EFFECT OF NITROGEN FERTILIZATION AND LATE SPRING BURNING ON DIET AND PERFORMANCE OF YEARLING STEERS GRAZING NATIVE BLUESTEM RANGE

by

JOHN S. WOOLFOLK

B. S., University of Tennessee at Martin, 1971

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Science and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

Approved by:

Ed F. Smith

Major Professor

ILLEGIBLE

THE FOLLOWING DOCUMENT (S) IS ILLEGIBLE DUE TO THE PRINTING ON THE ORIGINAL BEING CUT OFF

ILLEGIBLE

ACKNOWLEDGMENTS

The author wishes to extend sincere thanks and gratitude to his major professor, Dr. Ed. F. Smith for his help in the preparation of this thesis. His guidance, patience, and understanding throughout the duration of the project are deeply appreciated.

Gratitude is also expressed to Dr. Robert Schalles and Dr. Clenton Owensby for their assistance and advice while serving as members of the supervisory committee. Special thanks are extended to Dr. Jack Riley and Dr. Miles McKee for their help in securing and supplying the animals which made this project possible.

I wish to also thank the faculty, staff, and fellow graduate students for their many courtesies which helped make my graduate studies at Kansas State a more enjoyable experience.

To my wife, Pat, I would like to express my deepest appreciation and love for her understanding, encouragement, and assistance throughout my graduate program.

I wish to dedicate this thesis to my parents, Mr. and Mrs. W. W. Woolfolk, as an expression of appreciation for their continuous encouragement and support throughout my academic career.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

THIS BOOK CONTAINS NUMEROUS PAGES WITH THE ORIGINAL PRINTING BEING SKEWED DIFFERENTLY FROM THE TOP OF THE PAGE TO THE BOTTOM.

THIS IS AS RECEIVED FROM THE CUSTOMER.

INTRODUCTION

With an increasing urban population daily engulfing more agricultural land, that which remains in production is under greater pressure to meet ever rising requirements for food and fiber. Fertilizers, herbicides, improved plant varieties, insecticides, and better management have contributed to a tremendous improvement in yields of grains, vegetables, and other field crops. Improved management practices combined with more efficient cattle have produced similar improvement from native prairie, but more research is necessary to study possible ways of further increasing present yield barriers.

Nitrogen applications have contributed greatly to increased yields of many crops, including some grasses. If supplemental nitrogen could be used to improve forage yields on native bluestem range, beef production potential would increase due to a greater carrying capacity of the land. Plot studies have shown that weeds and undesirable cool-season grasses respond more rapidly to additional nitrogen than do native warm-season grasses. However, annual late spring burning has significantly reduced weed production during previous trials on bluestem range.

Cattle with esophageal fistulas and fecal collection bags were used to evaluate effects of late spring burning and nitrogen fertilization alone and in combination on diet, dry matter intake, and weight gains.

PART ONE. REVIEW OF LITERATURE

A. Nitrogen Fertilization of Native Range

Interest in the possibilities of increasing annual type range production by fertilization was first shown by researchers and ranchers in the early 1940's. Bentley (1946), working at the San Joaquin Experimental Range near Fresno, California, found an increased herbage production when pit-run gypsum was applied to annual range. In these trials the first response to fertilizers was shown by native clovers and other leguminous plants. Increased vigor and herbage growth in these species apparently added significantly to soil nitrogen through natural assimilation which stimulated grass and non-leguminous herbs to greater growth in the second year after fertilization. Bentley, Green and Wagnon (1958) showed the beneficial effects of supplemental gypsum carried over through three growing seasons. Similar results (Bowns, 1972) have shown the effects of one application of 60 lb of nitrogen per acre of annual range may be carried over for two growing seasons for production and one season for crude protein.

Soil type, soil fertility, annual precipitation, air temperatures and vegetation affect nitrogen fertilizer performance. Kilcher (1958) showed favorable rainfall in May was an important requirement for the successful and economical use of fertilizer on southern Saskatchewan Canada range. Hoagland _et al_. (1952) reported low fertility limited forage production more than rainfall, or at least total rainfall did not vary enough among years to offset the beneficial effect of fertilizer on annual range in California. Retzer (1954) reported an increased growth rate of native plants growing on fertilized Colorado soils derived from granitic rocks when compared to similar vegetation on soils of different origins.

Rogler and Lorenz (1957) reported a shift in botanical composition on northern Great Plains rangeland after applications of nitrogen. Klipple and Retzer (1959) also indicated an increase in annual production of forbs on central Great Plains fertilized range. Similar results were obtained in the Central Cross Timbers Section of Oklahoma by Huffine and Elder (1960) when they reported weed production 2 to 5 times greater on nitrogen-fertilized pastures than on nonfertilized native pastures. Plots fertilized with 33 lb N/A had 858 lb/A weeds while nonfertilized range had only 363 lb/A. Weeds which were largely responsible for such a large increase were annual plantain (Plantago spp. L.), and western ragweed (Ambrosia psilostachya DC.). Big bluestem (Andropogon gerardi Vitman), little bluestem (A. scoparius Michx.), switchgrass (Panicum virgatum L.), Indiangrass (Sorghastrums nutans (L.) Nash), sideoats grama (Bouteloua curtipendula (Michx.) Torr.) and blue grama (B. gracilis (H.B.K.) Lag. ex Steud) did not respond as much as the weeds. Goetz (1969) applied 67 and 100 lb N/A to Northern Great Plains range and significantly increased total production on plots representing four different soil types (Vebar (sandy), Havre silt loam (loamy), Rhodes silt loam (panspots) and Manning silt loam (shallow)). That increase was much greater than the increase of grasses due to the increase in the forb component, mainly the sages, a species largely non-palatable to livestock. Owensby et al. (1970) reported that applications of 50 lb N/A on Kansas Flint Hills bluestem range resulted in an increase in the percentage of cool-season species particularly Kentucky bluegrass (Poa pratensis L.). Drawe and Box (1969) using various rates of nitrogen on coastal prairie bunchgrass-annual forb range showed no significant change in species composition of the flora receiving 300 lb or less nitrogen per acre. Applications of 600 and 900 lb per acre produced 300 to 400 lb additional grass per acre during the first season. After two years of fertilization grass yields from the 600 and 900 lb rates were only 1291 and 1262 lb/A, respectively, while 1711 lb/A was produced on the control. Forb production after two years was 535 lb/A on the control, 604 lb/A on the 600 lb treatment, and 963 lb/A at the 900 rate.

Graves and McMurphy (1969) reported increased forage production with both 40 and 80 lb N/A on poor condition central Oklahoma range with an average annual precipitation of 32 inches. The most important aspect of their study was the forage yield per pound of applied nitrogen. In 1966 the 40 and 80 lb levels produced 44 and 36 lb of forage respectively, per pound of nitrogen applied. In 1967, this was even better with 50 and 47 lb of forage produced for each pound of nitrogen applied. Four consecutive years of studies on bluestem range by Owensby et al. (1970) showed annual yields increased from 0.99 T/acre on nonfertilized plots to 1.88 T/acre on plots receiving 50 lb/A supplemental nitrogen. Rogler et al. (1957) also reported an increase in forage yields from Northern Great Plains rangeland fertilized with 30 and 90 lb N/A. Average forage yields over a six year period on heavily grazed range were 748 lb/A for the control, 1326 lb/A on the 30 lb/A treatment and 2271 lb/A on the 90 lb treatment. Yields from heavily grazed range were greater than those from moderately grazed areas under similar fertilization treatments. When 50 and 100 lb N/A were applied to Osage range in Oklahoma no significant improvements were measured in forage yields (Gay and Dwyer, 1965). However, when these fertilization rates were used in combination with burning, yields increased 45% and 13.9% for the 50 and 100 lb/A rates, respectively, above the 3088 lb/A yield of the control.

One of the most important aspects of supplemental nitrogen has been a reported increased protein level of the forage. Dee and Box (1967) working on the Southern Mixed Prairie in Texas found an increased crude protein level every month (September to March) in four mixed prairie grasses (blue grama, buffalograss (Buchloe dactyloides Nutt. Engelm.), windmill grass (Chloris verticillata Nutt.) and silver bluestem (Andropogon saccharoides Swartz)) which were treated with 33, 100 and 300 lb N/A. Their study showed the loss of protein content during the winter months was at an equal rate for all treatments, but due to higher levels initially, fertilized grasses remained higher in protein than control treatments when sampling was terminated in March. Owensby (1969) indicated that the effect of supplemental nitrogen on protein content of native forage in the True Prairie was somewhat dependent upon soil moisture. During the first and last year of a four year study, protein content of big bluestem clipped July 15 from fertilized plots exceeded that in nonfertilized plots. However, during the second growing season a drought reduced forage growth and the nitrogen present in the soil was not mobilized, thus no increase in protein content of the forage resulted from the fertilization. Drawe et al. (1969) found the 13.75% protein content of bunchgrasses produced under 300 lb N/A was a significant increase over the 8.12% of control forage, and 100 lb N/A produced forage with 9.38% protein while 600 and 900 lb N/A produced no increase in protein levels of sampled forage when compared to the 300 lb N/A rate. Nelson et al. (1972) applied 40 lb N/A to blue grama range in New Mexico and increased crude protein in harvested hays to 8.8%, an increase of 1.7% over controls. They also reported an increase in in vitro dry matter digestibility and decreases in ash, acid-detergent fiber and silica due to nitrogen fertilization.

Another advantage which may be realized from range fertilization is a more efficient use of available water, however, total water requirement increases also. Owensby (1969) reported increases as great as 56 lb dry matter for each inch of available water from plots which had received 50 lb N/A when compared to nonfertilized plots. The difference between fertilized plots and control plots was substantially less following a dry year due to nitrogen carried over from the previous year. Greater root exploration of the soil mass, stimulated by added nitrogen, may account for a large part of the increased water-use efficiency (McKell et al., 1962). Lorenz and Rogler (1966) in the Northern Great Plains found increased root weight with nitrogen application on native range. They hypothesized that increased root exploration enhanced both water-use efficiency and nitrogen recovery.

