Burning and Fertilization for Range Improvement in Central Oklahoma[1]

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Highlight

Controlled burning with combinations of nitrogen, phosphorus, and potassium fertilizer were evaluated for improving a poor condition range. After two annual burns the botanical composition was improved. Reduction of prairie threeawn and rapid recovery of decreaser species were the most obvious improvement factors. Fertilization did not contribute to the speed of recovery. Nitrogen fertilizer produced in excess of 36 lb of forage for each pound of nitrogen applied to the burned plots. Phosphorus produced a significant forage yield increase in 1967 but potassium was not effective in changing forage yield or species composition. Range containing much low quality vegetation should not be fertilized.

Nearly half the total land area of Oklahoma is native range. Many ranges have been depleted by abusive grazing and are producing less than their potential. Improvement methods generally rely upon natural succession, a very slow process which often covers a span of many years to approach the climax vegetation (Booth, 1941; Savage and Runyon, 1937).

Fire has been recognized as an environmental factor of the True Prairie before civilized man entered the ecosystem (Bray, 1901; Jackson, 1965; Sauer, 1950). Uncontrolled fires can be hazardous and often are harmful to production (Launchbaugh, 1964; Hopkins et al., 1948). More recently researchers have begun to try to understand fire and how to employ it as a tool in range management (Ehrenreich, 1959; Vogl, 1965; McMurphy and Anderson, 1965). The role of controlled burning for encouraging plant succession is not clear.

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Commercial fertilizer is getting cheaper every year. In 1968, nitrogen as ammonium nitrate was available throughout Oklahoma at 8¢/lb of actual nitrogen. Range fertilization in the Northern Great Plains has met with varying degrees of success in improving range condition and forage yield (Cosper et al., 1967; Rogler and Lorenz, 1957). Range fertilization in the Southern Great Plains has not increased forage yields appreciably and the species composition goes to undesirable cool season species (Elder and Murphy, 1958; Huffine and Elder, 1960).

Researchers have indicated that grasses in the early successional stages have a competitive advantage over climax grasses because these pioneer species have a lower nitrogen requirement (Roux and Warren, 1963; Rice et al., 1960). Furthermore, some pioneer species such as prairie threeawn (*Aristida oligantha*) appear to inhibit nitrifying bacteria of the soil, thus keeping the soil fertility at a low level. Soils in later stages of succession contain increased amounts of nitrogen and phosphorus (Roux and Warren, 1963).

The purpose of this study was to evaluate the role of controlled burning plus fertilization in accelerating plant succession for range improvement and for increased forage yields.

Materials and Methods

The study was initiated in June 1964 on a poor condition, loamy prairie range site about three miles north of the campus of Oklahoma State University. Average annual precipitation is 32 inches but during the study years it was 16 to 22% below normal each year.

The experimental design was a split plot with four replications. The main plots were burned versus not burned. Sub-plots were the 12 fertility combinations which were all possible combinations of 0, 40, and 80 lb/acre of actual nitrogen; 0 and 18 lb/acre of phosphorus; and 0 and 33 lb/acre of actual potassium.

Fertilizer elements were broadcast using ammonium nitrate, super phosphate, and muriate of potash. Fertilizer was applied in June, 1964, and around May 1 in 1965 to 1967. Thus, fertilizer was applied just after the warm season perennial grasses commenced growth and just before the cool season annuals reached anthesis.

Burning was done around April 1 each year in 1965 to 1967. The soil was moist and the fire burned against a 5 to 10 mph breeze. Unburned plots were mowed earlier in the spring and the residue removed for ease of yield measurement.

Dry matter yield was determined by hand clipping at ground level a sample 18 × 36 inches from each plot in late autumn each year. Yields are reported as lb/acre oven dry.

Species composition was determined using eight one-meter transects from each plot. The 1964 readings were taken in July and in subsequent years were taken in September. The one-meter rod was 0.25-inch steel and basal readings were made counting each plant that touched the rod.

Forb frequencies were determined in 1967 using 20 one-ft² quadrats per plot and recording presence or absence of foliage.

The climax vegetation on this site is usually a tall grass prairie. The principle decreasers were big bluestem (*Andropogon gerardi*), little bluestem (*A. scoparius*), and indiangrass (*Sorghastrum nutans*). The major increaser was sideoats grama (*Bouteloua curtipendula*) and the major invaders were prairie threeawn, buffalograss (*Buchloe dactyloides*), and windmillgrass (*Chloris verticillata*). A more complete list of species was reported by Sims and Dwyer (1965).

