EFFECTS OF RANGE BURNING AND NITROGEN FERTILIZATION ON THE NUTRITIVE VALUE OF BLUESTEM GRASS

BY

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Leland Allen

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INTRODUCTION

Increasing population and higher per capita beef consumption in the United States and elsewhere call for new management practices to increase the carrying capacity of native rangelands. Annual late spring burning of true prairie rangelands stimulates beef cattle performance. Commercial fertilizers also have been used to increase production of cultivated crops in this region, but such use has been of questionable value on native bluestem rangeland.

Reported here are the effects of annual late spring burning and nitrogen fertilization, separately and collectively, on the nutritive value of big and little bluestem (*Andropogon gerardi* Vitman and *A. scoparius* Michx.), two true prairie dominants.

REVIEW OF LITERATURE

Part I

Range Burning

The Great Plains of America have been subjected to fire throughout recorded history (Steward, 1953). The effects of range burning have been studied by many researchers and their conclusions often seem contradictory. Inconsistent results are obtained because of variations in climatic, biotic, and edaphic conditions under which the effects of fire are studied. Therefore, range burning in one area of the country may be detrimental while in another area it may be beneficial. In this review these differences will be noted and the factors causing them will be discussed.

Several researchers have investigated the effects of burning on forage yields of native True Prairie rangeland. Hensel (1923) reported no differences in forage yields between burned and non-burned pastures in the True Prairie region of Kansas. Other researchers evaluated the effect of range burning on soil moisture. Aldous (1934) reported less soil moisture in burned areas and speculated that time of burning may affect soil moisture levels. Hanks and Anderson (1957) later reported decreased water infiltration on burned range and an apparent increase in soil water evaporation between the time of burning and the initiation of new plant growth.

Anderson, *et al*. (1970), in a Kansas study, reported that early and mid-spring burning reduced forage yields but late spring burning did not. Elwell, *et al*. (1941) reported in an Oklahoma study that burning decreased forage yields and increased runoff. From these studies it may be concluded that burning native rangeland in these areas of the True Prairie will reduce yields if burned before April 20. The factors causing this include decreased water infiltration and increased water runoff after the pasture is burned and the soil exposed. With late spring burning the time interval between burning and the initiation of new plant growth is minimal, resulting in less water loss and no significant decrease in forage yield.

The effects of range burning on forage yield have also been studied in other areas of the country. In New Mexico on blue grama-pinyon-juniper rangeland, Dwyer and Pieper (1967) reported a thirty percent decrease in forage production the year following burning. On the Texas high plains, Trlica and Schuster (1969) reported decreased forage production on fall, spring, and summer burned range. Duvall and Linnartz (1967) reported no change in forage production on the longleaf pine-bluestem range in Louisiana and Vogl (1965) reported a three-fold increase in grass and forb yield in Wisconsin on burned brush prairie savanna range.

These studies show that in areas where rainfall limits forage production, forage yields will decrease following range burning. In those areas where rainfall is not limiting, range burning may stimulate production as it did in the brush prairie savanna of Wisconsin.

Range burning may also influence the species composition of native rangelands. Steward (1953) contends fire is responsible for maintaining the grassland environment of the prairies of the West and the temperate and tropical grasslands throughout the world. Grassland areas climatically capable of supporting woody species, such as the True Prairie, will revert to this type of vegetation if fire is removed from its environment. Fire can maintain a grassland environment because woody plants are more susceptible to permanent damage by fire than are perennial grass plants. When fire damages or destroys a woody plant, many years of growth are destroyed. When a perennial grass plant is burned, it will usually recover within a very short time (Humphrey, 1962).

In the True Prairie region of Kansas, Anderson et al. (1970) reported spring burning reduced the cool-season grass and favored warm-season species, and some forbs phenologically similar to the warm-season grasses. In an Iowa study, Ehrenreich (1959) reported range burning decreased kentucky bluegrass (*Poa pratensis* L.), the same cool season grass reduced in the Kansas study. In Oklahoma, Graves & McMurphy (1969) reported that after two annual burns the botanical composition was improved due to the rapid recovery of the decreaser grass species. In the blue grama-pinyon-juniper range of New Mexico, Dwyer and Pieper (1967) reported no change in the species composition of the herbaceous vegetation but a large reduction in small juniper (*Juniperus monosperma* (Engelm.) Sarg.) and cholla (*Opuntia imbricota* (Haw.) DC.). Humphrey and Everson (1951) reported a decrease in several problem plant species with range burning in Arizona. The control of these species was most effective when burned during the driest time of the year. Lehman lovegrass (*Eragrostis lehmanniana* Nees) also decreased immediately after burning but no permanent damage resulted and it later recovered. Trlica and Schuster (1969) reported burning increased the vigor of blue grama (*Bouteloua gracilis* (H.B.K.) lag. ex Steud,) on the Texas high plains. In the Kansas True Prairie, Anderson *et al.* (1970) found late spring burning effective in the control of buckbrush coralberry (*Symphoricarpus orbiculatus* Moench) and red cedar (*Juniperus virginiana* L.). However, smooth sumac (*Rhus glabra* L.) is not controlled by late spring burning. Big bluestem (*Andropogon gerardi* Vitman) and indian grass (*Sorgastrum nutans* (L.) Nash) are increased by late spring burning and little bluestem (*Andropogon scoparius* Michx.) is not affected.

Burning True Prairie rangeland stimulates earlier spring plant growth due to the removal of old plant material and mulch from the soil surface. The soil warms earlier in the spring, thus stimulating earlier plant growth (Owensby, *et al*, 1970). Duvall (1962) and Grelen and Epps (1967) also reported the removal of herbaceous litter the main benefit of burning bluestem range of the South. In an Iowa study, Ehrenreich (1959) reported range burning increased soil temperature and stimulated earlier plant growth. Grass on the burned range also matured earlier.

Burning native rangeland may increase the nutritive value of the forage. Smith *et al.* (1960) reported an increase in the apparent digestibility (cattle) of the dry matter and crude fiber of vegetation on burned range in the True Prairie region of Kansas. The ether extract and nitrogen free extract also appeared more digestible. Aldous (1934) reported higher forage crude protein levels on burned range. Smith and Young

(1959) reported higher crude protein and ash levels in little bluestem following burning. Pearson, *et al.* (1972) in Arizona, reported higher crude protein, phosphorus, and *in vitro* digestibility from forage on burned range.

From the above studies it can be concluded that range burning increases both the digestibility and the level of nutrients in rangeland forage.

Part II

Range Fertilization

Much research has been performed in the United States and elsewhere in studying the effects of nitrogen fertilization on native rangeland. As with range burning, the effects of nitrogen fertilization are closely related to the local conditions. If the applied fertilizer contains the primary nutrient limiting plant growth, the response may be favorable. If water, or some other nutrient, or an environmental factor is limiting, then fertilization may not be beneficial.

The most desirable effect of nitrogen fertilization is to increase the yield of the desirable grasses in the range plant community. In North Dakota, Goetz (1969) reported higher grass and forb yields with nitrogen fertilization at 33 lb., 67 lb., and 100 lb. nitrogen per acre. In Nevada, on a mixed stand of cheatgrass (Bromus secalinus L.) and intermediate wheatgrass (Agropyron intermedium (Host) Beauv.), nitrogen fertilization increased forage yields only in the more favorable years (Kay and Evans, 1965). On a ponderosa pine zone in Arizona, Lavin (1967) reported a substantial increase in herbage yield the first year after fertilization. Cooper and Sawyer (1955) reported up to one ton per acre increase in hay yields with nitrogen fertilization at 60 lb. nitrogen per acre. In North Dakota, Lorenz and Rogler (1967) reported a two-fold increase in forage yield with 30 lb. nitrogen per acre and a three-fold increase with 90 lb. In 1957 they also reported similar responses to nitrogen fertilization with hay yields (Lorenz and Rogler, 1957). Hubbard and