Research primarily concerned with proper management of fertilized ranges or the correlation of such areas with unfertilized ranges in terms of a yearlong practical range-livestock operation was started in 1958 in California and reported by Woolfolk (1962). Conclusions drawn were that range herbage production, grazing use and weight gains of grazing animals could be effectively increased on California annual-type range by fertilization with nitrogen containing compounds. Blaser (1964) studied animal response to nitrogen fertilization of native pastures in Great Britain and showed that increases in the quantity of nitrogen applied, above a level of 50-100 kg/ha, generally result in greater output per hectare, because of the greater number of animals carried per unit area. However, high levels of application usually had little effect on the performance of individual animals. Similar animal performance was reported by Stephens and Marchant (1959) using steers grazing fertilized coastal bermuda in Georgia. They found no differences in average daily gains but gains per acre increased from 261 lb/A (50 lb N/A) to 449 lb/A (100 lb N/A) to an even greater 668 lb/A where 200 lb of nitrogen was applied per acre. Holmes and Lang (1965) hypothesized that responses of this type may be partially explained by a probable increase in digestibility of dry matter ingested on range fertilized with high rates of nitrogen. During their studies, although digestibility of high-nitrogen herbage was higher, intake of dry matter averaged 1.97 lb per 100 lb of live-weight with both fertilizer rates (150 or 40 lb N/A).

According to Rogler (1972), in general, the benefits of range fertilization outweigh the disadvantages in most areas. Benefits of added nitrogen which he listed are increased forage and livestock production, increased palatability, better livestock distribution, higher quality forage, increased root growth, greater water-use efficiency, greater use of solar energy and improvement in range condition when nitrogen fertilization is used with other improved management practices.

Rogler (1972) expressed disadvantages of range fertilization such as, problems of more intensive management, increased weed growth and other undesirable changes in the vegetation, possible ground water pollution and the remote possibility of metabolic disorders of livestock.

B. Burning of Native Range

Throughout the existence of our native rangelands, natural fires, caused chiefly by lightning, have continually swept the plains. Indians which inhabited this area for many years used fire as a tool in their continuous search for game. Not only did Indians start fires to force herds of animals off cliffs, but they were the first to realize that grazing animals were attracted to areas which had been burned making hunting easier (Komarek, 1966).

Burning studies were begun on Flint Hills range in 1918 (Hensel, 1923). Conclusions from these studies were that burning had no effect on forage production. Throughout the trials both maximum and minimum average soil temperatures were higher for the season on burned than on unburned plots. Aldous (1934) found a similar increase in soil temperature due to spring burning. In contrast to Hensel (1923), Aldous reported that burning decreased the total forage produced during a growing season.

Herbage yields on Georgia pine-wiregrass range protected from fire decreased 295 lb/A for four years (Lewis and Hart, 1972). Reintroduction of fire to these protected areas significantly increased forage yields by 320 lb/A during the first growing season. Burning has also increased yields of big and little bluestem and Indiangrass on True Prairie range in Iowa (Kucera et al., 1962).

Dodd and Holtz (1972) conducted their studies on prairie similar to the Rio Grande Plain Resource Area in southern Texas. Oven-dry grass yields from untreated areas were 370 lb/A. Grass production following mechanical treatment alone was 890 lb/A or 2.4 times greater than from the untreated area. On the mechanically treated and burned areas grass production averaged from 1640 to 1745 lb/A.

Owensby and Anderson (1967) found no difference between the 3529 lb/A air-dry forage produced on loamy upland range sites burned in late spring and the 3919 lb/A produced on similar range sites which were not burned. Weed production was significantly lower (139 lb/A) on the burned range than on similar sites on unburned areas. A 30-year study of Flint Hills burning (Anderson, 1965) showed a reduction in yields on ungrazed range regardless of the date of burning with the greatest reductions being caused by the earliest burning treatments.

An increase of over 2000 lb/A of oven-dry forage was reported by Owensby et al. (1970) due to a May 1st burning of Kaw big bluestem plots. Increases in yield in this study may have been due to the removal of excessive mulch, since Dix (1960) and Weaver and Rowland (1952) labeled excessive mulch as a yield supressor. Another possible explanation for this increase could be that big bluestem yields do increase under burning but other species respond differently and the total yield of mixed stands may decrease.

Launchbaugh (1964) reported yields of buffalograss, blue grama, and western wheatgrass (Agropyron smithii Rydb.) following a wildfire were 65% below the 3600 lb/A yield of an adjacent nonburned pasture. During the following year yields were reduced 39% by the previous year's fire. No differences in yields were present during the third growing season.

Hopkins et al. (1948) found yield reductions of little bluestem stands when burned on range receiving less than 25 inches of annual precipitation. One explanation which has been offered for yield reductions due to burning is a decreased infiltration rate that restricts the amount of soil moisture (McMurphy and Anderson, 1965; Hanks and Anderson, 1957).

Two major factors which result in the widespread use of range burning as a management tool are weed control and increased cattle gains. Burning in late spring has been successfully used in reducing weed yields (Owensby et al., 1967). Kentucky bluegrass (Poa pratensis L.) and other cool-season grasses have also been controlled by late spring burning. McMurphy and Anderson (1965) reported satisfactory control of Japanese brome (Bromus japonicus Thunb.) and buckbrush (Symphoricarpos orbiculatus Moench) due to late spring burning of True Prairie.

Ehrenreich (1959) reported repeated burning about the first of March resulted in a sharp decrease in number of Kentucky bluegrass plants. That reduction was probably caused by heat injury to this introduced grass which normally begins growth very early in the spring unlike native grasses which remain dormant until late spring.

Spring burning favors the desirable warm-season grasses such as big and little bluestem, Indiangrass and switchgrass and as a result some weedy species also benefit from the fire (Anderson et al. 1970). McMurphy et al. (1965) found that smooth sumac (Rhus globra L.) populations were significantly increased under annual late spring burning.

Smith et al. (1965) reported from a 15 year study the average beef gains on mid and late spring burned pastures to be 20 and 23 lb/steer higher than gains on an adjacent unburned pasture. This increased gain may be partially explained by an increased protein content of little bluestem in burned pastures when compared to nonburned pastures (Smith and Young, 1959 and Allen, 1973) and an increased apparent dry matter digestibility and crude fiber digestibility (Smith et al., 1960).

Another potential for controlled range burning is in combination with other management practices. Dodd et al. (1972) integrated burning with mechanical manipulation on south Texas grassland and doubled total herbage production while grass production was increasing 5 fold. Gay et al. (1965) studying burning and nitrogen fertilization on the Oklahoma Osage range found no increase in production levels due to burning alone. Yields achieved by combining burning and 100 lb N/A increased yield 54% above the 3197 lb/A of nonburned treatment which was fertilized with 100 lb N/A.

C. Intake and Digestibility of Forage by Grazing Animals

One of the major problems which has prevented accurate evaluation of the performance of range animals, has been obtaining a sample of forage which is representative of the grazing animals' diet. Torell (1954) introduced a successful procedure for surgically fitting animals with an esophageal fistula. Since the introduction of the esophageal fistula, many studies have been conducted to measure the effects of saliva and chewing on the chemical composition of ingested materials. Bath et al. (1956) found little difference in chemical composition of forage due to the process of passing through the mouth and out an esophageal fistula. Other research has failed to confirm Bath's report as various differences have been found. One of the most commonly reported effects on nutritive content is an increase in the percent ash (Wallace and Denham, 1970; Campbell et al., 1968; Hoehne et al., 1967; Blackstone et al., 1965; and Van Dyne and Lofgreen, 1964).

Even though experiments by Van Dyne et al. (1964) indicated that the increased ash content from salivary contamination has no significant influence on the estimation of digestion coefficients, most researchers agree that chemical components of the diet should be reported on an ash-free basis. Acid-detergent fiber and acid insoluble lignin have also been found at higher levels in esophageal fistula samples than in control samples (Barth et al., 1970; Kiesling et al., 1969; and Lesperance et al., 1960).

Nonsignificant changes have been noted in crude protein (Barth and Kazzal, 1971; Lesperance and Bohman, 1964; Bath et al., 1956). Campbell et al. (1968) did find an increase in protein content of fistula samples when feeding steers clipped native grass. Their conclusions, however, were that the protein increase was probably due either to incomplete sample recovery or selective grazing. Barth et al. (1971) suggested that a nitrogen loss due to leaching by saliva is highly unlikely since plant proteins are so tightly bound up that they are virtually insoluble. Effects of salivary nitrogen contamination and nitrogen leaching are approximately equal, resulting in no change in crude protein content of fistula samples. McManus (1960) demonstrated by in vitro studies there is no significant leaching of nitrogen from succulent or roughage plant material.

Total fructose and water soluble carbohydrates have been shown to be lower in esophageal samples than in clipped samples (Hoehne et al., 1967). They suggested the leaching of soluble carbohydrates by saliva passing through the screen bottom of the collection bag accounted for much of the loss. Also, it is possible that some change, possibly digestion by bacteria, of the soluble carbohydrates occurred during drying of samples contaminated with saliva. Tests by Lesperance and Bohman (1964) have indicated the amount of saliva varies with the type and quantity of forage consumed. The composition of saliva and the amount secreted is adequate to account for the mineral contamination of fistula samples (Lesperance and Bohman, 1964).

Sample preparation after collection can have greater effects on the carbohydrate and lignin fractions than fistula collection. Immature high protein grasses are particularly sensitive to heat drying, thus Van Soest (1964) recommended $50^{\circ}C$ as a maximum temperature for drying samples that are to be used in lignin determinations. Smith et al. (1967) found that the lignin content of ruminal fistula samples and fecal samples was 53.2% and 28.8% greater, respectively, when dried at $60^{\circ}C$ than when freeze dried.

One area of concern in the use of fistula samples is the portion of forage ingested which is collected as the sample. Reported values range from 67% (Barth et al., 1971) to 100% (Alder, 1969). Alder determined that the recovery percentage is directly related to the digestibility of the herbage. He also found that apparently the quantity of herbage intake is not altered by the presence of esophageal fistulas.

A system of estimating forage digestibilities through analysis of esophageal samples was proposed by Goering and Van Soest (1970). This system utilizes a summative digestibility equation:

$$\% \text{ digestible dry matter} = 0.98S + WD_c - M$$

where: S = cellular contents of an average digestibility of 98%;

W = the percent cell-wall contents;

D_c = the estimated digestion coefficient of the cell walls;

M = estimated metabolic fecal losses.

Metabolic fecal losses for cattle are calculated using the following regression equation:

$$M = 36.57 - 0.275X$$

where: X = estimated true digestibility of diet.

