THE EFFECTS OF NITROGEN FERTILIZATION ON NATIVE VEGETATION UNDER THE CONDITIONS OF CLIPPING, GRAZING, AND BURNING

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CHAPTER I

INTRODUCTION

There are approximately 20 million acres of native grass rangeland in Oklahoma, and of this, some 415,000 acres are utilized as hay meadows.[1] Previously, ranchers operated under the assumption that perennial native grass was a "take care of itself" crop. A changing economic picture has forced the rancher into more intensive management of his rangelands. Methods of increasing forage production and utilization by livestock are now being sought by the rancher. One of these methods may be the use of nitrogen fertilizers.

In this study, the effects of ammonium nitrate fertilizer at two levels were considered on native prairie in north central Oklahoma. Forage production figures were obtained from fertilized plots on a hay meadow under combinations of burning and clipping. The principal species studied under these conditions were little bluestem[2] (Andropogon scoparius Michx.), big bluestem (Andropogon gerardi Vitmin), indiangrass (Sorghastrum nutans L. Nash.), and switchgrass (Panicum virgatum L.). These species were selected because of their grazing value to livestock (Dwyer, 1961) and their dominant position in the prairie (Harlan, no date).

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[1]USDA Statistical Reporting Service 1962.

[2]Common names used will follow Anderson (1961)

The effects of nitrogen fertilizer on the utilization of native grasses were also studied in a pasture under free-choice grazing by Hereford cattle. Species composition, degree of utilization, and forage production of fertilized and unfertilized portions of the pasture were determined.

CHAPTER II

LITERATURE REVIEW

Hay production on a meadow of cool season grasses in the Harney Valley of eastern Oregon was increased when nitrogen was applied at three levels (Cooper and Sawyer, 1955). The check plots averaged 1.75 tons, while 20 pounds of nitrogen averaged 2.11 tons, 40 pounds of nitrogen yielded 2.44 tons, and 60 pounds of nitrogen gave 2.75 tons of forage per acre. Fertilizer was applied in the fall.

A fertilization study by Mader (no date) on a native grass hay meadow in eastern Kansas showed response at two levels of nitrogen application. Average production from 1951 to 1956 on the untreated plots was 0.87 tons of hay. The plots receiving 50 pounds of nitrogen produced an average of 1.23 tons of hay during the same period. Greatest average production was recorded on plots treated with a combination of 100 pounds nitrogen and 100 pounds of P_2O_5 per acre annually. These plots averaged 1.60 tons per acre. Potash gave little response.

Elder and Murphy (1958) working on a native meadow near Warner, Oklahoma, found some response to ammonium nitrate fertilizer. The four year average for the unfertilized check was 1,836 pounds of air-dry forage per acre, while the meadow fertilized with 33 pounds of nitrogen averaged 2,094 pounds of air-dry forage. Lime, P_2O_5, and nitrogen in combination changed the botanical composition of the meadow by causing an increase in annual weedy grasses and forbs making the hay less desirable for livestock use.

Similar results were obtained on eroded cropland by Huffine and Elder (1960) when 300 pounds of superphosphate and 33 pounds of nitrogen per acre were applied annually 1952 through 1955. Unfertilized check plots produced 754 pounds when clipped in 1957 and 847 pounds in 1958. Fertilized plots produced 714 pounds in 1957 and 504 pounds in 1958. The fertilizer treatment caused an increase of weedy grasses and forbs.

Williams (1953) found that 60 pounds of nitrogen per acre on native grass near Lincoln, Nebraska, returned 2.28 tons of forage in May, 2.38 tons in June, and 2.64 tons in August. The unfertilized check plots produced 0.50 tons in May, 0.76 tons in June, and 1.20 tons in August. The addition of 80 pounds of P_2O_5 did not significantly increase the yield.

First year data by Dwyer (1963) showed good response of native grass to nitrogen at two levels of application. A 40 pound per acre treatment applied June 1 produced 4,490 pounds of oven-dry forage. An 80 pound treatment produced 5,035 pounds of forage, compared to the check plots which produced only 3303 pounds.