Results

Botanical composition was taken in 1964 shortly after the experiment was started to establish a basis of comparison. Dry matter yields in 1964 were undoubtedly influenced by the fact that the pasture was closely grazed until June 13, 1964. No botanical composition data were collected in 1965 because no visual differences were apparent. Dry matter yields were taken each year but until 1966 the species composition was so dominated by prairie threeawn that the value of this forage was very low.

Early in 1966 it became obvious that species composition changes were occurring. The burned plots had more of the desirable decreaser species and fewer of the undesirable annuals.

Potassium had no appreciable effect on either forage yield or species composition. Soil tests revealed 270 lb/acre of available potassium—apparently an adequately amount.

Species Composition

There were no appreciable differences in species composition among treatment plots in 1964, before any burning was done. The botanical composition was composed of 18% decreasers, 37% increasers, and 45% invaders.

Table 1. Decreaser percentages[1] showing improvement through years and from burning.

Fertilizer			1964		1966		1967	
N	P	K	B[2]	U	B	U	B	U
0	0	0	16.1	19.7	37.0	23.5	44.6	35.7
0	0	33	14.5	12.6	37.8	37.5	30.3	53.8
0	18	0	23.1	20.4	49.0	27.1	50.5	53.8
0	18	33	18.6	14.0	37.4	29.5	40.0	50.4
40	0	0	15.4	16.6	35.2	25.4	33.3	43.5
40	0	33	22.0	14.7	34.0	29.2	39.8	41.1
40	18	0	16.4	16.1	37.5	31.2	47.9	43.8
40	18	33	19.1	22.7	32.0	33.0	37.1	47.1
80	0	0	13.5	11.9	51.4	15.9	53.6	39.8
80	0	33	19.9	19.0	51.4	31.3	54.2	51.7
80	18	0	16.2	16.4	50.1	31.3	57.8	58.6
80	18	33	20.4	22.1	46.0	36.4	61.1	47.0
Average[3]			17.9	17.3	41.6	29.3	45.9	47.2

[1] Determined by the meter rod transect (percentage of total plant population).
[2] B = Burned; U = Unburned. Plots not burned in 1964.
[3] Difference between burned and unburned was significant in 1966.

The improvement which can be credited to the burning treatment was apparent in 1966 (Table 1). The decreaser percentage was significantly greater and at the same time the invader percentage (data not shown) was significantly lower on the burned plots. The invader percentage averaged 15% for the burned plots and 30% for the unburned ones. No significant difference in increaser percentages (data not shown) occurred in 1966 as a result of burning.

By 1967 there was no significant difference in decreaser percentage attributed to burning. Thus, it appears that controlled burning accelerated the succession of decreaser species by about one year over the four-year period. The percentage of invaders was becoming less each year, but the unburned plots still contained significantly greater percentgaes of invaders in 1967.

The burned plots did contain significantly more increasers in 1967. These were dominated by sideoats grama which is one of the more desirable increasers.

The total improvement in decreaser percentage is worthy of note. From 1964 thru 1967 the decreasers improved from an average of 17.9% to 45.9% of the total vegetation. On the unburned plots the decreasers improved from an average of 17.3 to 47.2% during the same period.

The dominant invader species in the unburned plots for 1966–67 was prairie threeawn (Table 2). Prairie threeawn was also visibly abundant in all plots in 1965. By the end of 1966, after 2 controlled burns and 2½ years of deferment from grazing, prairie threeawn was well under control in all burned plots. A significant reduction in prairie threeawn had been achieved.

Table 2. Prairie threeawn, percentages of total vegetation[1] showing improvement from burning.

Fertilizer			1966[2]		1967[2]	
N	P	K	Burned	Unburned	Burned	Unburned
0	0	0	6.0	10.4	.2	7.5
0	0	33	2.1	10.5	1.2	6.6
0	18	0	2.2	16.9	.4	5.6
0	18	33	1.2	13.1	.1	9.0
40	0	0	1.4	17.6	.2	11.1
40	0	33	.5	20.9	1.0	8.4
40	18	0	.2	12.1	0.0	6.0
40	18	33	1.5	5.5	.2	4.1
80	0	0	.2	44.0	.2	16.2
80	0	33	.5	11.4	0.0	6.4
80	18	0	.5	1.9	0.0	.8
80	18	33	0.0	3.2	.2	1.5

[1] Determined by the meter rod transect.
[2] Significant difference (P = .05) between burned and unburned.

