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SYNOPSIS: Selected prairie species were observed during the first growing season following a prescribed burn on Kalsow Prairie, a mesic tall grass prairie in central Iowa. Changes in dry weight, vegetative cover, and flowering response were measured on burned, unburned and mowed areas. Significant changes were recorded for many species following the burn ranging from a flowering response of prairie dropseed *(Sporobolus heterolepis)* on burned areas 30 times that on unburned areas to a slight reduction in flowering of bluegrass *(Poa pratensis)* on burned areas.
INDEX DESCRIPTORS: Fire, Grasslands, Prairie.

Although fire regularly swept across the plains of the mid-continental United States in the past, responses of prairie vegetation to burning are not well documented. Self-burying, awned seeds, persistent leaf sheaths, late spring emergence and a number of other means evolved as the plants adapted to meet this stress; however, the prairie climax may have come to depend upon, as well as endure, fire for its survival. Early man used fire, regarding it as a valuable tool, but modern man has largely eliminated intentional burning in attempting to preserve natural vegetation. However, since a change in any one factor tends to affect the entire ecosystem, protection from fire may upset the natural balance in native grasslands.

In northern Iowa accumulated litter equals or exceeds the annual yield of vegetation in 4 to 6 years following fire. Growth of native prairie species is then inhibited by the accumulation of decaying vegetation, causing a general stagnation of the community. Prairie species fail to reproduce while woody species increase (Ehrenreich and Aikman, 1963). Studies on the effects of fire have given conflicting results due to the complexity of factors involved in a burn as well as the diverse climates, vegetation, and local conditions under which the investigations have been made.

Effective prairie management requires understanding of the effects of fire on individual species as well as the entire community. This investigation (Richards, 1969) was undertaken to provide data on the effects of fire for preservation of individual species of the tall grass prairie in Iowa. The primary concern was to determine the effects of an April fire on cover values, dry weight production and flowering response of selected species. A secondary consideration was a comparison of the effects of mowing with burning.

STUDY AREA

The study area was Kalsow Prairie, a state preserve 5 miles NW of Manson, Iowa. The burned area comprised approximately 40 acres, the northern one-third consisting of an old pasture which had been released from grazing in 1948. The dominant species in this area are *Poa pratensis* and *Solidago canadensis* which have persisted since the time of grazing, and *Andropogon gerardi*, a rapidly invading prairie species. The remainder is ungrazed prairie. To the south there is a gradual slope, rising approximately 20 feet, on which the dominant grass changes upslope from *Andropogon gerardi* to *Sporobolus heterolepis*. The vegetation consists of variations of tall grass prairie composed of more than 230 species (Brotherson, 1969). Near the south end there is a pothole containing species of *Scirpus* and *Polygonum*, surrounded by zones of *Calamagrostis canadensis* and *Phalaris arundinacea*.

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METHODS

Preparation for the fire was made early in April, 1968, by mowing a 50-foot wide lane the length of the prairie about 150 yards from the western edge, and five perpendicular lanes dividing the isolated strip into smaller units. This strip was burned during the afternoon of April 18, 1968, by a headfire. The ground and litter were very moist due to light precipitation during the previous 24 hours.

Thirty large plots were established, half on each side of the mowed fire lane which was also divided into 15 plots. Cover estimates for each species were recorded during the third weeks of June, July and August according to Daubenmire (1959). Three subsamples were taken in each plot in the burn and control areas, and two subsamples in each mowed plot. Positions were randomly determined by tosses of a 20 x 50-cm wire quadrat. In June all plots were clipped for dry weight analysis. In August only the two rows of plots adjacent to the mowed area were sampled. After the cover estimates were recorded, the vegetation within each quadrat was clipped to within 2 cm of the soil, sorted to species, oven-dried to constant weight at 100°F and the weight recorded to the nearest decigram. The data for 30 abundant species were selected for analysis. Flowering stalk data were recorded when the clipped plots were sorted. Flowering stalk data for less abundant or clumped species were gathered by counting stalks in random quadrats in portions of the prairie selected for the species in question.

RESULTS AND DISCUSSION

A summary of responses following burning is shown in Table 1. Cover values for June, July, and August are combined, yield values are separated for June and August, and flowering stalk data are combined. Responses to burning varied considerably between species and between the techniques used in assessing the response. Cover values decreased for five species, increased for five species and re-

TABLE 1. SUMMARY OF RESPONSES FOLLOWING BURNING. + REPRESENTS A POSITIVE RESPONSE, - NEGATIVE, O NO RESPONSE, N NOT SAMPLED.