Digestibility of cell walls is variable and depends on lignification, silification, and other factors. Lignin is expressed as a percentage of acid-detergent fiber. Cell wall digestibility (D_c) can be estimated by the following equation when lignin is determined by the permanganate method (Van Soest and Wine, 1968):

$$D_c = 180.8 - 96.6 \log_{10} [(\text{Lignin/acid detergent fiber})\ 100].$$

A high correlation between dry matter digestibility predicted with the summative equation and digestibility coefficients obtained in conventional trials led Colburn _et al._ (1968) to conclude that the summative equation produced valid results.

Smith _et al._ (1971) found a correlation coefficient of +.77 between cell soluble content of dry matter and rate of cell wall digestion, theorizing that with a higher percentage of cell solubles, less development of the cell wall might allow bacteria greater access for digestion. _In vitro_ organic matter digestibility was reported by Smith _et al._ (1971) to decrease 1.09% for each 1.0% increase in cell wall contents of the forage and decrease 2.74% for each 1.0% increase in acid detergent lignin.

Although digestibility of the diet affects voluntary intake, Hodgson (1968) suggested that the physical distension of the gut was still the most important factor controlling herbage intake of calves even when the diet was 80-85% digestible. In trials conducted over a range of digestibilities, he found a consistent increase in herbage organic matter intake while fecal organic matter output did not change significantly. Further work by Hodgson and Wilkinson (1968) indicated that the digestibility of the diet selected was more important than the amount of herbage available per unit area in determining the quantity of herbage eaten by cattle. Intake was considered by Smith et al. (1972) to be more important in limiting productivity than digestibility, but both are interrelated to total digestible intake. Vavra et al. (1973) explained decreased animal performance on pastures grazed at heavy intensity by both a decreased forage intake which could be related to limited available forage as compared to pastures being grazed at light intensities and lower dry matter digestibility.

Forage intake varies highly from one animal to another even when the animals are grazing in the same pasture (Streeter, 1966). Lambourne and Reardon (1963) suggested 23% as the standard error of an estimate of the intake of a single animal predicted from a general regression equation. Intake studies on winter-range forage produced average intake levels of 51 g per kg body weight 0.75 which was only 50-70% of intake levels recommended by the National Research Council. Blaxter, Wainman and Davidson (1966) found similar intake levels of 57 g per kg body weight 0.75. Intake levels lower than National Research Council recommendations were also reported by Elliot (1967) when cattle were consuming low quality roughage.

Most dry matter intake prediction equations require determination of total fecal output by the feeding animal. Connor et al. (1963) reported that fecal collections were essentially the same, whether determined by grab samples using chromic oxide or with total collections.

Collection apparatus used for total fecal collections has no effect on coefficients of digestibility or daily intake of grazing cattle (Phar *et al.*, 1971).

LITERATURE CITED

Alder, F. E. 1969. The use of cattle with esophageal fistual in grassland experiments. J. Brit. Soc. 24:6-13.

Aldous, A. E. 1934. Effect of burning on Kansas bluestem pastures. Kans. Agr. Exp. Sta. Tech. Bull. 38.

Allen, L. J. 1973. Effects of range burning and nitrogen fertilization on the nutritive value of bluestem grass. Thesis. Kansas State Univ., Manhattan.

Anderson, K. L. 1951. The effects of grazing management and site conditions on Flint Hills bluestem range in Kansas. Thesis. Univ. of Nebr., Lincoln.

Anderson, Kling L. 1965. Time of burning as it affects soil moisture in an ordinary upland bluestem prairie in the Flint Hills. J. Range Manage. 18:311-316.

Anderson, K. L. and C. L. Fly. 1955. Vegetation-soil relationships in Flint Hills bluestem pastures. J. Range Manage. 8:163.

Anderson, Kling L., Ed F. Smith, and Clenton E. Owensby. 1970. Burning bluestem range. J. Range Manage. 23:81-92.

A.O.A.C. 1970. (11th Edition). Official methods of analysis. Association Official Agricultural Chemists. Washington, D. C.

Arnold, G. E. 1960. Selective grazing by sheep and two forage species at different stages of growth. Australian J. Agr. Res. 2:1027.

Barth, Karl M. and Najeeb T. Kazzal. 1971. Separation of true selective grazing by cattle from effects of esophageal fistula. J. Anim. Sci. 33:1124-1127.

Barth K. M., J. E. Chandler, M. E. Fryer and H. C. Wang. 1970. Effect of saliva and drying temperature on composition and digestibility of samples collected through esophageal fistulas. J. Anim. Sci. 31:794.

Bath, D. L., W. C. Weir and D. T. Torell. 1956. The use of esophageal fistula for the determination of consumption and digestibility of pasture forage by sheep. J. Anim. Sci. 15:1166.

Bentley, J. R. 1946. Range fertilization--one means of improving range forage. Calif. Cattleman.

Bentley, J. R., L. R. Green and K. A. Wagnon. 1958. Herbage production and grazing capacity on annual-plant range pastures fertilized with sulfur. J. Range Manage. 11:133.

Blackstone, J. B., R. W. Rice and W. M. Johnson. 1965. A study of the esophageal fistula sampling technique. West. Sect. Amer. Soc. Anim. Sci. Proc. 16:IXXV-1.

Blaser, R. E. 1964. Symposium on forage utilization: Effects of fertility levels and stage of maturity on forage nutritive value. J. Anim. Sci. 23:1.

Blaxter, K. L., F. W. Wainman and J. L. Davidson. 1966. The voluntary intake of food by sheep and cattle in relation to their energy requirements for maintenance. Anim. Prod. 8:75.

Bowns, James E. 1972. Low level nitrogen and phosphorus fertilization on high elevation ranges. J. Range Manage. 25:273-275.

Colburn, M. W., J. N. Evans and C. H. Ramage. 1968. Apparent and true digestibility of forage nutrients by ruminant animals. J. Dairy Sci. 51:1450-1455.

Connor, J. M., V. R. Bohman, A. L. Lesperance and F. E. Kinsinger. 1963. Nutritive evaluation of summer range forage with cattle. J. Anim. Sci. 22:961.

Crampton, E. W. and L. E. Harris. 1969. Applied animal nutrition (2nd Edition). W. H. Freeman and Company, San Francisco.

Dee, Richard F. and Thadis W. Box. 1967. Commercial fertilizers influence crude protein content of four mixed prairie grasses. J. Range Manage. 20:96-99.

Dodd, J. D. and S. T. Holtz. 1972. Integration of burning with mechanical manipulation of south Texas grassland. J. Range Manage. 25:130.

Drawe, D. Lynn and Thadis W. Box. 1969. High rates of nitrogen fertilization influence coastal prairie range. J. Range Manage. 22:32-36.

Ehrenreich, John H. 1959. Effect of burning and clipping on growth of native prairie in Iowa. J. Range Manage. 12:133-137.

Elliot, R. C. 1967. Voluntary intake of low protein diets by ruminants. I. Intake of food by cattle. J. Agr. Sci. Camb. 69:383.

Gay, Charles W. and Don D. Dwyer. 1965. Effects of one year's nitrogen fertilization on native vegetation under clipping and burning. J. Range Manage. 18:273-277.

Goering, H. K. and P. J. Van Soest. 1970. Forage fiber analysis. U.S.D.A. Agr. Sci. Handbook No. 379.

Goetz, Harold. 1969. Composition and yield of native grassland sites fertilized at different levels of nitrogen. J. Range Manage. 22:384-390.

Graves, James E. and Wilfred E. McMurphy. 1969. Burning and fertilization for range improvement in central Oklahoma. J. Range Manage. 22:165-169.

Hanks, R. J. and Kling L. Anderson. 1957. Pasture burning and moisture conservation. J. Soil and Water Conserv. 12:228.

Hardison, W. A., J. T. Reid, C. M. Martin, and P. G. Woolfolk. 1954. Degree of herbage selection by grazing animals. J. Dairy Sci. 37:89.

Hensel, R. L. 1923. Effects of burning on vegetation in Kansas pastures. J. Agr. Res. 23:631.

Hoagland, O. K., H. W. Miller and A. L. Hafenrichter. 1952. Application of fertilizer to aid conservation. J. Range Manage. 5:55-61.

Hodgson, J. 1968. The relationship between the digestibility of a sward and the herbage consumption of grazing calves. J. Agr. Sci. 70:47-51.

Hodgson, J. and J. M. Wilkinson. 1968. The influence of the quantity of herbage offered and its digestibility on the amount eaten by grazing cattle. J. Brit. Grassl. Soc. 23:75-79.

Hoehne, D. E., D. C. Clanton and C. L. Streeter. 1967. Chemical changes in esophageal fistula samples caused by salivary contamination and sample preparation. J. Anim. Sci. 26:628-631.

Holmes, J. C. and R. W. Lang. 1965. Effects of fertilizer nitrogen and herbage dry-matter content on herbage intake and digestibility in bullocks. Anim. Prod. 5:17-26.

Hopkins, H., F. W. Albertson and A. Riegel. 1948. Some effects of burning upon a prairie in west-central Kansas. Trans. Kans. Acad. Sci. 51:131.

Huffine, Wayne W. and W. C. Elder. 1960. Effect of fertilizers on native grass pastures in Oklahoma. J. Range Manage. 13:34-36.

Kiesling, H. E., A. B. Nelson and G. H. Herble. 1969. Chemical composition of tobosa grass collected by hand plucking and esophageal fistulated steers. J. Range Manage. 22:155.

Kilcher, Mark R. 1958. Fertilizer effect on hay production of three cultivated grasses in southern Saskatchewan. J. Range Manage. 1:231-234.

Klipple, G. E. and John L. Retzer. 1959. Response of native vegetation of the central Great Plains to application of commercial fertilizer. J. Range Manage. 12:239-243.

Komarek, E. V. Sr. 1966. The meteorological basis for fire ecology. Proc. 5th Annu. Tall Timbers Fire Ecology Conf. 5:85-126.

Kucera, C. L. and J. H. Ehrenreich. 1962. Some effects of annual burning on central Missouri prairie. Ecology. 42:334.

Launchbaugh, J. L. 1964. Effects of early spring burning on yields of native vegetation. J. Range Manage. 17:5-6.

Lesperance, A. L. and V. R. Bohman. 1961. Apparatus for collecting excreta from grazing cattle. J. Anim. Sci. 20:503-506.