Mason (1967) reported forage yield on British Columbia range increased directly with increased nitrogen fertilizer, except when rainfall became the most limiting factor. Rehm, et al. (1972) in Nebraska found that 80 lb. nitrogen per acre increased the forage yield of a seeded mixture of warm season grasses three years out of four. The year no response was detected was abnormally dry, so water was the most limiting nutrient. An added response was detected when 20 lb. phosphorus was added to the 80 lb. nitrogen. Russel, et al. (1965) found nitrogen fertilization had no effect on dry matter production except when phosphorus was also added. In another study in British Columbia, Mason and Miltimore (1972) found 750 lb. nitrogen per acre on beardless wheatgrass (*Agropyron inerme* (Scribn. and Smith) Rydb.) increased the ten year accumulated forage yield two and one-half times. Holt and Wilson (1961) detected an increase in herbage production due to nitrogen fertilization on a desert grassland site in Arizona. Black (1968) reported nitrogen and phosphorus fertilization, separately and collectively, consistently increased forage yields of native grass and crested wheatgrass (*Agropyron desertorum* (Fisch.) Schult.). In a Kansas study in the True Prairie, 33 and 67 lb. nitrogen per acre increased the yield of range forage. Phosphorus had no effect (Moser and Anderson, 1964). Huffine and Elder (1960) reported a two to five-fold increase in the production of weeds with nitrogen fertilization and a slight decrease in the grass yield in an Oklahoma study. In other Kansas studies, increases in yields of bluestem range with fertilization have been reported by Elder and Murphy (1958) and Williams (1953). Anderson (1943) reported the effects of nitrogen fertilization over a fifteen year period. Sixteen pounds nitrogen per acre did not affect yields but 32 lb. per acre increased forage yields an average of 665 lb. per acre. These same plots were fertilized from 1951 to 1954 with 50 and 100 lb. nitrogen, 44 lb. phosphorus, and 42 lb. potassium in all combinations. A yield response was obtained from only nitrogen (Mader, 1956).

In addition to increasing the aerial plant parts, nitrogen fertilization may increase development of the plant root system. Reed and Dwyer (1971) reported shoot and root production increased about the same magnitude on a blue grama range in New Mexico. Smika, et al. (1961) reported grass root weight through a six-foot soil profile increased when nitrogen was applied at 90 lb. per acre. Lorenz and Rogler (1967) found that nitrogen at 30 lb. per acre increased root weight, with no added response at heavier applications. McKell (1966) reported increased root development with nitrogen fertilization on annual range.

The increased ability of plants to draw water and nutrients from the soil is the primary advantage of a larger root system. This is especially important during drought, when plants with large, well-developed root systems can continue to grow while those with smaller root systems stop. Improved water relations due to increased root systems have been reported by McKell (1959), Black (1968), and Owensby (1970).

Fertilization may affect the nutrient content of native grasses. The change most frequently noted is an increase in crude protein. Dee and Box (1967) analyzed blue grama, buffalo grass (Buchloe dactyloides (Nutt.) Engelm), windmillgrass (Chloris verticillata Nutt.), and silver bluestem (Andropogon saccharoides Swartz) for crude protein. All levels of nitrogen fertilization (33, 100, and 300 lb. per acre) increased the crude protein of blue grama and windmillgrass. The two highest rates increased the crude protein of buffalo grass. Silver bluestem had higher crude protein levels only at the highest rate. Increased crude protein in fertilized blue grama was also reported by Kelsey, et al. (1972). Owensby, et al. (1970) reported higher nitrogen levels in big bluestem in the Kansas True Prairie with nitrogen fertilization at 50 lb. per acre. Nitrogen fertilization also increased the crude protein of intermediate wheatgrass on the ponderosa pine region in Arizona (Lavin, 1967). Lorenz and Rogler (1957) detected increased crude protein in grass fertilized with 90 lb. nitrogen per acre. When only 30 lb. was applied, the crude protein content was lowered, due to the "dilution factor". Rehm, et al. (1972) in Nebraska, found no differences in the nutrient content of fertilized warm-season grasses. Jones (1963) in a California study on annual grasslands, determined the crude protein in individual species during the growing season after various levels of nitrogen was applied. All rates of nitrogen fertilization increased protein early in the season but as the grass reached maturity the crude protein was lower than in the non-fertilized grass. This was probably due to the "dilution factor", the nitrogen fertilizer stimulated plant growth such that nitrogen levels in the plant were decreased. Moser and Anderson (1964) reported a small, linear increase in the crude protein of big bluestem with 33 and 67 lb. of nitrogen fertilizer per acre. In a study by Luebs, et al. (1971), plant nitrogen content was increased on sites where forage production was lower. The total uptake of applied nitrogen was constant for all sites. Evidently on sites where growing conditions were more favorable the growth stimulation from fertilization diluted the nitrogen content of the plants.

Nitrogen fertilization may also affect the levels of other grass nutrients and their digestibilities. Kelsey, et al. (1972) reported nitrogen fertilization of blue grama increased calcium and decreased silicon, acid detergent lignin, in vitro organic matter digestibility, and in vitro dry matter digestibility. No changes in cell walls, acid detergent fiber, or fiber digestion were detected. In a British Columbia study, Mason and Miltimore (1972) detected sharp declines in calcium and zinc levels of beardless wheatgrass, and no changes in potassium, magnesium, manganese, and iron due to nitrogen fertilization. Rehm, èt al. (1972) found no differences in nutrient content or dry matter digestibility with nitrogen fertilization of warm-season grasses in Nebraska.

Researchers have reported dissimilar species response to nitrogen fertilization, giving some species ecological advantages over others. Goetz (1969) in a North Dakota study, found blue grama generally decreased, western wheatgrass (Agropyron smithii Rydb.) usually increased, and the response of other grass and sedge species variable. Kay and Evans (1965) found applied nitrogen favored cheatgrass at the expense of intermediate wheatgrass in a Nevada study. Owensby, *et al*. (1970), in the Kansas True Prairie, found nitrogen fertilization changed bluestem range to undesirable cool-season dominance at the expense of warm-season species.

Fertilization may modify the phenological development of the grass plant. With 40 and 80 lb. nitrogen per acre, Reed and Dwyer (1971) detected 142 and 263 percent increase in seed stalks and 181 and 277 percent increase in spike numbers. Leaf blades and sheaths also increased since seed stalks had an average of 3.34 leaves. Goetz (1969) found certain grass species tended to profusely branch, greatly increasing the area of the plant. Kelsey, *et al*. (1972) found nitrogen fertilization of blue grama increased the percent culms, decreased leaf blades and had no effect on the other parts. Goetz (1970), in North Dakota, found nitrogen fertilization did not appreciably affect the phenological development of the various species. He reported leaf tip drying began earlier in the season and progressed more rapidly without nitrogen fertilization. This trend reversed itself later in the growing season. He also observed differences in leaf heights between treatments from mid May to the end of the growing season. Thirty-three pounds nitrogen per acre did not greatly increase the leaf height of any species. Maximum leaf heights were observed at 67 lb. per acre with no additional increase at 100 lb.

Nitrogen fertilization may also increase the palatability and green growth period of native grass. Hooper, *et al*. (1969) reported fertilization increased forage palatability and could be used as a management tool to improve livestock distribution.

Smith and Lang (1958) in a Wyoming study on mountain range, reported fertilization increased the palatability of native range and attracted cattle to undergrazed areas. Holt and Wilson (1961) reported in Arizona the green growth period was increased six weeks with nitrogen fertilization. In another study in Arizona, Lavin (1967) reported nitrogen fertilization increased the amount of green growth during the late summer and early fall. Finally, in a third study from Arizona, Hommas, et al. (1959) reported range fertilization lengthened the green feed period two to four weeks for blue grama, two to six weeks for hairy grama (*Bouteloua hirsuta* Lag.) and had no effect on side-oats grama (*Bouteloua curtipendula* (Michx.) Torr.). On the other hand, Sneva, et al. (1958), in an Oregon study, reported a shortening of the green growth period of crested wheatgrass with nitrogen fertilization, due to more rapid depletion of soil moisture.

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EFFECTS OF RANGE BURNING AND NITROGEN FERTILIZATION ON THE NUTRITIVE VALUE OF BLUESTEM GRASS

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HIGHLIGHT

This research determined the effects of range burning and nitrogen fertilization, separately and collectively, on the nutritive value of big and little bluestem in Kansas True Prairie. Late spring burning decreased concentrations of dry matter, crude fiber, cell walls, acid detergent fiber, cellulose, and lignin, and increased crude protein, ether extract, nitrogen free extract, ash, and hemicellulose. Nitrogen fertilization decreased concentrations of nitrogen free extract and cell wall cellulose, and increased ash and lignin. Big bluestem was higher than little bluestem in crude protein and nitrogen free extract, and lower in crude fiber, cell walls, acid detergent fiber, lignin and cellulose.