A long time study of native grass production under fertilization near Stillwater, Oklahoma, by Harper (1957) showed that the highest average yield of 4,039 pounds air-dry forage was obtained from a treatment of 42 pounds nitrogen, 20 pounds P_2O_5, and 12.5 pounds K_2O per acre applied annually in the spring. Fertilization with 21 pounds of nitrogen as ammonium sulfate averaged 3,294 pounds forage, while 21 pounds of nitrogen as sodium nitrate yielded an average of 3,531 pounds of air-dry forage per acre. Annual applications of 42 pounds of nitrogen as ammonium sulfate and sodium nitrate yielded 3,436 pounds and 3,445 pounds of air-dry forage, respectively. The unfertilized check averaged 3,097 pounds of forage per acre for the same period.

When they used three levels of nitrogen, Nelson and Castle (1958) found that a point of diminishing returns was reached with heavy applications. Fifty pounds of nitrogen per acre produced 3.6 pounds of hay per pound of nitrogen. A 100 pound treatment yielded 24.4 pounds of hay per pound of nitrogen. When the rate was increased to 200 pounds of nitrogen, 18.3 pounds of hay per pound of nitrogen were produced.

In their study in western South Dakota, Cosper and Thomas (1961) found the limiting factor of maximum production from fertilization to be precipitation rather than fertilization levels. Increased precipitation required higher levels of fertilization to obtain peak production. Decreased precipitation required less fertilizer to obtain the maximum response.

Increased utilization by livestock of native grass after fertilization was found by Van Dyne (1961). This Montana study showed a 33 percent average use of the forage on all plots and replications under fertilization. Check plots produced 617 pounds of forage with 210 pounds being utilized. Those plots which received 50 pounds of nitrogen per acre, produced 876 pounds of forage with utilization increasing to 298 pounds. At the 100 pound rate of fertilization, 1162 pounds of forage were produced and 383 pounds were utilized. It was reported that normally unpalatable species in the 100 pounds of nitrogen per acre treatment were eaten readily.

Holt and Wilson (1961) fertilized a desert grassland site with 25 pounds, 50 pounds, and 100 pounds of nitrogen per acre. Both ammonium phosphate and ammonium nitrate fertilizers were used as sources of nitrogen. Both fertilizers, at all rates, nearly doubled forage production. Utilization on the 25, 50, and 100 pound treatments was 3, 4, and 5 times that of the unfertilized checks, respectively. Cattle showed no species preference on the fertilized plots compared to marked differences on unfertilized plots.

CHAPTER III

STUDY REGION

This study was conducted at the 33,000 acre K. S. Adams Ranch located in northern Osage County, Oklahoma, and southern Chautauqua and Cowley County, Kansas. The ranch is situated in the Osage hills, a southern continuation of the Flint Hills of Kansas. It is an area long known for its bluestem pastures and grass fattened cattle. Weaver (1954) defined this area as part of an "enormous prairie that extends from near the Nebraska state line entirely across Kansas and into Oklahoma, where it is known as the Osage Hills."

Climate

Climate of the region is characterized by dry, hot summers and wet springs and falls. United States Weather Bureau Records at Foraker, Oklahoma, a small town 5 miles south of the ranch headquarters, showed a mean annual precipitation of 32.81 inches for the years 1944 to 1963. About three-fourths of this amount normally falls during the growing season from mid-April to late September. Precipitation for the study period of April through August, 1963, was approximately 60% below normal. Total rainfall for these months was 9.46 inches (Table 1).

Summer temperatures are normally high, often exceeding 100 degrees F. The mean annual temperature is 61 degrees F., with the lowest monthly average of 37.5 degrees occurring in January and the highest, 83.7 degrees, in July.

TABLE I

LONGTIME AVERAGE RAINFALL AND RAINFALL FOR THE GROWING SEASON, 1963[1]

	April	May	June	July	August	Total
Longtime Average	3.39	5.35	4.42	3.06	3.12	19.34
1963	0.90	1.66	1.53	3.07	2.30	9.46

Vegetation

Dwyer (1958) reported more than 300 species of grasses, grass-like plants, and forbs were present on Adams Ranch. The dominant grasses were little bluestem, big bluestem, indiangrass, and switchgrass. These grasses often compose 70 to 90 percent of the vegetative composition on a climax loamy prairie range site. These grasses are referred to as the "major four" throughout the remainder of this paper. Tall dropseed (*Sporobolus asper* [Michx.] Kunth.), sideoats grama (*Bouteloua curtipendula* [Michx.] Torr.), and scribner panicum (*Panicum scribnerianum* Nash) are also found in association with the major four.