Lesperance, A. L. and V. R. Bohman. 1964. Chemical changes in forage induced by sample preparation. Proc. West. Sec. Amer. Soc. of Animal Sci. LIV-1.

Lesperance, A. L., E. H. Jensen, V. R. Bohman and R. A. Madsen. 1960. Measuring selective grazing with fistulated steers. J. Dairy Sci. 43:1615.

Lewis, Clifford E. and Richard H. Hart. 1972. Some herbage responses to fire on pine-wiregrass range. J. Range Manage. 25:209-212.

Lorenz, R. J. and G. A. Rogler. 1966. Root growth of Northern Plains grasses under various fertilizer and management practices. Proc. Amer. Forage and Grassland Council. 1-11.

McManus, W. R. 1961. Properties of roughage feedstuffs collected from esophageal fistulas. Australian J. Exp. Agr. and An. Husb. 1 (4):159-163.

McMurphy, Wilfred E. and Kling L. Anderson. 1965. Burning Flint Hills range. J. Range Manage. 18:265-269.

Nelson, A. B., Joe D. Wallace, G. S. Smith and R. J. Kelsey. 1972. Nutritive value of fertilized blue grama. Livestock Feeders Day Report. New Mexico State Univ. p. 21.

Owensby, Clenton E. 1969. Effect of clipping and added moisture and nitrogen on loamy upland bluestem range. Ph.D. Dissertation. Kansas State Univ., Manhattan. 97 pp.

Owensby, Clenton E. and Kling L. Anderson. 1967. Yield responses to time of burning in the Kansas Flint Hills. J. Range Manage. 20:12-16.

Owensby, Clenton E., Robert M. Hyde and Kling L. Anderson. 1970. Effects of clipping and supplemental nitrogen and water on loamy upland bluestem range. J. Range Manage. 23:341-346.

Owensby, C. E., G. M. Paulsen, and J. D. McKendrick. 1970. Effect of burning and clipping on big bluestem reserve carbohydrates. J. Range Manage. 23:358-362.

Phar, P. A., N. W. Bradley, C. O. Little, L. V. Cundiff and J. A. Boling. 1971. Nutrient digestibility using fecal collection apparatus and indicator method for steers fed ad libitum. J. Anim. Sci. 33:695.

Rao, M. R. 1972. Nutritive evaluation of forage selected by cattle on Flint Hills range. Ph.D. Dissertation. Kansas State Univ., Manhattan. 125 pp.

Rauzi, Frank, Robert L. Lang and L. I. Painter. 1968. Effects of nitrogen fertilization on native rangeland. J. Range Manage. 21:287-291.

Retzer, John L. 1954. Fertilization of some range soils in the Rocky Mountains. J. Range Manage. 7:69-73.

Rittenhouse, L. R., D. C. Clanton and C. L. Streeter. 1970. Intake and digestibility of winter-range forage by cattle with and without supplements. J. Anim. Sci. 31:1215.

Rogler, George A. 1972. Paper presentation for the forage fertilization symposium.

Rogler, G. A. and Russell Lorenz. 1957. Nitrogen fertilization of northern Great Plains rangeland. J. Range Manage. 10:156-160.

Stephens, J. L. and W. H. Marchant. 1959. Influence of rates of nitrogen on Coastal bermudagrass. Ga. Agr. Exp. Sta. Cir. N.S. 13.

Streeter, C. L. 1966. Methods of estimating the digestibility of voluntary intake of range forage consumed by grazing cattle. Ph.D. Thesis. Univ. Nebraska, Lincoln.

Smith, E. F., Kling L. Anderson, F. W. Boren and C. V. Degeer. 1965. Different methods of managing bluestem pasture. 52nd Annu. Feeders' Day Prog. Rep., Kansas Agr. Exp. Sta. Bull. 483:25-28.

Smith, E. F. and V. A. Young. 1959. The effect of burning on the chemical composition of little bluestem. J. Range Manage. 12:139-140.

Smith, E. F., V. A. Young, K. L. Anderson, W. S. Ruliffson and S. N. Rogers. 1960. The digestibility of forage on burned and nonburned bluestem pasture as determined with grazing animals. J. Anim. Sci. 19:388-391.

Smith, G. S., A. B. Nelson and Eloy J. A. Boggino. 1971. Digestibilities of forages in vitro as affected by content of "silica." J. Anim. Sci. 33:331.

Smith, L. W., H. K. Goering and C. H. Gordon. 1972. Relationship of forage compositions with rates of cell wall digestion and indigestibility of cell walls. J. Dairy Sci. 55:1140.

Smith, L. W., H. K. Goering, D. R. Waldo and C. H. Gordon. 1971. In vitro digestion rate of forage cell wall components. J. Dairy Sci. 54:71.

Torell, D. T. 1954. An esophageal fistula for animal nutrition studies. J. Anim. Sci. 13:878-884.

Van Dyne, G. M. and G. P. Lofgreen. 1964. Comparative digestion of dry annual range forage by cattle and sheep. J. Anim. Sci. 23:823-832.

Van Dyne, G. M. and D. T. Torell. 1964. Development and use of the esophageal fistula: A review. J. Range Manage. 17:7.

Van Soest, P. J. 1964. Symposium on nutrition and forage and pastures: New chemical procedures for evaluating forages. J. Anim. Sci. 23:838-845.

Van Soest, P. J. 1965. Symposium on factors influencing the voluntary intake of herbage by ruminants: Voluntary intake in relation to chemical composition and digestibility. J. Anim. Sci. 24:834.

Van Soest, P. J. 1967. Development of a comprehensive system of feed analysis and its application to forages. J. Anim. Sci. 26:119.

Van Soest, P. J. and R. H. Wine. 1968. Determination of lignin and cellulose in acid-detergent fiber with permanganate. J. Ass'n. Official Agr. Chem. 51:780.

Vavra, M., R. W. Rice and R. E. Bement. 1973. Chemical composition of the diet, intake and gain of yearling cattle on different grazing intensities. J. Anim. Sci. 36:411-415.

Wallace, Joe D. and A. H. Denham. 1970. Digestion of range forage by sheep collected by esophageal fistulated cattle. J. Anim. Sci. 30:605-608.

Wallace, Joe D. and George M. Van Dyne. 1970. Precision of indirect methods for estimating digestibility of forage consumed by grazing cattle. J. Range Manage. 23:424-428.

Woolfolk, E. J. and D. A. Duncan. 1962. Fertilizers increase range production. J. Range Manage. 15:42-45.

PART TWO. EFFECT OF NITROGEN FERTILIZATION AND LATE SPRING BURNING ON DIET AND PERFORMANCE OF YEARLING STEERS GRAZING NATIVE BLUESTEM RANGE

HIGHLIGHT

This study was conducted on typical True Prairie range in the Flint Hills near Manhattan, Kansas. Cattle with esophageal fistulas and fecal collection bags were used to evaluate the effects of late spring burning and nitrogen fertilization alone and in combination on diet, dry matter intake, and weight gains.

Diet quality was influenced by higher protein and hemicellulose and lower acid detergent fiber on burned pastures than on nonburned pastures. Hemicellulose and neutral detergent fiber increased above nonfertilized levels when 40 lb N/A was applied. Cellulose and lignin were not affected by either treatment.

Average daily gain and gain per acre were higher for steers on burned pastures than on nonburned pastures. Gain per acre on fertilized pastures exceeded gains from nonfertilized pastures primarily due to a heavier stocking rate and not increased individual performance.

Apparent dry matter digestibility was not different among treatments. Dry matter intake was lower on burned pastures than on nonburned.

INTRODUCTION

The two million plus acres of bluestem range present in the Kansas Flint Hills has long been recognized as one of the world's greatest native ranges in terms of potential beef production. Research has been conducted to explore possible means of increasing the productive capacity of this area. Controlled annual spring burning has been recommended as a management tool which can be used to increase beef gains (Smith *et al.*, 1965) and decrease production of undesirable weeds and cool-season grasses (Owensby and Anderson, 1967). Long term studies by Anderson (1965) on ungrazed areas showed that annual spring burning reduced total forage yields, thus, reducing the potential carrying capacity of the land. Later work by Owensby *et al.* (1967) on grazed range showed no significant reduction in forage yields from Flint Hills range due to late spring burning.

Nitrogen has the potential to increase herbage yields (Owensby *et al.*, 1969). They applied 50 lb N/A to research plots on bluestem range and measured herbage dry matter yields of 0.99 T/A and 1.88 T/A from control and fertilized plots, respectively, however, a portion of the additional production was increased weeds and cool-season grasses. Rogler and Lorenz (1957) applied 40 and 80 lb N/A to North Dakota native range and increased beef gains 42 and 70 lb/A, respectively.

This project studied the nutritive value of diet and performance of animals grazing bluestem range as influenced by late spring burning and nitrogen fertilization.

MATERIALS AND METHODS

Grazing trials were conducted on the Kansas State University Range Research Unit near Manhattan on an area described by Anderson (1951) as typical True Prairie. Big bluestem (*Andropogon gerardi* Vitman) and little bluestem (*A. Scoparius* Michx.) make up 50 to 60% of the total vegetation on the ordinary upland and limestone break range sites (Anderson and Fly, 1955).

Three other warm-season grasses, Indiangrass (Sorghastrum nutans (L.) Nash), switchgrass (Panicum virgatum L.) and sideoats grama (Bouteloua curtipendula (Michx.) Torr.) comprise another 10 to 20%. Numerous forb and grass species constitute the remainder. Shrubs are mainly confined to rocky ridges and lowland areas.

Two 44-acre pastures were burned April 28, 1972; two adjacent 60-acre pastures remained nonburned. Granular urea fertilizer (45% N) was applied at 40 lb N/A to one burned and one nonburned pasture. Application was made aerially on May 17, 1972, at an application cost of $1.00 per acre plus $.02 per pound of material applied. Urea cost was $69.00 per ton.

The grazing season began on May 2 and extended to October 3, 1972. The pastures were stocked with yearling Angus steers with an average initial weight of 402 lb. The steers were purchased from the southeastern United States; shipped to Kansas in March; and maintained in a dry lot on rations of hay and silage until the grazing trials began. Unfertilized treatments were stocked at 5.0 acres per animal unit and the fertilized pastures at 3.33 acres per animal unit. Individual animals were identified and were weighed the first of each month following an overnight stand without feed or water. For the starting and final weight all steers were mixed and weighed at random. Salt was available ad lib in each pasture. Weight changes of fistulated steers and steers used for fecal collections were not included in the pasture gains.