INTRODUCTION

Range burning is a widely used management tool in the True Prairie region of Kansas. Aldous (1934) reported burning increased range forage protein levels. Smith and Young (1959) reported higher crude protein and ash levels in little bluestem following burning. Smith, et al. (1960) noted that burning increased apparent digestibility of dry matter and crude fiber.

Although nitrogen fertilization of native True Prairie rangeland has not been widely used, in recent years attempts to increase carrying capacity has stimulated interest in the pracitice. Little is known about the effects of nitrogen fertilization on the nutritive value of native grass. Moser and Anderson (1964) reported a small linear increase in forage crude protein levels with 33 lb and 67 lb applied nitrogen per acre. Owensby (1970) also reported higher plant nitrogen levels after fertilizing with 50 lb nitrogen per acre.

The purpose of this study was to determine the effects of annual late spring burning and nitrogen fertilization, separately and collectively, on the nutritive value of big bluestem (*Andropogon gerardi* Vitman) and little bluestem (*Andropogon scoparius* Michx.), co-dominants in the True Prairie.

STUDY AREA AND METHODS

The study was conducted during the 1972 growing season on native, True Prairie rangeland near Manhattan, Kansas. Elevation varies from 353.6 m (1160 ft) to 406.9 m (1335 ft) above sea level. Average annual precipitation is 85.12 cm (33.51 in) of which 74 % is received as rain during the growing season (May - October). Between May and October there were 55.12 cm (21.7 in) of rainfall; 87.3 % of the normal for the period. The four pastures used varied from 17.8 ha (44 acres) to 24.3 ha (60 acres), and were described by Anderson and Fly (1955).

The following treatments were applied to each of the four pastures:

Burning: April 28, with a light northern breeze.

Nitrogen: Urea, aerially applied May 17 at 18.14 kg (40 lb) nitrogen per acre.

Burning and Nitrogen: A combination of the individual treatments.

Control: No burning or nitrogen fertilization.

Grass samples were clipped from within exclosures 7.6 m (25 ft) square, in three random ordinary upland sites within each pasture on May 15 and the first of each month thereafter through November. Due to lack of growth on May 15, samples were not taken on all treatmnets. The plants were clipped at ground level and stored frozen in plastic bags. Before analysis they were dried overnight at 90° C in a forced air oven and ground in a Wiley mill through a 1 mm screen.

Proximate analyses were determined according to AOAC (1970). Cell wall constituents were estimated according to Goering and Van Soest (1970).

Data were analyzed by least square analysis of variance, separating burning treatment, fertilization treatment, grass species, month of sampling, and all possible two-way interactions. Three and four-way interactions remained in the error term (Table 8).

RESULTS AND DISCUSSION

Dry Matter

Samples ranged from 22.5 % dry matter in May to 75.0 % in November (Table 1). As the growing season advanced, dry matter content increased. Burning decreased ($P<.05$) dry matter content 3 of 5 months, when compared to non-burning. Little bluestem samples had more ($P<.05$) dry matter than big bluestem during July and October and less during November (Table 3). Fertilization had no effect on percent dry matter (Table 2).

Ether Extract

Percent ether extract (EE) in all samples ranged from 1.96 to 2.86 (Table 1). Between May and August percent EE decreased. During September and October it increased and then dropped slightly in November. Burning increased ($P<.05$) percent EE during July, August, September, and November, when compared to samples from non-burned treatments (Table 3). During June and November the increases were non-significant. Nitrogen fertilization did not affect percent EE (Table 2). Little bluestem was higher ($P<.05$) than big bluestem in percent EE from August to October, and non-significantly higher during all other months except July (Table 3). Burning increased ($P<.05$) percent EE of both species above non-burning but little bluestem responded more than big bluestem (Table 5).

Crude Protein

Percent crude protein (CP) of all samples ranged from 17.70 in May to 2.89 in November (Table 1), and decreased as the grass matured. During August, September, and October percent CP remained relatively constant at 4.2 to 4.5. Only during June did burning increase ($P<.05$) percent CP above those from non-burned treatments (Figure 1). Burning increased percent CP of little bluestem and non-significantly increased big bluestem above that of the non-burned pastures (Table 5). Burning and fertilization combined produced an increased ($P<.05$) percent CP but fertilization alone produced a non-significant decrease when compared to the control (Table 6).

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

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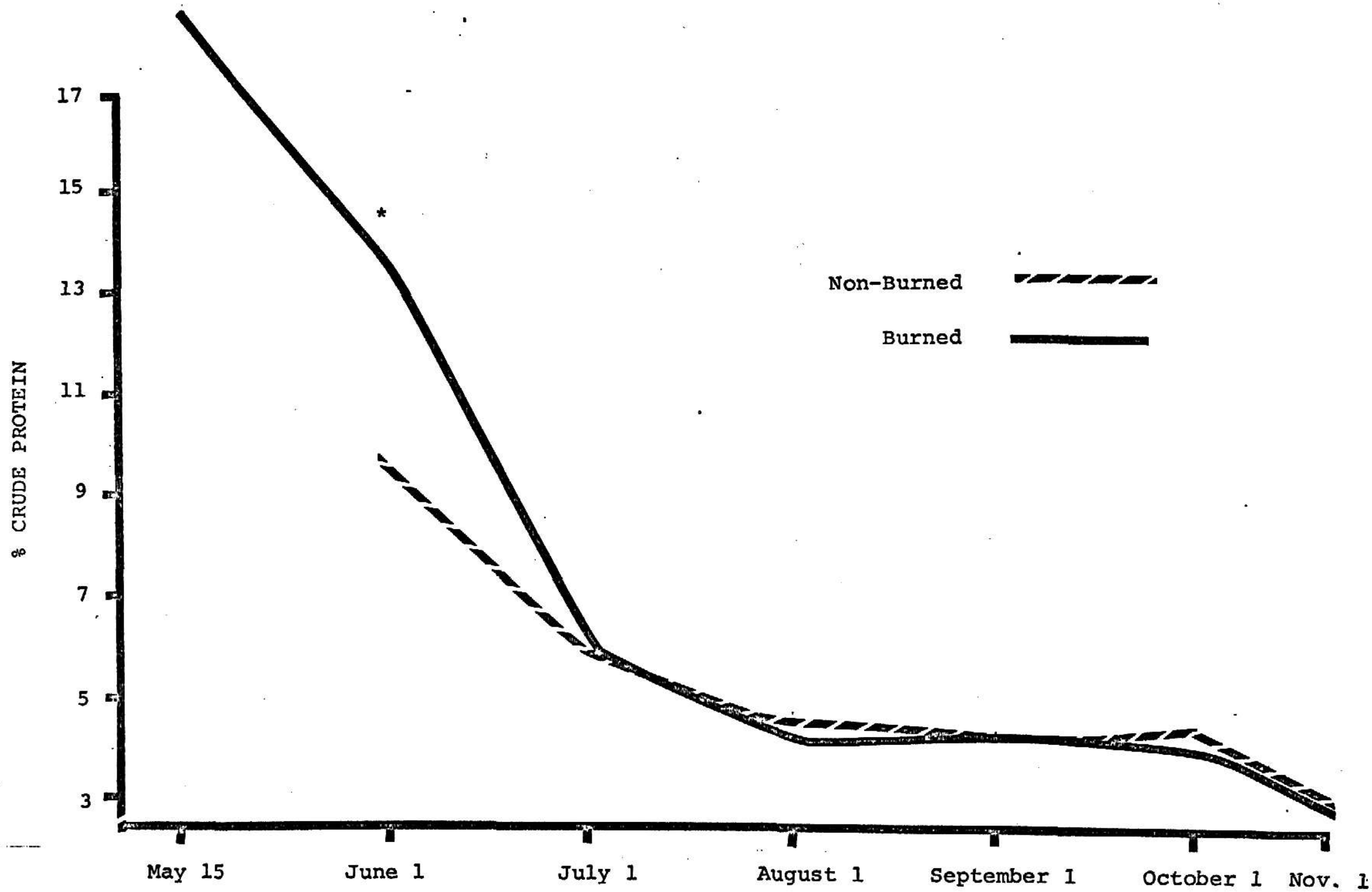

Figure 1. Percent crude protein in big and little bluestem (samples combined) clipped at monthly intervals. Asterisk above a given clipping date indicates statistically significant difference at the .05 level due to burning treatment.