Species	Cover	Yield	June Yield	August Yield	Flowering
Achillea lanulosa	O	O	O	O	N
Amorpha canescens	–	–	–	O	+
Andropogon gerardi	–	O	O	O	+
Aster ericoides	O	O	O	O	+
Aster laevis	O	+	O	O	N
Aster simplex	O	O	O	O	N
Carex sp.	O	O	O	O	N
Elymus canadensis	O	O	O	O	O
Equisetum sp.	+	+	O	+	N
Eryngium yuccifolium	O	O	O	O	O
Fragaria virginiana	O	O	O	O	N
Galium obtusum	O	O	O	O	N
Helianthus grosseserratus	–	O	–	O	–
Helianthus laetiflorus	O	O	O	O	N
Liatris aspera	O	+	O	O	N
Oxalis sp.	O	O	O	O	N
Panicum sp. (rosette)	O	O	+	O	+
Panicum virgatum	+	+	O	+	+
Petalostemum purpureum	O	O	O	O	–
Phlox pilosa	+	+	O	+	N
Poa pratensis	–	–	–	O	–
Ratibida pinnata	+	O	O	O	+
Rosa sp.	O	O	O	O	N
Scutellaria leonardii	O	O	O	–	N
Silphium laciniatum	O	O	O	O	N
Solidago canadensis	O	+	+	+	+
Solidago rigida	–	O	O	O	N
Sporobolus heterolepis	O	O	+	O	+
Viola pedatifida	O	O	O	O	N
Zizia aurea	+	+	O	+	+

mained unchanged for 20, whereas yield decreased for two, increased for seven and remained unchanged for 21. The most obvious response was measured in flowering, with nine species increasing significantly, one remaining unchanged, and three decreasing, the remaining 16 not being sampled.

Yield

Dry weight values for *Amorpha canescens* and *Helianthus grosseserratus,* although significantly lower in the burned area when measured in June, showed no difference between the burn and control areas in August. Conversely, June yield was higher on the burn for the rosette panic grasses, but this difference was largely erased during the secondary period of growth that occurred after the response to burning.

Poa pratensis, which flowers in May and June, was adversely affected by the burn. Several inches of new growth were destroyed by the fire, requiring extra food reserves to be drawn from the root system for the second emergence. In contrast with the rosette panic grasses, *Poa pratensis* was significantly reduced in yield in the burn plots. McMurphy and Anderson (1965) have reported that all burns on the Kansas Flint Hills have been detrimental to *Poa* species.

Although the clumps of *Sporobolus heterolepis* smoldered and burned longer than any other vegetation in the fire, this species had an increased yield in the burned area in June. The difference in yield disappeared by August when the plants in the burn plots flowered profusely in contrast with those in the control plots where flowering was almost nonexistent. August yields for *Equisetum* sp., *Phlox pilosa, Panicum virgatum* and *Zizia aurea* were significantly higher in the burn plots than the control plots. The only species which showed a significant yield response in both June and August was *Solidago canadensis,* in which the dry weight remained high in the burn plots during the entire sampling period. Combined June and August data showed *Liatris aspera* to be higher yielding in the burned plots. *Scutellaria leonardii* was the only species with a significantly higher yield in the control plots during August.

Generally, species that emerge and bloom early in the growing season were stimulated or at least not harmed as long as they had not emerged before the fire. Due to the reduction of litter and early warming of the soil, the period of vegetative growth was effectively increased for these species before their energy was directed towards flower and seed production. The only species in this category that appeared to be harmed by the fire was *Poa pratensis,* which had begun growth before the fire.

Species that bloom during late summer and fall showed yield responses ranging from no effect as in *Elymus canadensis* to a very positive stimulation as in *Panicum virgatum.* None showed a serious decline in yield that could be attributed to burning. Similar results on Iowa prairie species have been reported by Ehrenreich (1959).

Cover

Cover data indicate that 10 of the 30 species considered showed a significant overall response to burning. *Amorpha canescens* and *Andropogon gerardi* showed less overall cover, but this may be explained by the vastly increased flowering response. Overall yield was also down in *Amorpha canescens,* but it did not seem affected in *Andropogon gerardi. Solidago rigida* also showed less cover in the burn, but this was not correlated with either a decrease in yield or in flowering response. Both cover and flowering were low in *Helianthus grosseserratus* and *Poa pratensis* in the burn. *Equisetum* sp., *Phlox pilosa* and *Zizia aurea* showed significantly greater yields as well as cover. *Ratibida pinnata* and *Panicum virgatum,* later maturing species, showed increased cover and flowering response with *Panicum virgatum* also showing a definite increase in yield.