Soils

The soils of the region have developed from limestones and clay shales of the Lower Permian and Upper Pennsylvanian Age (Gray and Galloway, 1959). The study areas were divided into two range sites: loamy prairie and claypan.

Loamy prairie sites represent about 70 percent of the total area, and are characterized by a deep (more than 36 inches) fertile soil of the Labette and Summit series (Gray and Galloway, 1959). These soils support a vegetative cover composed mostly of the major four.

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[1]U.S. Weather Bureau Station records, Foraker, Oklahoma

The claypan site occurs in patchwork fashion throughout the area. These soils, belonging to the Parsons series, have 5 to 16 inches of silt loam over a compact clay layer. They have developed from mottled olive, yellow, and dark brown clayey shales (Gray and Galloway, 1959). Because of the tightly compacted clay layer, water and root penetration is poor. Therefore, deep rooted grasses give way to the shallow rooted buffalograss (Buchloe dactyloides [Nutl.] Engelm.), and blue grama (Bouteloua gracilis [Willd.] Griffiths).

Figure 1. Bluestem prairie in the Osage Hills

CHAPTER IV

METHODS

Forage Production

Description of the Area

Forage production data was recorded from plots in a native grass hay meadow west of the ranch headquarters (Figure 2). Hazell (1964) found that little bluestem was the dominant species in this meadow comprising 62.4 percent of the total grass composition. Big bluestem made up 23.5 percent, indiangrass 5.5, and switchgrass 2.2 percent of the grass composition. Other grasses found in association with these major four were buffalograss, tall dropseed, and sideoats grama.

Plot Establishment

The plots were established on this loamy prairie range site April 11, 1963. Each plot was 30 feet long and 15 feet wide, and was separated from adjoining plots by a 6 foot wide mowed strip (Figure 3). Plots were laid out in a randomized complete block design with five replications (Figure 4).

Burning

Three plots in each replication were burned at the time of plot establishment, April 11, 1963 (Figure 5). These plots were designated as B, D, and F (Figure 4).

During the burning period, certain measurements were recorded. All plots were burned against a northeasterly wind with a velocity of 10 to

Figure 2. Forage production plots in a tall grass hay meadow near the ranch headquarters.

Figure 3. Forage production plots showing plot layout and mowed separation strip.

Figure 4.

Forage Production Plot Diagram

NORTH

B-1 Burn —— B-2 Burn	D-1 100#N Burn —— D-2 100#N Burn	C-2 100#N —— C-1 100#N	F-1 50#N Burn —— F-2 50#N Burn	E-2 Control —— E-1 Control	A-1 50#N —— A-2 50#N	I
B-2 —— B-1	A-1 —— A-2	C-2 —— C-1	F-2 —— F-1	D-2 —— D-1	E-1 —— E-2	II
D-1 —— D-2	E-2 —— E-1	F-1 —— F-2	A-1 —— A-2	C-1 —— C-2	B-1 —— B-2	III
B-2 —— B-1	F-2 —— F-1	E-1 —— E-2	D-2 —— D-1	C-1 —— C-2	A-1 —— A-2	IV
F-2 —— F-1	D-2 —— D-1	C-1 —— C-2	A-1 —— A-2	E-1 —— E-2	B-1 —— B-2	V

15 miles per hour. The sky was overcast. Air temperature was 68.5° F. and the relative humidity 33 percent, when burning began at 1:30 p.m. Air temperature and relative humidity were 64° F. and 38 percent, respectively, at the termination of burning. Approximately 1,500 to 1,800 pounds of dead vegetation per acre were burned. Moisture content of this material was 18.5 percent. Rhizomes of the major four grass species were breaking dormancy with some green shoots about half an inch high. Average burning time per plot was 12 minutes with a range of 10 to 14 minutes. The soil surface was moist.

