common Name	Species Name
GRASSES:	
Smooth brome	*Bromus inermis*
Red top	*Agrostis stolonifera*
Timothy	*Phleum pratense*
FORBS:	
Azure aster	*Aster ericoides*
Black-eyed Susan	*Rudbeckia hirta*
Butterfly milkweed	*Asclepias tuberosa*
Downy gentian	*Gentiana puberula*
Golden Alexanders	*Zizia aurea*
Hoary vervain	*Verbena stricta*
Indian paint	*Lithospermum canescens*
Marijuana	*Cannabis sativa*
Mustard	*Sisymbrium spp.*
Panicled aster	*Aster simplex*
Pansy violet	*Viola pedata*
Prairie phlox	*Phlox pilosa*
Prairie wild rose	*Rosa arkansana*
Purple prairie clover	*Petalostemum purpureum*
Smooth blue aster	*Aster laevis*
Venus' looking glass	*Triodanis leptocarpa*
Western ironweed	*Vernonia baldwinii*
White dog's-tooth violet	*Erythronium mesochoreum*
White sage	*Artemesia ludoviciana*
Wholeleaf rosinweed	*Silphium integrifolium*
Yellow sweetclover	*Melilotus officianalis*

Appendix Table III. Biomass ± SE (g/m^2) of combined Grasses, Forbs, Woody Plants and Sedges for June and August evaluations.

TREATMENT	JUNE EVALUATION	AUGUST EVALUATION
Spring Burn		
Grasses	281 ± 9	514 ± 29
Forbs, Woody Plants and Sedges	18 ± 2	50 ± 5
Spring Mow		
Grasses	300 ± 12	496 ± 16
Forbs, Woody Plants and Sedges	17 ± 1	36 ± 7
Summer Mow[1]		
Grasses	475 ± 17	498 ± 11
Forbs, Woody Plants and Sedges	14 ± 1	53 ± 5

[1]Biomass from summer mow plots includes litter and standing dead material from previous years.