Cover in *Aster simplex* was at a peak earlier in the burn than in the control plots, whereas the peak cover for *Zizia aurea* occurred in the burn plots in August and in the control plots in June and July. *Carex* sp. also grew for a longer time in the burn plots. *Eryngium yuccifolium* and *Sporobolus heterolepis* had significantly higher cover values in the burn plots early in the season, but by July no difference was discernible. Conversely, cover values for *Panicum virgatum* increased throughout the season in the burn plots, but remained at their June values in the control plots. Such variation of response indicates that frequent sampling throughout the entire growing season is advisable if cover is used as a measurement.

Flowering

A dramatic increase in flowering response occurred in the burn for several of the dominant grasses (Table 2). The number of plots containing inflorescences of *Andropogon gerardi* was doubled while the total number of inflorescences increased four and one-half times. In the rosette panic grasses the number of inflorescences almost doubled. For *Panicum virgatum* both the number of plots containing inflorescences and total number of stalks more than doubled. The number of plots containing flowering stalks of *Sporobolus heterolepis* tripled, while the total number of stalks increased 30 times. Flowering in *Poa pratensis* like other re-

TABLE 2. FLOWERING RESPONSE OF SELECTED GRASSES AND FORBS.

** REPRESENTS A 1% SIGNIFICANCE LEVEL, * A 5% SIGNIFICANCE LEVEL.

Species	Number of Inflorescences			Level of Significance		
	Burn	Control	Mow	Burn-Control	Mow-Control	Burn-Mow
Agrostis alba	0	135	47	**	**	**
Amorpha canescens	1016	506	–	**		
Andropogon gerardi	116	25	92	**	**	
Asclepias tuberosa	404	411	–			
Elymus canadensis	29	28	37			
Eryngium yuccifolium	745	745	–			
Helianthus grosseserratus	8	32	10	**	**	
Heliopsis helianthoides	158	131	–			
Panicum sp. (rosette)	111	70	–	**		
Panicum virgatum	88	35	35	**		**
Petalostemum sp.	140	186	–	*		
Phleum pratense	8	24	83	**	**	**
Poa pratensis	189	311	66	**	**	**
Ratibida pinnata	344	258	–	*		
Solidago canadensis	71	41	31	**		**
Sporobolus heterolepis	150	5	57	**	**	**

sponses was inhibited, as was flowering in *Phleum pratense* and *Agrostis alba*, two other introduced pasture species. *Elymus canadensis* was the only grass that appeared unaffected by the fire.

Among the forbs, flowering in *Helianthus grosseserratus* and *Petalostemum* sp. was depressed by the fire, flowering in *Eryngium yuccifolium, Asclepias tuberosa* and *Heliopsis helianthoides* did not appear to be affected, while flowering in *Solidago canadensis, Amorpha canescens* and *Ratibida pinnata* was increased.

In *Andropogon gerardi, Helianthus grosseserratus* and *Poa pratensis* flowering was affected similarly by burning and mowing. In *Solidago canadensis* and *Panicum virgatum* the mowing had little effect, and for *Sporobolus heterolepis* the mowing was a distinct stimulus, although the response was not as intense as to burning. The several types of responses shown by these species indicate that flowering in prairie species does not react in a generalized way to either burning or mowing.

Data from the mow area were insufficient to indicate statistically significant yield comparisons with the burn and control data, but indications are that mowing did not affect yield in *Amorpha canescens, Ratibida pinnata, Zizia aurea, Carex* sp., *Solidago rigida* and *Panicum virgatum* whereas burning did. Conversely, *Equisetum* sp., *Liatris aspera, Aster ericoides* and *Phlox pilosa* appeared to be stimulated by both burning and mowing, while *Eryngium yuccifolium, Scutellaria leonardii* and *Viola pedatifida* were depressed.

The reduction in cover, yield and flowering in *Poa pratensis* indicates that this species can be controlled in the tall grass prairie by early spring burning. Furthermore, fire can be a significant stimulus for flowering in certain native prairie grasses and forbs.

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