Figure 5. Plots being burned against the wind, April 11, 1963.

Soil surface temperatures were recorded using asphalt plates scribed with temperature indicating crayons. These plates were placed on the soil surface just under the mulch layer.

Fertilization

Prilled ammonium nitrate fertilizer was hand broadcast May 11, 1963. Two treatments received 100 pounds of actual nitrogen per acre (C and D) and two treatments received 50 pounds of nitrogen per acre (A and F) (Figure 4).

Clipping

Each plot was divided (see Figure 4) and designated as number one or number two by a coin flip. The plot halves designated number one were clipped at the end of the growing season, August 25, 1963. At that time the samples were separated into big bluestem, little bluestem, indiangrass, switchgrass, other grasses, and forbs. The plot halves numbered two were clipped twice in identical locations on June 18, 1963, and August 25, 1963. No separations were made in these samples.

Five subsamples 11.5" x 24" were clipped at ground level within each of the plot halves. The forage was oven-dried and weighed in grams. The oven-dry weight in grams was multiplied by the factor 50 to determine pounds of forage per acre.

Soil Analysis

Soil samples were taken from the center of each plot November 7, 1963. Cores 2" x 6" deep were taken and composite samples for each treatment were made. The soil analysis was performed by the Oklahoma State University Soils Testing Laboratory.

Forage Utilization

Description of the Area

Forage utilization data was recorded in a 1,500 acre pasture grazed by 157 Hereford and Angus cows with calves. These animals were used to determine the effects of fertilization upon plant preference by their "free choice" grazing. Both loamy prairie and claypan range sites were studied.

Fertilization

Ammonium sulfate fertilizer was applied by tractor and spreader at the rate of 50 pounds of actual nitrogen per acre May 11, 1963, in a strip

50 feet wide across the pasture, fence to fence. This strip lay in an east west direction positioned so that cattle would cross it in their daily travels to salt, water, or grazing areas (Figure 6).

Figure 6. Aerial view of the fertilized strip in the forage utilization study.

<u>Species Composition, Percent Grazed, and Grazed Height</u>

Species composition and the percent of plants grazed were determined along 4 paced transects within the fertilized strip and 2 paced transects along both sides of the strip. A total of 125 points were examined in each transect. This gave a grand total of 1,000 points within the fertilized strip and 1,000 points in the adjacent unfertilized areas. The eight transects were run June 25 and August 20, 1963.

The method of investigation consisted of placing a metal rod into the ground at the toe of the observer every 8 paces. The perennial grass nearest the point was identified and recorded as grazed or ungrazed and heights recorded in inches.

CHAPTER V

RESULTS AND DISCUSSION

Forage Production

Twice Clipped vs. Once Clipped

Two seasonal clippings significantly[1] increased forage production over one seasonal clipping for all unburned treatments (Figure 7). The control plots clipped twice during the growing season averaged 3,329 pounds of oven-dry forage per acre while the control plots clipped once, at the termination of growth, produced 3,088 pounds of forage. Yield from plots treated with 50 pounds of nitrogen and clipped once was 2,457 of forage per acre, but increased to 3,875 pounds when clipped twice. Those plots which received 100 pounds of nitrogen showed an average yield of 3,197 pounds of forage for the single clipping and 4,041 pounds when clipped twice.

The addition of fertilizer to the plots clipped twice significantly increased their yields over the control. Those treated with 50 pounds of nitrogen increased production 16.4% and plots treated with 100 pounds of nitrogen showed an increase of 21.4% over the control.

When the treatments mentioned above were coupled with burning, a

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[1]Significance established at the 1% level by analysis of variance unless otherwise indicated. See Appendix A for detailed analysis. Individual production figures appear in tables in Appendix B and C.