Two Holstein steers per pasture, esophageally fistulated according to the method of Van Dyne and Torell (1964), were used to collect representative diet samples on all treatments. Fistula samples were taken during the first week of each month June through October. Steers were penned late in the evening of the day prior to sampling. This 12 to 15 hour fasting period aided in reducing sample contamination due to regurgitation. Adequate samples were generally obtained in less than the one hour maximum suggested by McManus (1962).

Total fecal collections were made simultaneously with the diet sample collections from the same pastures using two Angus steers per pasture. Steers were randomly selected from the large group of research animals prior to the first trial and were trained to carry fecal collection bags. Bags and harnesses were similar to those described by Lesperance and Bohman (1961). Feces were collected and weighed twice during a 24-hour period. Morning and evening collections were pooled and an approximately 200 g sample was taken for analysis.

All samples were dried in a forced-air oven at 50°C until a near constant weight was achieved; ground in a Wiley mill (40-mesh screen); and stored in glass bottles until laboratory analysis was completed. Crude protein, dry matter and ash were determined by the procedures set forth by the A.O.A.C. (1970). Analysis of cell constituents was conducted using procedures outlined by Goering and Van Soest (1970). Reported dry matter digestibility values were determined using the summative digestibility equation (Goering et al., 1970). Lignin ratio techniques (Crampton and Harris, 1969) and the fecal nitrogen equation (Rao, 1972) were also used and found to give unsatisfactory results in estimating dry matter digestibility. Intake was predicted according to Crampton et al. (1969).

The least squares analysis of variance (Kemp, 1972) and Duncan's New Multiple Range Test (Steele and Torrie, 1960) were used for data analysis.

RESULTS AND DISCUSSION

Diet Sample Composition

Crude protein content of samples taken from all treatments, except burning, declined monthly June through August (Fig. 1). Protein content of forage from the burning treatment increased slightly during June to reach a peak in July before declining rapidly. Protein levels of forage consumed from the control, burned and the fertilized pastures increased rapidly in September while the level of the burned with 40 lb N/A declined. Allen (1973) reported protein content of ungrazed big and little bluestem to be relatively constant during August and September, thus the late season increase reported here was probably due to the availability of rapidly growing cool-season species, especially on the nonburned pastures. In every month protein of forage from all treatments was above 7.8%, the required level for maintenance of 400 to 600 lb steers. The 11.15% mean protein level of forage from the burned-fertilized pasture was significantly higher than the average level produced by any other treatment during the season (Table 1). Burning increased protein content of ingested forage over that of nonburned (Table 2). A similar increase was reported by Smith and Young (1959) when they studied the effects of burning on little bluestem. An increase in protein levels was found in fertilized samples as compared to nonfertilized ones (Table 3). Owensby (1969) indicated increased protein content of native forage on Flint Hills range due to nitrogen fertilization was somewhat dependent upon adequate soil moisture. Precipitation during the 1972 grazing season was only 87.3% of normal for these five months, thus this may partially explain why a larger increase in protein due to nitrogen fertilization was not found.

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

THIS IS AS RECEIVED FROM CUSTOMER.

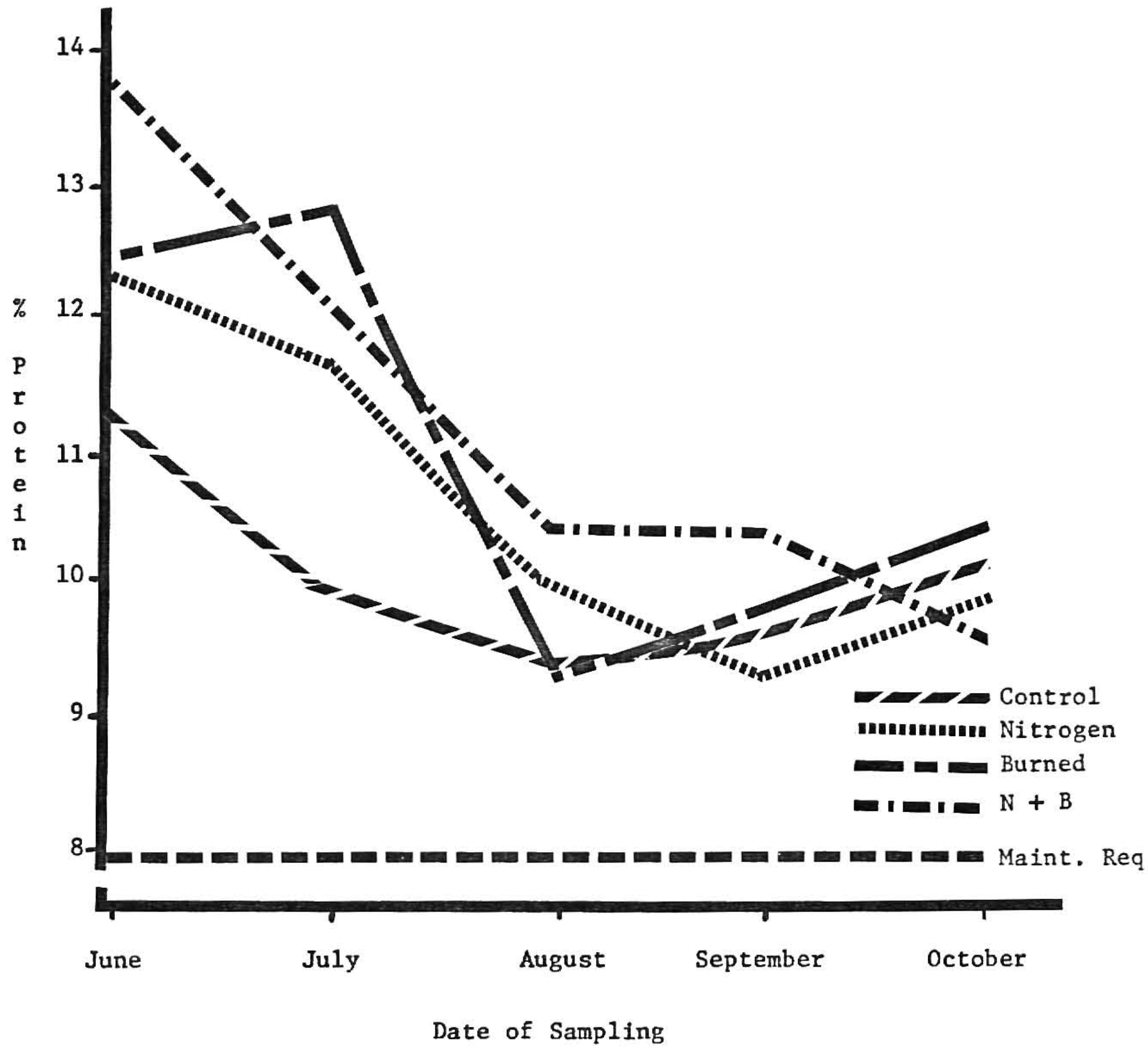

Fig. 1. Protein content of diet samples collected by esophageally fistulated steers grazing bluestem range as compared to the maintenance requirement of these animals.

Table 1. Least square means of chemical constituents of diet samples collected from four treatment steers grazing bluestem pasture.

Cell Components[a]	Treatments: Control	40 lb N/A	Burned	40 lb N/A & Burned
Crude Protein (%)	10.24^{b}	10.89^{b}	10.95^{b}	11.15^{c}
Neutral Detergent Fiber (%)	80.70^{b}	84.64^{c}	82.41^{bc}	83.09^{c}
Cell Solubles (%)	31.37^{c}	27.59^{b}	29.99^{bc}	28.85^{b}
Acid Detergent Fiber (%)	52.97^{bc}	54.35^{c}	51.39^{b}	50.78^{b}
Hemicellulose (%)	24.50^{a}	26.86^{ab}	28.08^{b}	29.30^{b}
Cellulose (% of ADF)	66.34^{b}	67.62^{b}	67.11^{b}	67.09^{b}
Lignin (% of ADF)	24.07^{b}	21.96^{b}	22.09^{b}	23.10^{b}

[a]Values are expressed on an ash-free basis.
[bc]Values within a row with similar superscripts are not significantly ($P<.05$) different.

Table 2. Chemical constituents of diet samples affected by late spring burning.

	Treatments		
	Burned	Nonburned	P<
Protein (%)	11.05	10.55	.10
ADF (%)	51.07	53.63	.005
Hemicellulose (%)	28.69	25.68	.002

Table 3. Chemical constituents of diet samples affected by applying 40 lb N/A.

	Nitrogen (lb/A)		
	40	0	P<
Protein (%)	11.01	10.59	.17
NDF (%)	83.97	81.43	.005
Cell Solubles (%)	28.13	30.80	.008
Hemicellulose (%)	28.08	26.29	.05

Neutral detergent fiber (NDF) in forage samples increased through the first four months of the grazing season, but decreased in October to a seasonal low of 76.50%. That late season decline in fiber content differed from Allen (1973) when he reported NDF in big and little bluestem to be higher in October than in any earlier month of the grazing season. That decline in NDF of diet samples (Fig. 2) was probably due to increased consumption of rapidly growing cool-season species such as Kentucky bluegrass (Poa pratensis L.).

Since the dry matter of forage is composed entirely of NDF and cell soluble material, an increase in NDF is accompanied by a subsequent decrease in cell solubles. Goering et al. (1970) reported cell soluble material to be 98% digestible by the ruminant. The declining cell soluble concentration June through August (Table 4) partially explains a decline in apparent dry matter digestibility during these months (Table 5). Nitrogen fertilization increased NDF and decreased cell soluble levels in diet samples (Table 3). Neither NDF nor cell solubles was significantly affected by burning.

The monthly trend of acid detergent fiber (ADF) was identical to the previously discussed NDF trend. ADF content of forage collected in June on burned pastures was lower than any other samples collected during the trials. Samples collected from burned pastures exhibited a 2.56% decrease in ADF apparently due to burning (Table 2).

Burning and nitrogen fertilization both produced an increase in hemicellulose present in cells of grazed forage (Tables 2 & 3). Hemicellulose declined as the grazing season progressed (Table 2). Burning with 40 lb N/A produced the highest hemicellulose concentration (Table 1).