Crude Fiber

Percent crude fiber of all samples ranged from 25.9 in May to 34.9 in November (Table 1). Generally percent crude fiber increased as the grass matured but during August and October decreases were detected. When compared to the control, burning decreased ($P<.05$) percent crude fiber throughout the study period (Figure 2). Fertilization increased ($P<.05$) percent crude fiber compared to non-fertilized treatments and big bluestem was lower ($P<.05$) in crude fiber than little bluestem (Table 2).

Nitrogen Free Extract

Percent nitrogen free extract (NFE) for all samples varied from 43.31 to 56.38 (Table 1). NFE content increased from May to August, decreased in September, and continued at that level during the remainder of the study. Burning increased ($P<.05$) percent NFE, when compared to non-burning, every month except September (Figure 3). Burning increased ($P<.05$) percent NFE in both bluestem species when compared to non-burning, but little bluestem was somewhat lower on the unburned treatments and did not increase to the same degree (Table 5). Nitrogen fertilization decreased ($P<.05$) percent NFE, when compared to not fertilizing, in July, September, and November, and non-significantly decreased it the remaining months (Table 3).

Ash

Percent ash of all samples ranged from 6.4 to 10.17 (Table 1). Grass from burned areas was higher ($P<.05$) in ash than from areas not burned during June and November but non-significantly different during the other months (Table 3). Nitrogen fertilization in-

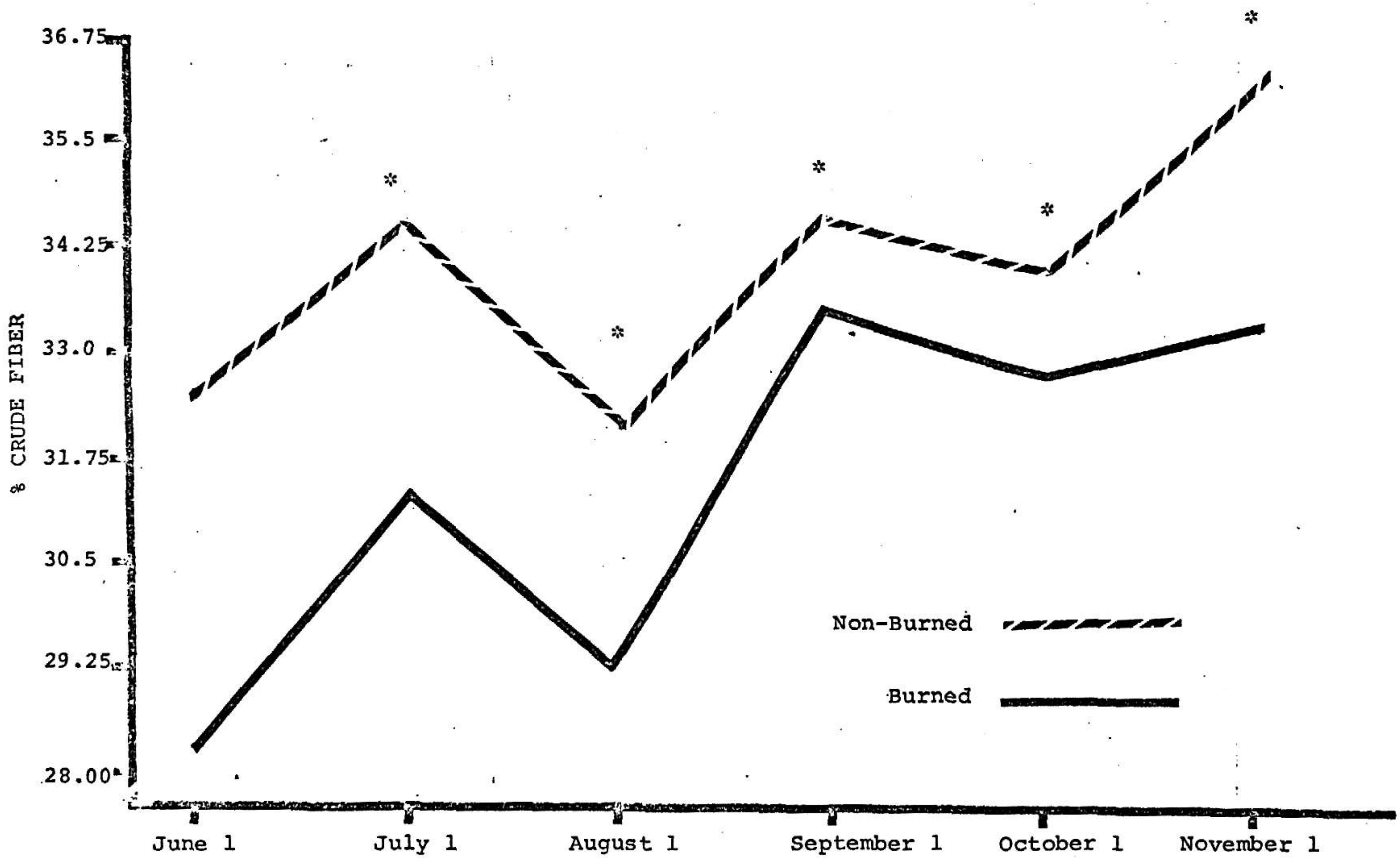

Figure 2. Percent crude fiber in big and little bluestem (samples combined) clipped at monthly intervals. Asterisk above a given clipping date indicates statistically significant difference at the .05 level due to burning treatment.

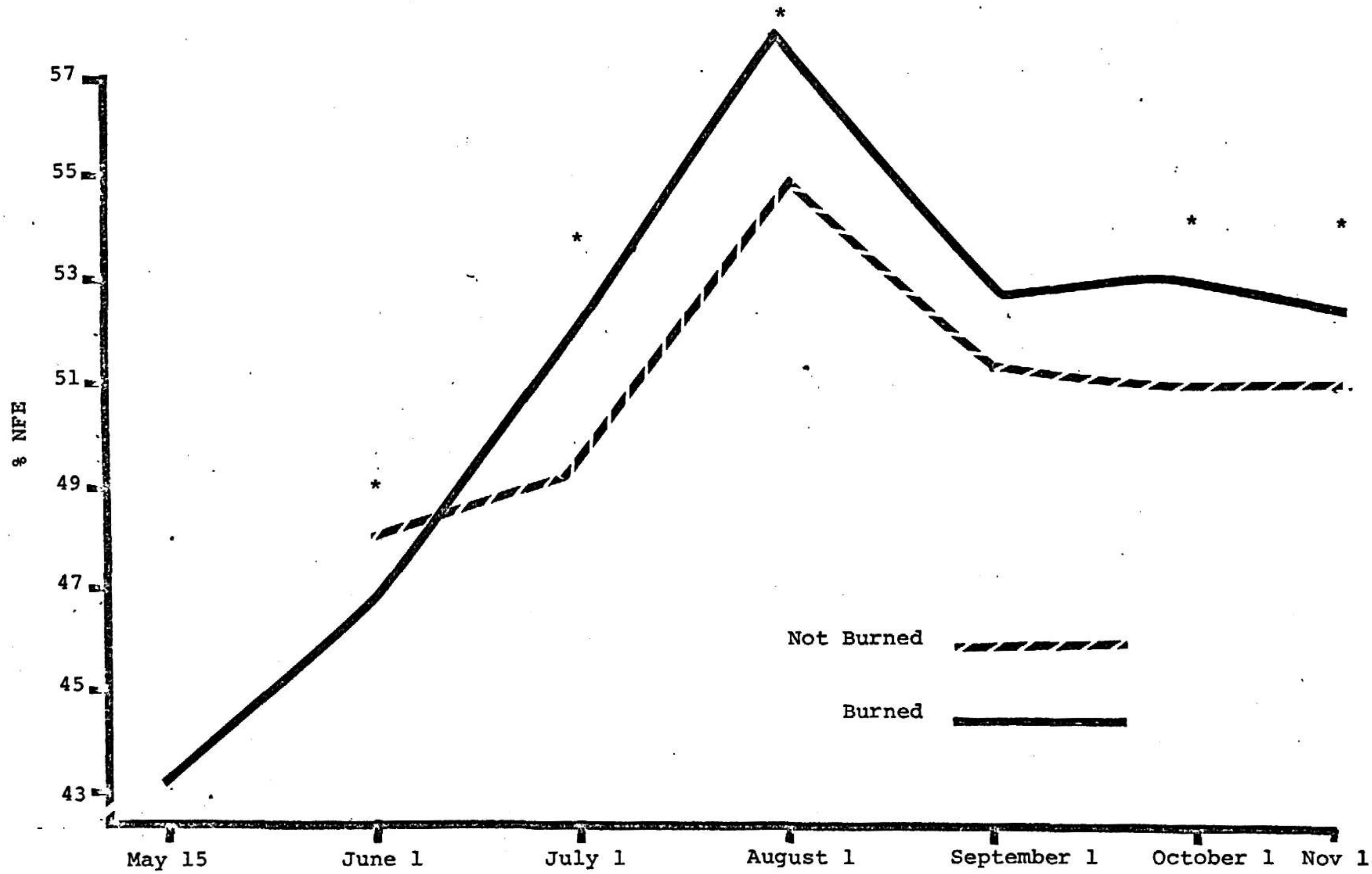

Figure 3. Percent nitrogen free extract in big and little bluestem (samples combined) clipped at monthly intervals. Asterisk above a given clipping date indicates statistically significant difference at the .05 level due to burning treatment.