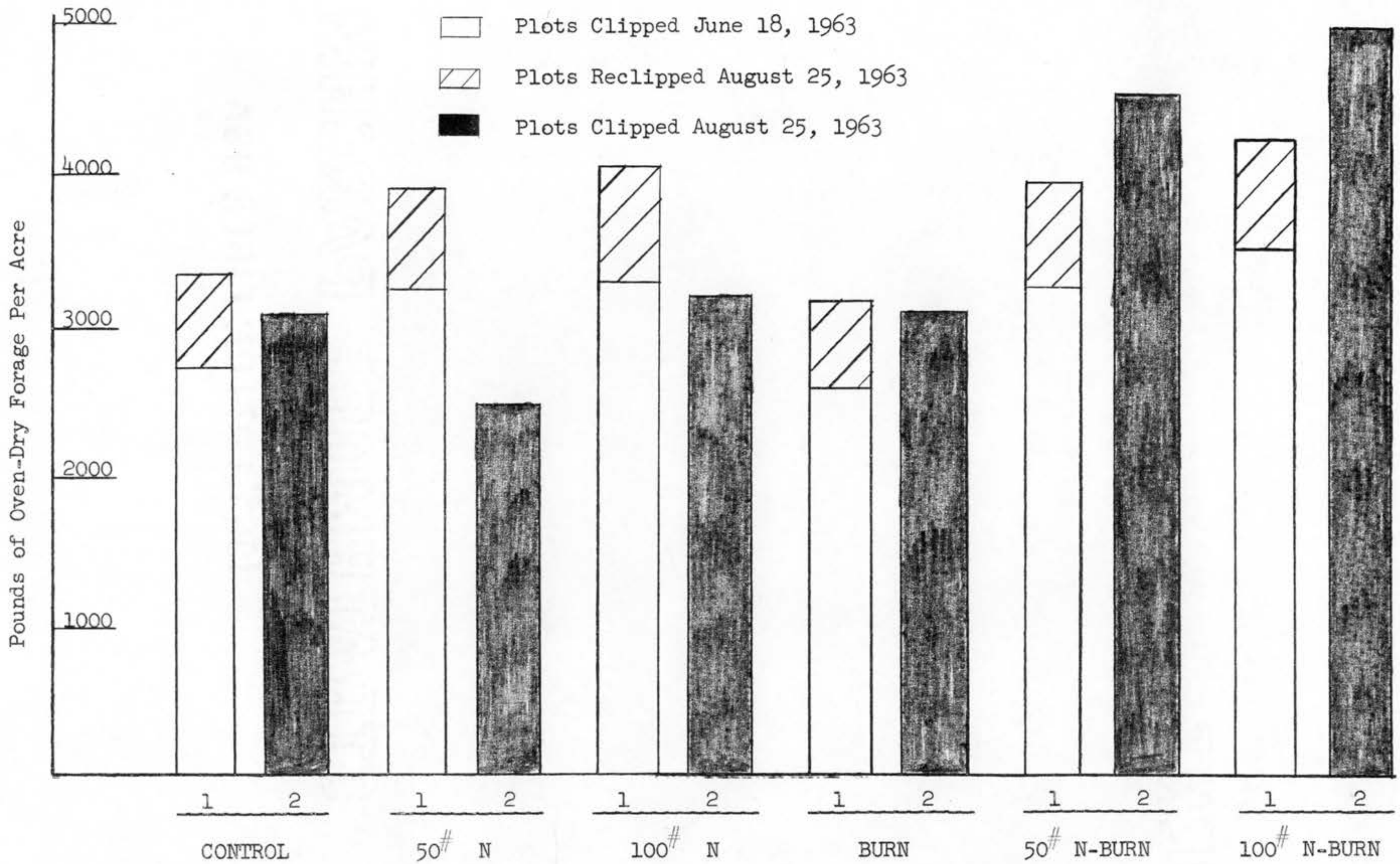

Figure 7. Forage Production by Treatments Comparing Two Seasonal Clippings with One Seasonal Clipping.

different trend was observed. Clipping twice did not significantly increase forage on plots that were burned and unfertilized. Those plots burned and clipped twice produced 3,178 pounds of forage, an increase of only 106 pounds per acre over the plots burned and clipped once (Figure 7). Plots treated with nitrogen fertilizer and burned produced more forage than all other treatments when clipped once. Those burned, treated with 50 pounds of nitrogen, and clipped twice produced 3,918 pounds of oven dry forage compared to the same treatment, clipped once which produced 4,492 pounds, an increase of 14.7% over the double clipping. One hundred pounds of nitrogen combined with burning and one clipping produced 4,921 pounds of forage, a 17.4% increase over the 4,194 pounds for the twice clipped plots.