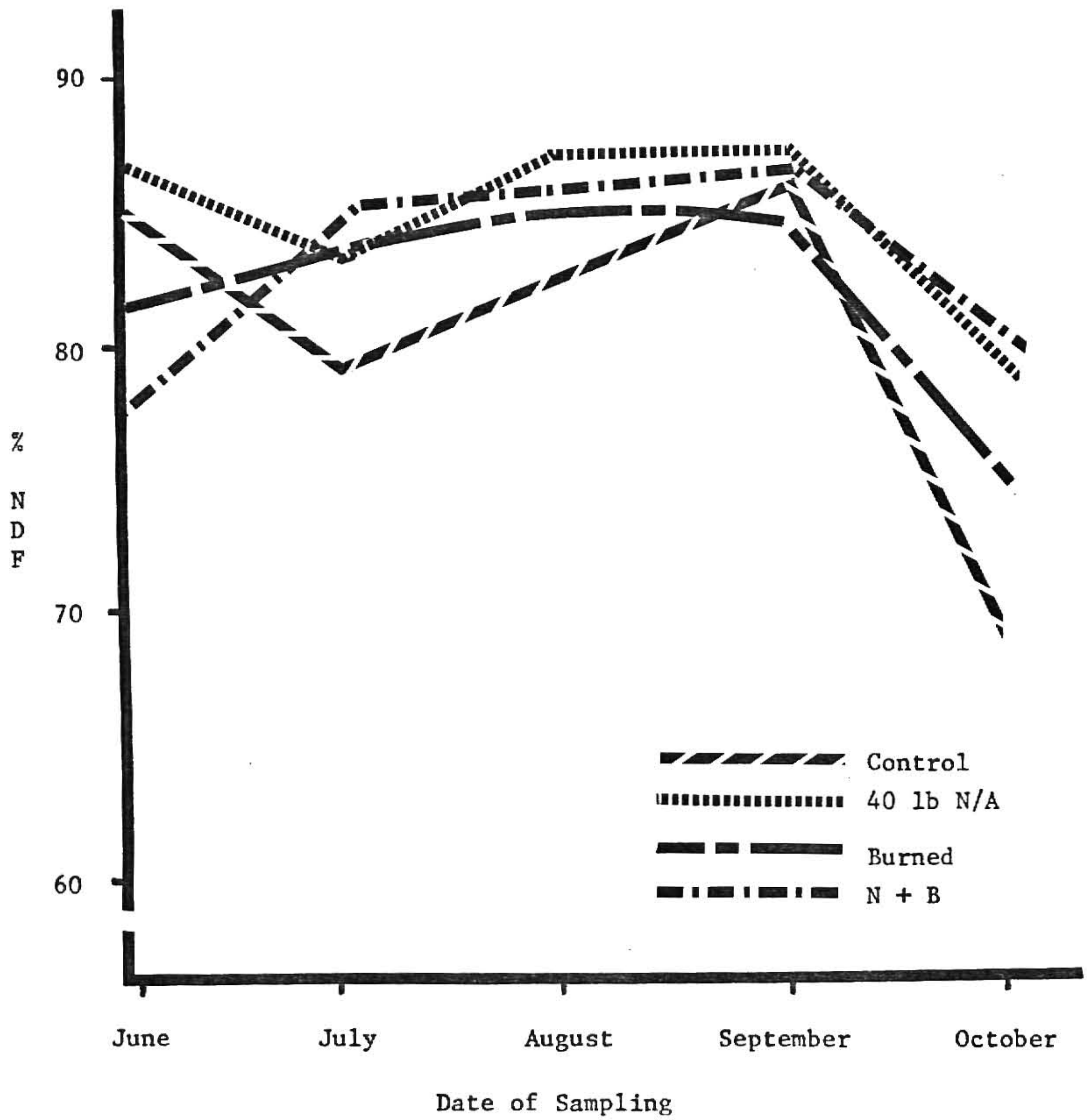

Fig. 2. Neutral detergent fiber of forage collected by esophageally fistulated steers grazing bluestem pasture.

Table 4. Least square means of chemical constituents of diet samples collected during five months by steers grazing bluestem pasture.

Cell Components[a]	Months				
	June	July	August	September	October
Crude Protein (%)	12.45[d]	11.74[d]	9.80[bc]	9.72[b]	10.23[c]
Neutral Deter. Fiber (%)	82.89[c]	83.11[c]	85.69[d]	85.84[d]	76.05[b]
Cell Solubles (%)	28.66[c]	28.28[c]	25.71[b]	26.37[b]	38.22[d]
Acid Deter. Fiber (%)	47.76[b]	53.93[c]	53.64[c]	55.26[d]	52.27[c]
Hemicellulose (%)	31.87[d]	27.26[c]	27.91[c]	27.05[c]	22.50[b]
Cellulose (% of ADF)	67.89[b]	69.08[b]	66.84[b]	67.92[b]	64.41[b]
Lignin (% of ADF)	19.90[b]	20.73[b]	22.83[b]	22.82[b]	27.20[c]

[a]Values are expressed on an ash-free basis.
[bc]Values within a row with similar superscripts are not significantly ($P<.05$) different.

Table 5. Apparent dry matter digestibility (%) of forage collected by esophageally fistulated steers grazing bluestem pasture.

Month	Treatments				Means
	Control	40 lb N/A	Burned	40 lb N/A & Burned	
June	52.62	51.47	52.06	52.74	52.33[c]
July	51.25	50.20	49.43	50.36	50.31[d]
August	46.61	45.46	47.13	45.42	46.16[a]
September	46.57	45.84	48.22	46.87	46.88[a]
October	51.74	46.65	48.95	45.97	48.33[b]
Means	49.76[a]	47.92[a]	49.16[a]	48.27[a]	

[abcd]Means in a row or a column with similar superscripts are not significantly ($P<.05$) different.

Neither burning nor nitrogen fertilization produced significant changes in cellulose or lignin. Lignin was higher in October forage than in forage collected during any other month of the trial.

Animal Performance

Forty lb N/A did not affect daily gains except on the burned pasture (Fig. 3). Burning increased daily gains on fertilized and nonfertilized pastures when compared to gains on nonburned pastures with a similar fertilization treatment. That increase in daily gain produced steers 48 lb heavier at the end of the season than steers on nonburned pastures. That gain exceeded the 23 lb per steer increased gain reported by Smith *et al.* (1965) for steers on burned pastures compared to steers on adjacent nonburned pastures.

Highest beef production was 98 lb/A on the burned pasture with 40 lb N/A (Fig. 4). Even though fertilizing with 40 lb N/A produced lower daily gains than burning, gains per acre were higher on the fertilized pasture than on the burned, nonfertilized due to a heavier stocking rate.

Apparent dry matter digestibility was lower each succeeding month from June through August (Table 5). Dry matter digestibility increased in October on all treatments except burned with 40 lb N/A. There was no significant difference in digestibility due to treatments, however, where nitrogen was applied digestibility values were lower. These results differed from Smith *et al.* (1960) when they reported a significant increase in dry matter digestibility due to spring burning.

During each month daily gains of steers used for fecal collections were nonsimilar on every pasture to gains of the remainder of the cattle

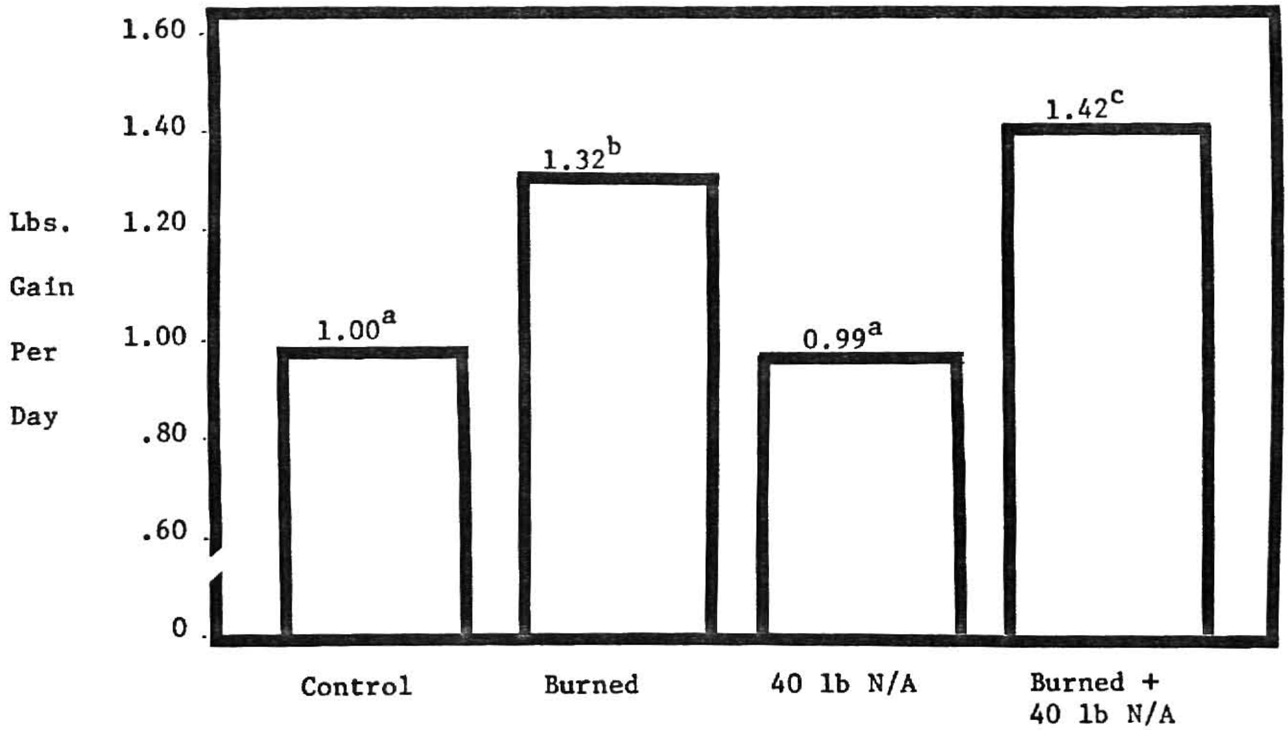

Fig. 3. Steer gains per head daily on bluestem pasture, May 2 to October 3, 1972.

[abc]Values with similar superscripts are not significantly different (P<.05).