creased ($P<.05$) percent ash above that not fertilized only during June and July (Table 3). Percent ash of non-burned, fertilized grass was equal ($P<.05$) to that of grass from the burned areas which was fertilized (Table 6). Percent ash of both bluestem species was increased ($P<.05$) by nitrogen fertilization, but big bluestem increased more (Table 7).

Cell Walls

Percent cell walls (CW) of all samples ranged from 72.54 in June to 79.25 in November (Table 1). Compared to forage from non-burned areas, burning increased forage quality by decreasing ($P<.05$) CW every month except September and October (Figure 4). Fertilization had no effect on percent CW, either separately or in combination with range burning (Table 6). Burning reduced ($P<.05$) percent CW in both bluestem species when compared with non-burning (Table 5).

Acid Detergent Fiber

Percent acid detergent fiber (ADF) of all samples increased from 39.99 in June to 50.98 in November (Table 1). Burning increased forage quality by decreasing ($P<.05$) ADF below that of forage from non-burned areas every month during the study (Table 4). Big bluestem was lower ($P<.05$) than little bluestem in percent ADF every month during the study except November (Table 4). Fertilization had no effect on ADF (Table 2).

Hemicellulose

Percent hemicellulose (HMC) of all samples ranged from 32.55 in June to 28.26 in November (Table 1). Percent HMC of cell walls ranged from 44.90 in June to 35.68 in November (Table 1).

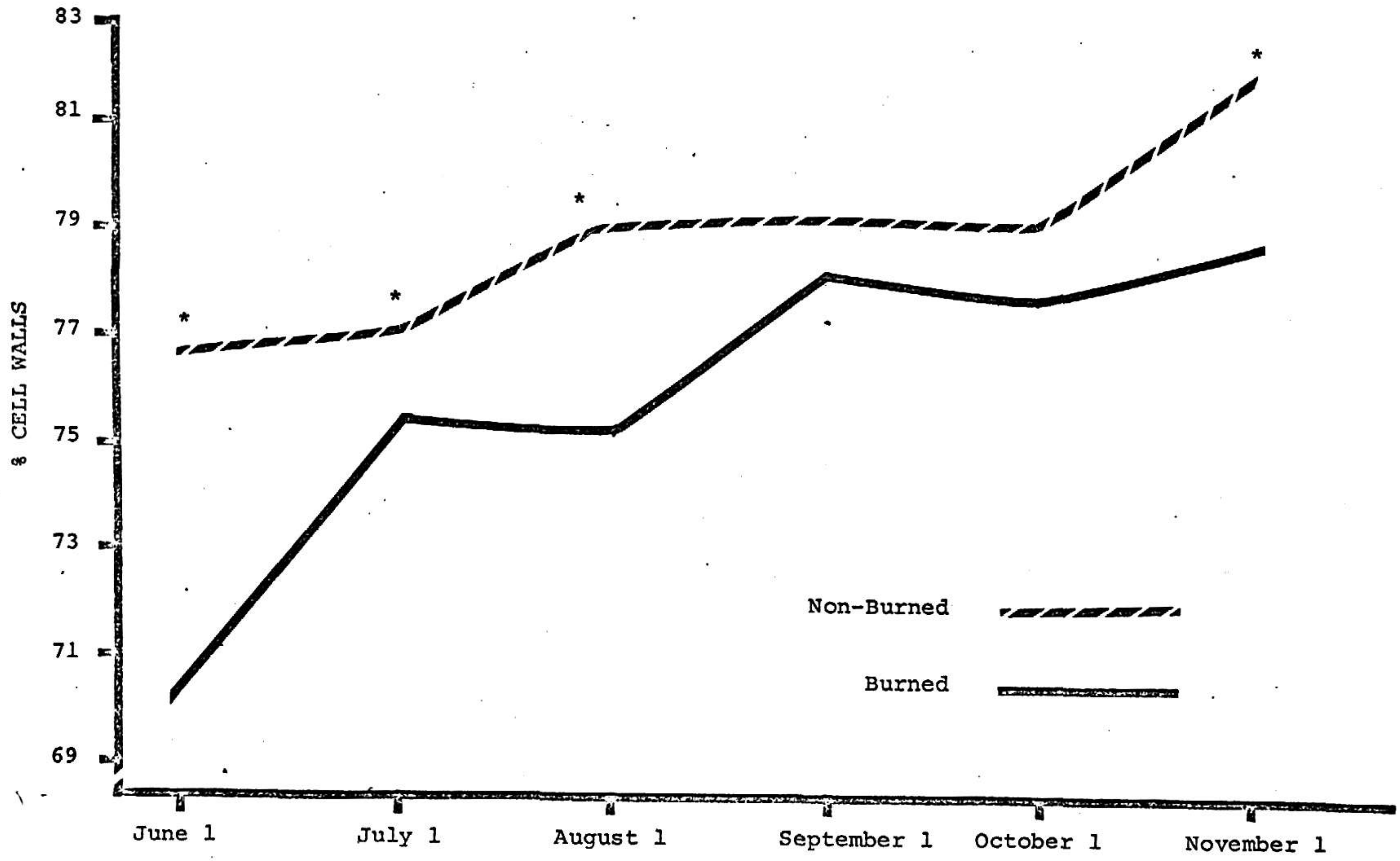

Figure 4. Percent cell walls in big and little bluestem (samples combined) clipped at monthly intervals. Asterisk above a given clipping date indicates statistically significant difference at the .05 level due to burning treatment.

Burning decreased ($P<.05$) percent HMC of forage below that of forage from non-burned areas during June, increased it during July, and had no effect during the remainder of the study. HMC content of cell walls increased ($P<.05$) with burning during 5 of the 6 months, compared to those areas not burned (Table 4). Nitrogen fertilization decreased ($P<.05$) HMC levels during 3 months and increased it 1 month, compared with non-fertilization (Table 4). Burning increased ($P<.05$) both the overall HMC content of big bluestem and HMC percent in its cell walls compared to non-burned big bluestem (Table 5). Percent HMC of little bluestem cell walls increased ($P<.05$) with burning above that from non-burned areas, but not as much as did big bluestem (Table 5).