The most abundant undesirable forbs were western yarrow (*Achillea lanulosa*), western ragweed (*Ambrosia psilostachya*), and Louisiana sagewort (*Artemisia ludoviciana*). The meter transect which measured basal area was inadequate for measuring these forbs because the topgrowth seemed to vary. Therefore, in 1967, square foot quadrats were used to determine their frequency. The controlled burning could be credited with causing a significant reduction of these undesirable forbs (Table 3). Visually there appeared to be a tendency for the combination fertility treatment of nitrogen with phosphorus to stimulate a more rank growth of these forbs. The meter transect and square foot quadrats were either inadequate for measuring this, or the difference was not a true one.

Previous research on range fertilization had been plagued by the response of undesirable cool season species (Elder and Murphy, 1958; Huffine and Elder, 1960). Burning has been shown to control cool season species (McMurphy and Anderson, 1965). Therefore, the burning was included to control the expected invasion of cool season species, primarily Japanese brome (*Bromus japonicus*). The expected invasion never materialized. In the spring of 1966, blackeyedsusan (*Rudbeckia hirta*) and daisy fleabane (*Erigeron strigosus*) flowered profusely on the unburned plots but were absent on burned plots. These species had matured and disappeared by late summer when the meter transects were read.

Table 3. Percent frequency of major forbs[1] in 1967, using ft^2 quadrats.

Fertilizer				
N	P	K	Burned[2]	Unburned
0	0	0	27	38
0	0	33	25	40
0	18	0	21	49
0	18	33	27	46
40	0	0	22	43
40	0	33	28	50
40	18	0	29	50
40	18	33	29	51
80	0	0	28	46
80	0	33	17	42
80	18	0	34	49
80	18	33	27	58

[1] Western yarrow, western ragweed, and Louisiana sagewort.
[2] Significant difference (P= .05) between burned and unburned.

Table 4. Forage yield[1] as affected by nitrogen fertilization on burned plots.

		Nitrogen Fertilizer (lb/acre)		
Year		0	40	80
1966	Production[2]	3235c	5011b	6122a
	lb forage/lb N		44	36
1967	Production	3263c	5256b	6987a
	lb forage/lb N		50	47

[1] Lb oven-dry forage per acre.
[2] Means within a year followed by the same letter are not significantly different (P = .05).

The effect of the different fertility treatments on improving species composition was inconclusive. The high variability of these plots led to a finding of no significant difference in statistical analysis. One conclusive observation was that undesirable vegetation will grow profusely if fertilized.

Forage Production

The term "forage production" was inappropriate for much of the yield data because of the high content of prairie threeawn, forbs, and low quality vegetation. For example, one unburned plot receiving 80 lb/acre nitrogen produced over 3 tons of dry matter. The botanical composition of this plot was 70.5% prairie threeawn. Three tons of prairie threeawn should not be called forage. The example is probably the extreme, but does represent the problem.

The forage produced on the burned plots in 1966 and 1967 was primarily of desirable, high quality grasses. Therefore only these two years' dry matter are presented as forage yield (Table 4).

Nitrogen fertilizer gave the greatest responses in forage production. Significant increases in production occurred at each increased level of nitrogen fertilizer. The most important aspect was the forage yield per pound of applied nitrogen. In 1966 the 40N and 80N levels produced 44 and 36, respectively, pounds of forage per pound of nitrogen applied. In 1967 this was even better with 50 and 47 pounds of forage produced per pound of applied nitrogen at the 40N and 80N rates, respectively. These dramatic responses to nitrogen fertilizer are better than those from any previous research in Oklahoma. The best from previous research was 28 pounds of forage per pound of nitrogen from a burned plot (Gay and Dwyer, 1965).

Phosphorus produced a significant increase averaging 667 lb/acre of forage in 1967. No significance was attributed to phosphorus in 1966, but there was an unexplainable significant nitrogen × phosphorus interaction.

Potassium did not significantly affect forage production.

The prospect of range fertilization should not be considered if the range is infested with low quality vegetation. These unpalatable species are capable of responding to fertilization (data not shown) and there was no measurable increase in speed of succession.

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