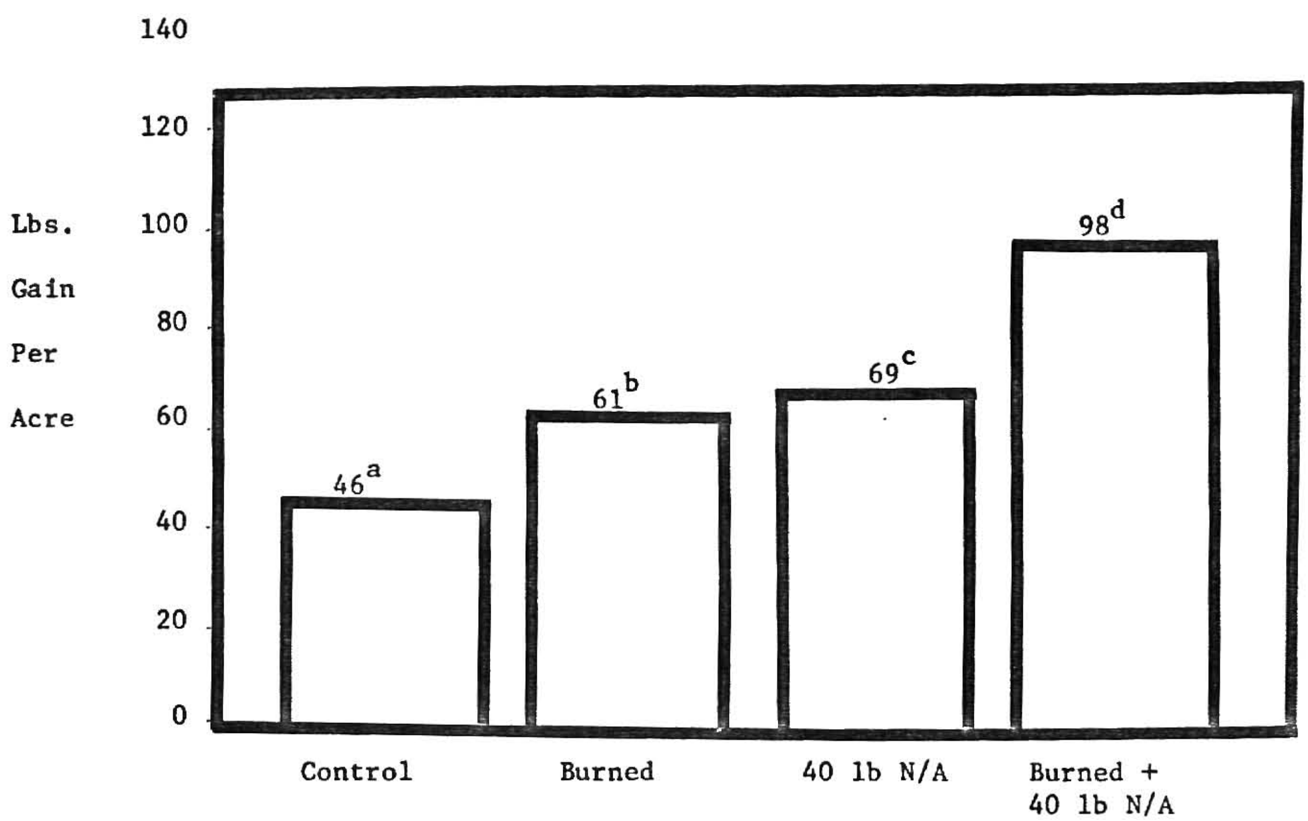

Fig. 4. Steer gains per acre on bluestem pasture, May 2 to October 3, 1972.

[abcd]Values with similar superscripts are not significantly different (P<.05).

on that respective pasture. Therefore, dry matter intake predictions are probably representative only for steers used in collecting samples. If more steers could have been utilized for fecal collections, predicted intake values would probably have been more representative of all animals on the study. Steers grazing the control pasture were found to have a higher dry matter intake than steers on any other pasture (Table 6). No differences were found between intake on the burned pasture and the fertilized pasture. Lowest predicted intake was for those animals on the burned, fertilized pasture. Dry matter intake was reduced by either burning or applying 40 lb N/A.

By combining predicted intake and protein content of the diet samples, it was possible to estimate the daily intake of protein. The estimated intake on every treatment was lower than the NRC suggested level for 500 lb steers gaining 1.10 lb/day (Table 6). On the burned pastures, with or without nitrogen fertilization, gains exceeded the 1.10 lb level even though protein intake appeared deficient.

CONCLUSIONS

Protein levels of bluestem forage collected by esophageal fistulated steers declined monthly June through October. Protein content of samples was increased .50% by burning and .42% by addition of 40 lb N/A. Acid detergent and neutral detergent fiber increased as plants matured through the growing season until the appearance of cool-season species in the diet during September lowered fiber levels. Burning decreased ADF while nitrogen increased NDF. Hemicellulose concentration was increased by both burning and fertilization.

Average daily gains were increased over controls by burning.

Table 6. Performance of steers used for total fecal collections while grazing bluestem pasture.

	Treatments			
	Control	40 lb N/A	Burned	40 lb N/A & Burned
D.M. Intake (lb/100 lb BW)	1.86^{c}	1.76^{b}	1.70^{b}	1.56^{a}
Protein Intake* (lb/day)	$.87^{a}$	$.94^{b}$	$.98^{b}$	$.86^{a}$
Gains (lb/day)	$.73^{a}$	$.71^{a}$	1.71^{c}	1.25^{b}

^{abc}Values within a row with similar superscripts are not significantly ($P<.05$) different.

*National Research Council protein requirement for 500 lb steers gaining 1.10 lb/day is 1.28 lb.

Combining 40 lb N/A and burning produced higher average daily gains and gains per acre than other treatments. Gains per acre produced from either burning or adding 40 lb N/A were increased over control gains but were significantly lower than when both treatments were combined.

Apparent dry matter digestibility decreased June through September and then increased slightly in October. Forty lb N/A slightly lowered digestibility of dry matter, while burning had no effect.

Dry matter intake was lowest on the burned pasture with 40 lb N/A while the 1.86 lb/100 body weight intake on the control pasture was the highest of all pastures.

The decline in growth rate of steers through September while dry matter intake, protein and cell soluble levels were rising above previous months cannot be explained.

One year's data is not sufficient to adequately evaluate the long term effects of these treatments. If continuing research finds results similar to those obtained during the 1972 grazing season, certainly the parameters studied here show promise in increasing future beef production from native bluestem ranges.

LITERATURE CITED

Allen, Leland J. 1973. Effects of range burning and nitrogen fertilization on the nutritive value of bluestem grass. Thesis. Kansas State Univ., Manhattan. 45pp.

Anderson, K. L. 1951. The effects of grazing management and site conditions on Flint Hills bluestem pastures in Kansas. Unpbl. Ph.D. Thesis. Univ. Nebr., Lincoln.

Anderson, Kling L. 1965. Time of burning as it affects soil moisture in an ordinary upland bluestem prairie in the Flint Hills. J. Range Manage. 18:311-316.

Anderson, K. L. and C. L. Fly. 1955. Vegetation-soil relationships in Flint Hills bluestem pastures. J. Range Manage. 8:163-165.

A.O.A.C. 1970. (11th Edition). Official methods of analysis. Association Official Agricultural Chemists. Washington, D.C.

Crampton, E. W. and L. E. Harris. 1969. Applied Animal Nutrition (2nd Edition). W. H. Freeman and Company, San Francisco.

Goering, H. K. and P. J. Van Soest. 1970. Forage fiber analysis. U.S.D.A. Agr. Sci. Handbook No. 379.

Kemp, K. E. 1972. Least squares analysis of variance, a procedure, a program, and examples of their use. Kan. Agr. Exp. Sta. Contribution 168, Dept. of Statistics and the Statistical Lab. research paper 7.

Lesperance, A. L. and L. R. Bohman. 1961. Apparatus for collecting excreta from grazing cattle. J. Anim. Sci. 20:503-507.

McManus, W. R. 1962. Studies of the relationship of saliva to rumen function of sheep on low feed intakes. Aust. J. Agr. Res. 13(5):907-923.

Owensby, Clenton E. and Kling L. Anderson. 1967. Yield responses to time of burning in the Kansas Flint Hills. J. Range Manage. 20:12-16.

Owensby, Clenton E. 1969. Effect of clipping and added moisture and nitrogen on loamy upland bluestem range. Ph.D. Dissertation. Kansas State Univ., Manhattan. 97pp.

Rao, M. R. 1972. Nutritive evaluation of forage selected by cattle on Flint Hills range. Unpbl. Ph.D.Dissertation. Kansas State Univ., Manhattan. 125pp.

Rogler, G. A. and Russell Lorenz. 1957. Nitrogen fertilization of northern Great Plains rangeland. J. Range Manage. 10:156-160.

Smith, E. F., Kling L. Anderson, F. W. Boren and C. V. Degeer. 1965. Different methods of managing bluestem pasture. 52nd Ann. Feeders' Day Prog. Rep., Kansas Agr. Expt. Sta. Bull. 483:25-28.

Smith, E. F., V. A. Young, K. L. Anderson, W. S. Rulliffson, and S. N. Rogers. 1960. The digestibility of forage on burned and nonburned bluestem pasture as determined with grazing animals. J. Anim. Sci. 19:388-391.

Steele, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York.

Van Dyne, G. M. and D. T. Torell. 1964. Development and use of the esophageal fistual: A review. J. Range Manage. 17:7-11.

APPENDIX

Table 1. Least square means of crude protein (%) in diet samples collected on bluestem pasture.

	Treatments[ab]				
Months	Control	40 lb N/A	Burned	40 lb N/A & Burned	Means
June	11.17	12.33	12.60	13.71	12.45 (.35)
July	10.09	11.68	12.91	12.28	11.74 (.32)
August	9.37	10.10	9.33	10.39	9.80 (.32)
September	9.50	9.39	9.58	10.39	9.72 (.32)
October	10.26	9.90	10.98	9.76	10.23 (.39)
Means	10.08 (.31)	10.68 (.34)	11.08 (.28)	11.31 (.28)	10.78

[a]Numbers within parentheses are standard errors.
[b]All values reported on an ash-free basis.

Table 2. Least square means of chemical constituents of diet samples as influenced by burning or nitrogen fertilization.