Lignin

Percent lignin of all samples increased from 4.66 in June to 8.49 in November and percent lignin of cell walls increased from 11.56 in June to 16.61 in November (Table 1). Burning decreased percent lignin during June, August, and November with non-significant decreases during July and September, when compared to forage from non-burned areas (Figure 5). In contrast with burning, nitrogen fertilization decreased forage quality by increasing lignin levels. Nitrogen fertilization increased ($P<.05$) percent lignin above non-fertilized levels during July and September (Figure 6). Little bluestem had higher lignin values than big bluestem during August and September (Table 4). Nitrogen fertilization did not affect lignin in forage from unburned areas, but did increase ($P<.05$)

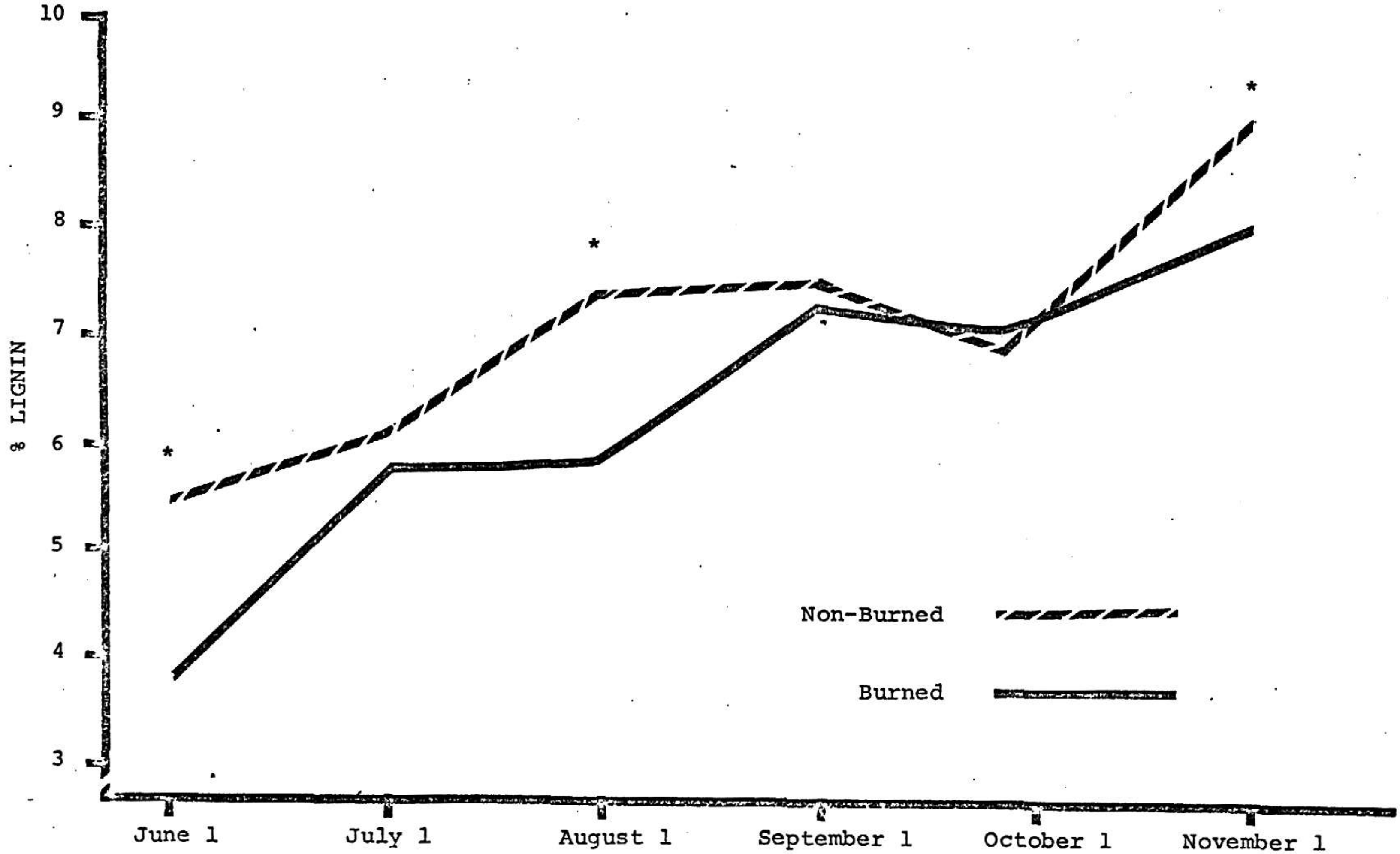

Figure 5. Percent lignin in big and little bluestem (samples combined) clipped at monthly intervals. Asterisk above a given clipping date indicates statistically significant difference at the .05 level due to burning treatment.

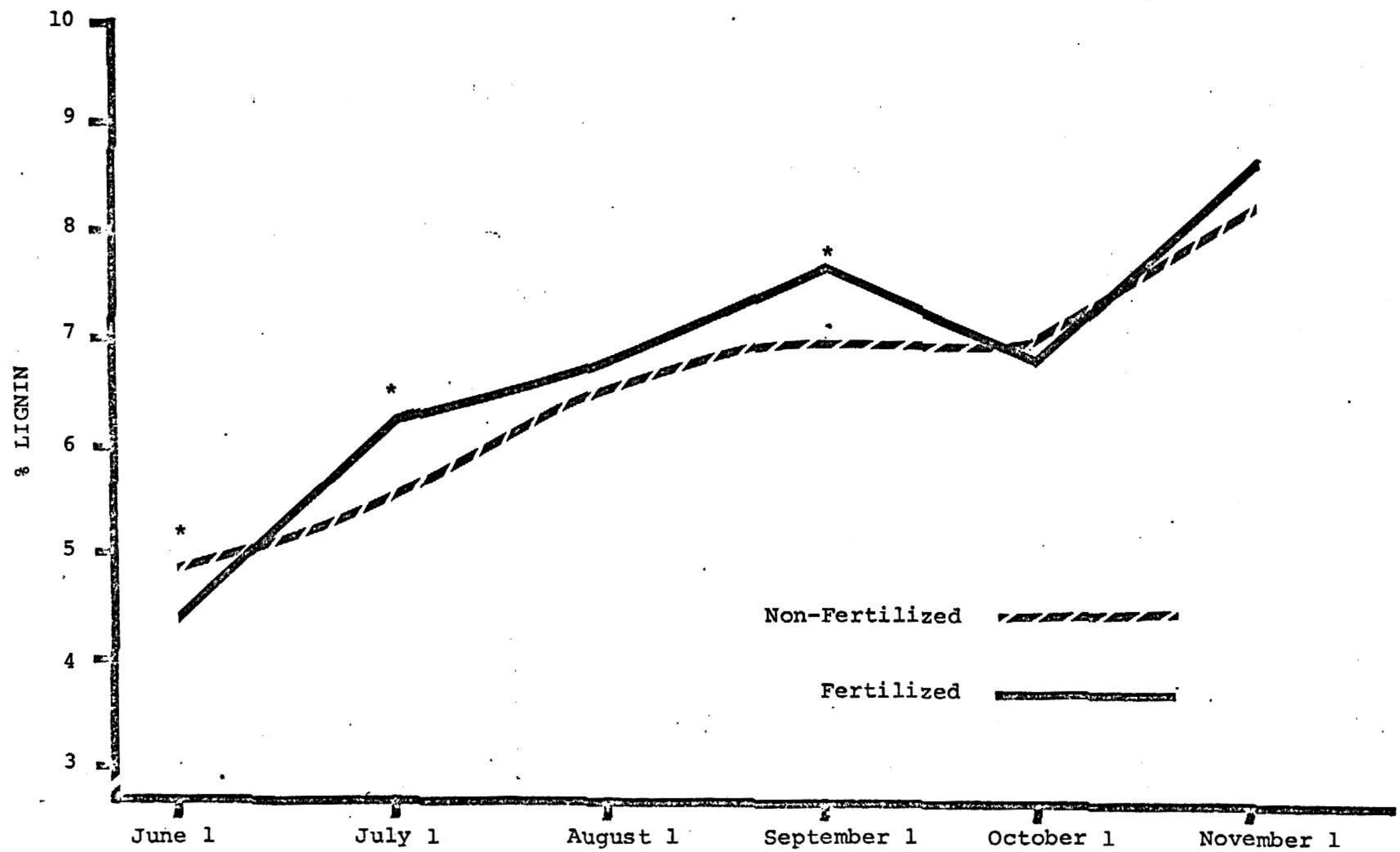

Figure 6. Percent lignin in big and little bluestem (samples combined) clipped at monthly intervals. Asterisk above a given clipping date indicates statistically significant difference at the .05 level due to nitrogen fertilization treatment.

lignin in forage from fertilized and burned areas when compared to forage from only burned treatments (Table 6).

Cellulose

Percent cellulose of all samples ranged from 32.28 in June to 36.28 in November (Table 1). When compared to forage from non-burned areas, burning decreased percent cellulose during June, July, August, and November (Table 4). Table 1 also shows the percent cellulose of acid detergent fiber decreased from 80.75 in June to 71.18 in November. That trend is similar to that detected for hemicellulose and shows that as the grass matures cellulose content decreases and nutritive value deteriorates. When compared to non-fertilization, nitrogen decreased percent cellulose in acid detergent fiber (Table 2). Big bluestem was lower in percent cellulose than little bluestem (Table 2).