Constituents	Burned		Fertilization (lb/A)	
	No	Yes	0	40
Neutral Detergent Fiber (%)	82.67	82.75	81.56	83.87
Acid Detergent Fiber (%)	53.66	51.08	52.18	52.57
Hemicellulose (%)	29.25	31.68	29.69	31.24
Cellulose (% ADF)	67.07	67.15	66.76	67.46
Lignin (% ADF)	22.74	22.60	22.95	22.44

Table 3. Least square means of neutral detergent fiber (%) in diet samples collected on bluestem pasture.

	Treatments[ab]				
Months	Control	40 lb N/A	Burned	40 lb N/A & Burned	Means
June	84.57	87.22	82.37	77.39	82.89 (.93)
July	79.50	83.58	84.31	85.03	83.11 (.84)
August	83.88	86.46	85.89	86.51	85.69 (.84)
September	86.16	87.37	83.69	86.14	85.84 (.84)
October	69.40	78.59	75.79	80.42	76.05 (1.0)
Means	80.70 (.82)	84.64 (.88)	82.41 (.75)	83.10 (.75)	

[a]Numbers within parentheses are standard errors.
[b]All values are reported on an ash-free basis.

Table 4. Least square means of acid detergent fiber (%) in diet samples collected on bluestem pasture.

	Treatments[ab]				
Months	Control	40 lb N/A	Burned	40 lb N/A & Burned	Means
June	51.10	51.73	45.49	42.70	47.76 (.91)
July	50.36	53.97	50.97	56.44	52.93 (.81)
August	55.98	55.28	52.88	50.42	53.64 (.81)
September	57.08	55.98	54.36	53.64	55.26 (.81)
October	50.35	54.81	53.24	50.69	52.27 (1.0)
Means	52.97 (.79)	54.33 (.86)	51.39 (.73)	50.78 (.73)	52.38

[a]Numbers within parentheses are standard errors.
[b]All values reported on an ash-free basis.

Table 5. Least square means of hemicellulose (%) in diet samples collected on bluestem pasture.

	Treatments[ab]				
Months	Control	40 lb N/A	Burned	40 lb N/A & Burned	Means
June	31.29	33.10	33.15	29.92	31.87 (1.60)
July	25.61	26.63	31.62	25.18	27.26 (1.00)
August	24.29	27.12	29.50	30.71	27.91 (.98)
September	25.68	27.90	26.13	28.48	27.05 (1.04)
October	17.76	21.87	21.87	27.59	22.50 (1.63)
Means	24.93 (.93)	27.51 (.99)	28.45 (.86)	28.38 (.86)	

[a]Numbers within parentheses are standard errors.
[b]All values reported on an ash-free basis.

Table 6. Least square means of cellulose (% ADF) in diet samples collected on bluestem pasture.

	Treatments[ab]				
Months	Control	40 lb N/A	Burned	40 lb N/A & Burned	Means
June	67.21	71.72	69.14	63.51	67.89 (1.04)
July	68.51	66.96	70.93	69.92	69.08 (.65)
August	66.19	66.50	66.21	68.46	66.84 (.63)
September	67.03	68.81	68.75	67.07	67.92 (.67)
October	63.17	65.66	62.36	66.46	64.41 (1.06)
Means	66.42 (.85)	67.87 (.91)	67.48 (.79)	67.08 (.78)	

[a]Numbers within parentheses are standard errors.
[b]All values reported on an ash-free basis.

Table 7. Least square means of lignin/acid detergent fiber (%) in diet samples collected on bluestem pasture.

	Treatments[ab]				
Months	Control	40 lb N/A	Burned	40 lb N/A & Burned	Means
June	21.46	14.56	18.28	25.27	19.90 (1.05)
July	20.65	22.62	17.95	21.70	20.73 (.95)
August	23.89	23.55	22.22	21.67	22.83 (.95)
September	24.09	22.18	21.72	23.28	22.82 (.95)
October	28.97	25.36	30.23	24.26	27.20 (1.17)
Means	23.81 (.93)	21.65 (.99)	22.08 (.86)	23.24 (.85)	

[a]Numbers within parentheses are standard errors.
[b]All values reported on an ash-free basis.

Table 8. Average gain per day and per acre (lb) for steers grazing bluestem pasture May 2, 1972 to October 3, 1972.

Months	Treatments			
	Control	40 lb N/A	Burned	40 lb N/A & Burned
May				
lb/day	1.07	1.28	1.01	1.01
lb/acre	9.61	17.22	9.08	13.78
June				
lb/day	1.10	1.09	2.08	2.22
lb/acre	9.88	14.67	18.69	30.28
July				
lb/day	1.36	1.44	1.59	2.37
lb/acre	12.22	19.38	14.29	32.32
August				
lb/day	.80	.93	1.15	1.15
lb/acre	7.19	12.52	10.33	15.69
September				
lb/day	.71	.20	.80	.40
lb/acre	6.38	2.69	7.19	5.46
Total				
lb/day (avg.)	1.00[a]	1.00[a]	1.34[b]	1.42[c]
lb/acre	45.73[a]	68.61[c]	61.08[b]	98.76[d]

[abcd]Values within a row with similar superscripts are not significantly ($P<.05$) different.

Table 9. Average daily gain (lb) of steers used for fecal collections during the 1972 grazing season (May 2 to October 3).

Months	Treatments				Means
	Control	40 lb N/A	Burned	40 lb N/A & Burned	
May	0.0	.73	1.05	.73	.63
June	1.02	.16	2.73	2.19	1.53
July	1.02	1.57	1.67	1.67	1.49
August	.63	.81	1.36	.36	.79
September	1.02	.29	1.94	1.48	1.19
Means	.74	.72	1.75	1.29	

Table 10. Dry matter intake (lb/100 lb body weight) of steers grazing bluestem pasture.

	Treatments				
Months	Control	40 lb N/A	Burned	40 lb N/A & Burned	Means
June	1.7	1.4	2.1	2.1	1.83
July	1.8	1.8	1.6	1.5	1.65
August	1.8	2.0	1.6	1.4	1.70
September	1.9	1.8	1.6	1.8	1.78
October	2.1	1.8	1.6	1.9	1.85
Means	1.86	1.76	1.70	1.74	1.72

Table 11. Average daily intake (lb) of crude protein by steers grazing bluestem pasture as compared to the recommended level of intake for animals of a similar weight to gain an estimated 1.10 lb per day.

Months	Treatments				Means
	Control	40 lb N/A	Burned	40 lb N/A & Burned	
June	.73(.86)[a]	.84(1.19)	1.08(1.08)	.95(1.08)	.90(1.05)
July	.79(.86)	1.06(1.28)	1.12(1.28	.84(1.28)	.96(1.15)
August	.81(1.19)	1.19(1.32)	.84(1.39)	.66(1.36)	.88(1.32)
September	.90(1.30)	1.01(1.43)	.88(1.54)	1.01(1.39)	.95(1.42)
October	1.17(1.43)	1.03(1.47)	.92(1.58)	1.06(1.47)	1.05(1.49)
Means	.88(1.13)	1.03(1.32)	.97(1.37)	.91(1.32)	

[a]Values in parentheses are NRC recommended protein levels for animals of a similar weight gaining 1.10 lb per day.

VITA

John S. Woolfolk, the second of three sons of William and Ella Woolfolk, was born June 1, 1949, in Jackson, Tennessee. He spent his childhood years on the family farm in Madison County where he was actively involved in the farming program from an early age.

John was educated in the public schools of Madison County attending Spring Creek Elementary for eight years and North Side High for four. In elementary school he became involved in 4-H Club activities which were to later lead to numerous awards and honors. While in high school the author was active in sports receiving letters in baseball, basketball and track. During his senior year he served as president of the student body.

John enrolled in the University of Tennessee at Martin in 1967 and received a B.S. degree in Agricultural Science in 1971. He served for a year each as president and treasurer of Alpha Upsilon Chapter of Alpha Gamma Rho and was also a member of Alpha Zeta and the UTM Honor Corp.

John was married to Pat Winslow June 13, 1971, and shortly afterwards they moved to Manhattan, Kansas, where he enrolled in Kansas State University to pursue a Master's degree in Animal Science & Industry.

EFFECT OF NITROGEN FERTILIZATION AND LATE SPRING BURNING ON DIET AND PERFORMANCE OF YEARLING STEERS GRAZING NATIVE BLUESTEM RANGE

by

JOHN S. WOOLFOLK

B. S., University of Tennessee at Martin, 1971

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Science and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

Grazing trials were conducted on native bluestem range to evaluate the effects of late spring burning and nitrogen fertilization on forage quality and animal performance. Sixty Angus steers were randomly allotted to four separate pastures at the beginning of the 1972 grazing season. Stocking rates were determined from previous studies of forage yields under burning and nitrogen fertilization treatments on similar type range.

Diet samples were collected using esophageally fistulated Holstein steers. Total fecal collections were made using Angus steers. Samples were collected the first of every month during the grazing season from four pastures treated as follows: (1) nonburned, nonfertilized; (2) nonburned with 40 lb N/A; (3) burned and nonfertilized; and (4) burned with 40 lb N/A. Samples were analyzed for crude protein, dry matter, and cell constituents using Proximate and Van Soest Analyses.

Protein content of forage was increased by burning when compared to nonburning. Highest protein levels were present in June on each treatment and then declined through the next three months. An increase in October may have been due to selection of rapidly growing, immature cool-season species with higher protein levels than warm-season grasses which were nearing maturity.

Acid and neutral detergent fiber increased through the season as plants matured. However, October samples contained lower levels of fiber than did September samples, again probably due to the consumption of immature cool-season species. Burning and fertilizer nitrogen both produced an increase in hemicellulose present in cells when compared to hemicellulose levels of control forage.

Neither cellulose nor lignin was influenced by either burning or nitrogen fertilization. Lignin concentration increased steadily throughout the grazing season, but only in October forage was lignin significantly higher than other months.

Average daily steer gains were increased above gains from the control pasture by burning. Although application of 40 lb N/A on the nonburned pasture did not increase daily gains, it did increase gain per acre due to the heavier stocking rate. Highest daily gains and gains per acre were on the burned pasture with 40 lb N/A.

Apparent dry matter digestibility of diet samples decreased monthly June through September and then increased in October. Digestibility was lower on samples taken from fertilized pastures than from nonfertilized ones. Estimated dry matter intake was highest on the control pasture and lowest on the burned pasture with 40 lb N/A.