CONCLUSIONS

Late spring burning improved the quality of bluestem grass above that of non-burned grass in Kansas True Prairie, primarily by increasing the quality of plant carbohydrates. Proximate and Van Soest analyses detected decreases in crude fiber, cell walls, acid detergent fiber, and lignin in forage from burned treatments; which are the less digestible carbohydrates (Goering and Van Soest). Increases in nitrogen free extract and cell contents, the very digestible portions of the plant cell, indicates the more digestible carbohydrates increase with range burning. These results agree with Smith, et al. (1960) who found increases in the apparent digestibility of dry matter and crude fiber portions of forage from burned range.

Nitrogen fertilization lowered nitrogen free extract and increased the crude fiber content of bluestem when compared to non-fertilization. That effect was not detected in the Van Soest cell content values although higher lignin values were detected on fertilized forage.

Apparently fertilization decreases forage quality and would be expected to decrease livestock gains. Woolfolk, et al. (1973) reported that 40 lb and 80 lb nitrogen per acre on the unburned range had a suppressing affect on average daily gains of yearling steers. Nitrogen fertilization of the burned range increased average daily gains at 40 lb nitrogen per acre and slightly decreased it at 80 lb per acre. Due to higher stocking rates all nitrogen fertilized pastures had higher gains on a per acre basis than did the non-fertilized pastures.

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Table 1. Proximate and Van Soest Analyses for Pooled Bluestem Grass Values at Monthly Intervals, May - November, 1972.

	May[1]	June	July	August	September	October	November
Dry Matter	22.50	27.40 A[2]	32.92 B	--	37.74 C	43.53 D	74.99 E
Ether Extract	2.86	2.54 A	2.40 AB	1.96 D	2.09 CD	2.35 B	2.24 BC
Protein	17.74	11.62 A	5.96 D	4.47 C	4.31 C	4.22 C	2.89 D
Nitrogen Free Extract	43.31	47.47 D	50.78 C	56.38 A	52.36 B	52.04 B	51.76 B
Crude Fiber	25.92	30.48 D	32.82 C	30.80 D	33.98 B	33.36 C	34.90 A
Ash	10.17	7.90 A	8.04 A	6.40 B	7.25 C	8.04 A	8.22 A
Cell Walls	---	72.54 E	75.38 D	76.25 CD	77.77 B	76.99 BC	79.25 A
Acid Detergent Fiber	---	39.99 D	42.20 C	42.32 C	45.83 B	45.56 B	50.98 A
Hemicellulose	---	32.55 BC	33.18 AB	33.93 A	31.94 CD	31.43 D	28.26 E
Hemicellulose/Cell Walls	---	44.90 A	44.02 A	44.53 A	41.06 C	40.81 B	35.68 B
Lignin	---	4.66 E	5.88 D	6.61 C	7.32 B	6.92 BC	8.49 A
Lignin/Acid Deterg. Fiber	---	11.56 E	13.93 D	15.56 C	15.95 BC	15.19 C	16.61 A
Cellulose	---	32.28 D	33.37 C	32.30 D	34.25 B	33.51 BC	36.28 A
Cellulose/Acid Deterg. Fiber	---	80.75 A	79.08 B	76.40 C	74.74 D	73.57 D	71.18 E

[1] May values were not statistically analyzed.

[2] Values within the same chemical constituent followed by the same letter are not significantly different at the .05 level.

Table 2. Effects of Burning Treatment, Fertilization Treatment, and Grass Species on the Proximate and Van Soest Analyses of Bluestem Grass.

	BURNING[1]		FERTILIZATION		SPECIES	
	Not Burned	Burned	Not Fert.	Fert.	Big Bluestem	Little Bluestem
Dry Matter	45.17 A	41.46 B	43.78 A	42.85 A	43.71 A	42.92 A
Ether Extract	2.07 A	2.45 B	2.28 A	2.25 A	2.16 A	2.36 A
Protein	5.30 A	5.86 B	5.57 A	5.59 A	5.66 A	5.50 A
Crude Fiber	34.04 A	31.41 B	32.57 A	32.88 B	32.28 A	33.16 B
Nitrogen Free Extract	51.12 A	52.48 B	52.39 A	51.20 B	52.26 A	51.33 B
Ash	7.47 A	7.81 B	7.19 A	8.09 B	7.63 A	7.65 A
Cell Walls	77.74 A	74.99 B	76.35 A	76.38 A	75.39 A	77.34 B
Acid Detergent Fiber	45.94 A	43.02 B	44.34 A	44.62 A	43.63 A	45.33 B
Hemicellulose	31.80 A	31.97 A	32.01 A	31.76 A	31.76 A	32.00 A
Hemicellulose/Cell Walls	40.94 A	42.72 B	42.00 A	41.67 A	42.23 A	41.44 B
Lignin	7.05 A	6.24 B	6.51 A	6.78 B	6.36 A	6.93 B
Cellulose	34.77 A	32.56 B	33.77 A	33.56 A	33.13 A	34.20 B
Cellulose/Acid Deterg. Fiber	75.86 A	76.04 A	76.41 A	75.50 B	76.25 A	75.65 A

[1]Values under the same major heading followed by the same letter are not significantly different at the .05 level.

All values are pooled across months.

Table 3. Proximate Analysis of Big and Little Bluestem Grass at Monthly Intervals, May - November, 1972, as Influenced by Range Burning, Nitrogen Fertilization, and Species Difference.

TREATMENT[2]	MAY[1]	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER
			DRY MATTER				
Not Burned	---	30.44 B[3]	31.77 BC	---	40.88 E	43.17 EF	79.57 H
Burned	22.50	24.35 A	34.07 CD	---	34.59 D	43.89 F	70.41 G
Big Bluestem	22.50	27.47 A	31.48 B	---	37.45 D	41.72 E	80.41 H
Little Bluestem	---	27.33 A	34.35 C	---	38.02 D	45.34 F	69.57 G
			ETHER EXTRACT				
Not Burned	---	2.43 D-F	2.20 CD	1.84 A	1.93 AB	2.28 CD	1.77 A
Burned	2.86	2.65 FG	2.60 FG	2.08 BC	2.25 CD	2.41 DE	2.70 G
Not Fertilized	2.86	2.79 D	2.51 C	1.94 A	1.93 A	2.26 B	2.20 B
Fertilized	---	2.29 BC	2.28 BC	1.98 A	2.25 B	2.43 BC	2.27 B
Big Bluestem	2.86	2.50 E-G	2.44 E-G	1.85 A	1.89 AB	2.15 CD	2.14 CD
Little Bluestem	---	2.58 G	2.36 D-G	2.08 BC	2.29 C-E	2.54 FG	2.33 D-F
			PROTEIN				
Not Burned	---	9.47 D	5.95 C	4.62 B	4.33 B	4.43 B	2.99 A
Burned	17.74	13.76 E	5.98 C	4.31 B	4.30 B	4.00 B	2.79 A
			CRUDE FIBER				
Not Burned	---	32.62 DE	34.47 G	32.22 D	34.50 G	33.90 FG	36.52 H
Burned	25.92	28.33 A	31.16 C	29.36 B	33.47 EF	32.83 DE	33.28 EF
			NITROGEN FREE EXTRACT				
Not Burned	---	48.10 B	49.51 C	55.02 F	51.29 DE	51.07 D	51.07 D
Burned	43.31	46.84 A	52.05 DE	57.74 G	52.81 E	53.00 E	52.44 E
Not Fertilized	43.31	47.75 A	52.33 DE	56.59 F	53.08 E	52.17 C-E	52.44 DE
Fertilized	---	47.19 A	49.23 B	56.17 F	51.65 CD	51.90 C-D	51.07 C
			ASH				
Not Burned	---	7.38 C	7.87 CD	6.29 A	7.32 C	8.32 DE	7.65 CD
Burned	10.17	8.41 DE	8.20 DE	6.50 AB	7.17 BC	7.76 CD	8.78 E
Not Fertilized	10.17	7.35 B-D	6.77 AB	6.29 A	6.92 A-C	8.02 D-F	7.78 DE
Fertilized	---	8.44 EF	9.30 G	6.51 A	7.57 CD	8.06 D-F	8.65 EF

[1] May values were not statistically analyzed.

[2] Big and little bluestem values were pooled in the burning and fertilization treatments.

[3] Values within the same treatment followed by the same letter are not significantly different at (P .05).

Means reported in percentages on a dry matter basis.

Table 4. Van Soest Analysis of Big and Little Bluestem Grass at Monthly Intervals, June - November, 1972, as Influenced by Range Burning, Nitrogen Fertilization, and Species Differences.

TREATMENT[1]	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER
			CELL WALLS			
Not Burned	75.76 BC[2]	76.19 C	78.22 D	78.35 D	77.21 CD	80.71 E
Burned	69.31 A	74.57 B	74.28 B	77.20 CD	76.77 CD	77.79 D
Big Bluestem	72.01 A	74.46 C	75.11 CD	76.20 DE	75.31 CD	79.24 C
Little Bluestem	73.06 B	76.30 DE	77.39 EF	79.34 G	78.67 FG	79.26 G
			ACID DETERGENT FIBER			
Not Burned	42.38 D	44.21 E	44.02 E	46.06 G	46.43 G	52.54 I
Burned	37.60 A	40.18 B	40.61 C	45.60 FG	44.69 EF	49.42 H
Big Bluestem	38.97 A	41.17 B	41.11 B	44.60 D	44.75 D	51.17 F
Little Bluestem	41.02 B	43.22 C	43.52 CD	47.06 E	46.38 E	50.79 F
			HEMICELLULOSE			
Not Burned	33.38 C-E	31.98 BC	34.20 E	32.29 B-D	30.78 B	28.16 A
Burned	31.71 B	34.39 E	33.66 DE	31.59 B	32.08 BC	28.37 A
Not Fertilized	33.08 E	32.44 DE	34.35 G	32.17 D	31.16 C	28.85 B
Fertilized	32.01 CD	33.92 G	33.51 F	31.72 CD	31.70 CD	27.68 A
			HEMICELLULOSE PER CELL WALLS			
Not Burned	44.06 EF	41.95 D	43.72 E	41.18 CD	39.84 C	34.90 A
Burned	45.73 G	46.09 G	45.34 FG	40.93 CD	41.78 D	36.46 B
			LIGNIN			
Not Burned	5.48 B	6.10 B	7.37 CD	7.46 CD	6.86 C	9.01 E
Burned	3.84 A	5.68 B	5.84 B	7.18 C	6.97 C	7.97 D
Not Fertilized	4.89 B	5.46 C	6.46 DE	6.97 F	6.96 F	8.31 H
Fertilized	4.41 A	6.29 D	6.75 EF	7.67 G	6.87 F	8.66 H
Big Bluestem	4.69 A	5.54 B	6.05 BC	6.78 DE	6.57 C-E	8.50 G
Little Bluestem	4.62 A	6.21 B-D	7.16 EF	7.86 FG	7.26 EF	8.48 G
			CELLULOSE			
Not Burned	34.02 C-E	35.01 E	33.41 CD	34.53 DE	33.85 C-E	37.80 F
Burned	30.54 A	31.73 B	31.20 AB	33.97 C-E	33.16 C	34.76 E

[1]Big and little bluestem values were pooled in the burning and fertilization treatments.

[2]Values within the same treatment followed by the same letter are not significantly different at (P .05).

Means reported on dry matter basis.

Table 5. Effects of Range Burning on Big and Little Bluestem.

	Big Bluestem	Little Bluestem
	Ether Extract	
Not Burned	2.05 A[1]	2.10 A
Burned	2.28 B	2.62 C
	Protein	
Not Burned	5.54 A	5.06 B
Burned	5.78 A	5.94 A
	Nitrogen Free Extract	
Not Burned	51.24 AB	50.99 B
Burned	53.28 C	51.68 A
	Ash	
Not Burned	7.60 AB	7.34 B
Burned	7.66 AB	7.95 A
	Cell Walls	
Not Burned	76.38 A	79.10 B
Burned	74.40 C	75.57 A
	Hemicellulose	
Not Burned	31.18 B	32.41 A
Burned	32.33 A	31.60 AB
	Hemicellulose per Cell Walls	
Not Burned	40.87 A	41.01 A
Burned	43.59 B	41.86 C

[1]Values under each major heading followed by the same letter are not significantly different (P .05).

Means reported in percentages on a. dry matter basis.

Table 6. Effects of Range Burning and Nitrogen Fertilization on Big and Little Bluestem.

	Not Fertilized	Fertilized
	Protein	
Not Burned	5.41 BC[1]	5.19 C
Burned	5.73 AB	5.98 A
	Ash	
Not Burned	6.84 B	8.10 A
Burned	7.54 C	8.08 A
	Cell Walls	
Not Burned	77.98 A	77.50 A
Burned	74.72 B	75.25 B
	Lignin	
Not Burned	7.13 A	6.97 AB
Burned	5.89 C	6.59 B

[1]Values under each major heading followed by the same letter are not significantly different (P .05).

Means reported in percentages on a dry matter basis.

Table 7.
Ash (%) of Big and Little Bluestem Grass as Influenced by Fertilization.

	Not Fertilized	Fertilized
Big Bluestem	7.03 A[1]	8.24 B
Little Bluestem	7.35 A	7.94 B

[1]Values followed by the same letter are not significantly different (P .05).
Means reported on dry matter basis

Table 8. Probabilities of a greater value for chemical components as influenced by main treatments and two-way interactions.

	D.M.[1]	E.E.[2]	Prot.[3]	NFE[4]	C.F.[5]	Ash[6]	C.W.[7]	ADF[8]	Hemi.[9]	H/CW[10]	Lig.[11]	L/ADF[12]	Cell[13]	C/ADF[14]
Month	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
Burned	.01	.01	.01	.01	.01	.03	.01	.01	.55	.01	.01	.01	.01	.65
Nitrogen	.11	.60	.92	.01	.09	.01	.93	.27	.38	.27	.05	.07	.39	.02
Species	.18	.01	.24	.01	.01	.01	.01	.39	.01	.01	.01	.01	.01	.30
M[15] x B[16]	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.25
M x N[17]	.91	.01	.20	.01	.40	.01	.23	.24	.05	.07	.06	.02	.91	.23
M x S[18]	.01	.03	.89	.55	.14	.96	.02	.02	.12	.06	.04	.11	.23	.48
B x N	.93	.51	.10	.38	.76	.02	.10	.77	.05	.11	.01	.01	.19	.16
B x S	.12	.01	.03	.01	.71	.06	.01	.41	.01	.01	.37	.37	.64	.64
N x S	.53	.49	.39	.83	.33	.04	.15	.62	.27	.53	.18	.21	.57	.79

[1]Dry Matter
[2]Ether Extract
[3]Protein
[4]Nitrogen Free Extract
[5]Crude Fiber
[6]Ash
[7]Cell Wall
[8]Acid Detergent Fiber
[9]Hemicellulose
[10]Hemicellulose per Cell Walls
[11]Lignin
[12]Lignin per Acid Detergent Fiber
[13]Cellulose
[14]Cellulose per Acid Detergent Fiber
[15]Month
[16]Burning Treatment
[17]Nitrogen Treatment
[18]Grass Species

EFFECTS OF RANGE BURNING AND NITROGEN FERTILIZATION ON THE NUTRITIVE VALUE OF BLUESTEM GRASS

by

LELAND JAMES ALLEN

B.S., Kansas State University, 1969

AN ABSTRACT OF A MASTER'S THESIS

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This research determined the effects of annual late spring burning and nitrogen fertilization, separately and collectively, on the nutritive value of big and little bluestem grass (Andropogon gerardi Vitman and A. scoparius Michx.) in the True Prairie region of Kansas. Four native, bluestem pastures were used. Each received one of the following treatments:

Range Burning: April 28 with a light northern breeze.

Fertilization: Urea, aerially applied May 17 at 18.14 kg (40 lb) nitrogen per acre.

Burning and Fertilization: Combination of the individual treatments.

Control: No burning or fertilization.

Grass samples were clipped at monthly intervals from within exclosures located on ordinary upland range sites in each pasture, placed in plastic bags and stored frozen. Before complete Proximate and Van Soest analyses, they were dried overnight at 90° C in a forced air oven and ground in a Wiley mill through a 1 mm screen.

Late spring burning decreased the percent dry matter, crude fiber, cell walls, acid detergent fiber, cellulose, lignin, and increased protein, ether extract, nitrogen free extract, ash, and hemicellulose when compared to non-burning. Nitrogen fertilization decreased percent nitrogen free extract, and cellulose content of cell walls, and increased ash and lignin when compared to no fertilization. Big bluestem was higher than little bluestem in protein, nitrogen free extract, and lower in crude fiber, cell walls, acid detergent fiber, lignin, and cellulose.