There was no significant difference in forage produced after the first clipping between treatments in those plots clipped twice. The range of forage produced after the first clipping was 578 to 778 pounds per acre for all treatments. Neither was there a significant difference between burned and unburned plots when fertilized equally and clipped twice. The control and burn only plots, which were clipped twice, differed by a scant 151 pounds of forage and plots treated with 50 pounds of nitrogen and burned produced only 43 pounds of forage more than those treated with 50 pounds of nitrogen only. A difference of only 154 pounds occurred between plots fertilized with 100 pounds of nitrogen and burned and those treated with 100 pounds of nitrogen only.

Moisture conditions probably had a great influence on results obtained. During the early part of the growing season, soil moisture was adequate for good growth and trends in production due to treatments were established at the time of the first clipping (Figure 7). Irouth conditions prevailed the remainder of the season and very little growth response was observed in any treatment, presumably due to limiting moisture.

Mulch appeared to play a role in the forage production of the plots. In the unburned plots, mulch was heavy, and aided early growth by preventing moisture loss from the soil. However, when moisture was depleted and precipitation occurred only as light summer showers, the mulch layer prevented rainfall from reaching the soil, thus causing a decreased response of forage growth to treatments.

Nitrogen Fertilization and Burning

Under the conditions of this study, fertilization as a singular treatment showed little value for increasing yields of forage. Only the plots treated with 100 pounds of nitrogen showed an increase in yeild over the controls (Figure 7). This increase of 109 pounds was not significant. Plots treated with 50 pounds of nitrogen per acre were significantly different from the control plots, but in a negative direction. These fertilized plots produced 25.6% less than the controls (Figure 7).

Both the 50 and 100 pound nitrogen treatments produced less forage at the end of season clipping (August 25) than the same treatments clipped June 18. The reasons for these decreases in production are only speculative. These data were recorded under drouth conditions and forage production in a single season may diminish after a peak is reached when moisture is limiting. In the early season, moisture was adequate and fertilization gave added impetus to forage production. As drouth conditions became severe, growth appeared to halt and dormancy began as moisture was exhausted. Fertilized plots reached this point faster than the controls.

Certain measurements were made at the time of burning. The beginning soil temperature was 59° F. at one-half inch. The soil temperature at the same depth, taken in the center of each burned plot immediately after the line of flame had passed, averaged 67.1° F. with a range of 61° to 72° F. The peak soil surface temperature during the burn averaged 400° F. with a range of 350 to 500 degrees F. It would seem that the temperatures recorded at the rhizome level (one-half inch below the surface) were not sufficient to cause severe injury to the plants.

Burning in combination with nitrogen fertilizer was of great significance as a treatment. Burning alone was not different from the control plots, but with the addition of nitrogen, production increased markedly above all other treatments.

When burned, forage showed the greatest response to the first 50 pounds of nitrogen added. An increase of 45.5% was noted in these plots over the controls, with forage production increasing from 3,088 pounds per acre to 4,492 pounds. The second 50 pound increment of nitrogen, as noted in the 100 pound treatment, increased yield only an additional 13.9% over the control (Figure 7). This combination of treatments also increased yield 54% over the plots treated with 100 pounds of nitrogen only (3,197 pounds per acre).

Here again the effect of moisture and the influence of mulch is clearly shown. Burning grasslands causes earlier initiation of growth by plants from winter dormancy (Aldous, 1934). This fact coupled with fertilizer and the early season moisture caused greater early differences between treatments in the burned plots than the unburned plots as shown by the data from the June 18 clipping. Plots treated with fertilizer only showed a decline in production after the June 18 clipping.

The removal of mulch by burning appears to be an important factor in causing increased yields in the burned plots. By opening the grass stand, light summer rains were allowed to penetrate into the soil. It was noted that puddles were formed after showers in the burned plots, while the soil of unburned plots remained dry. Because of this, green growth was found in burned plots long after unburned plots had become dormant.

Response by Species

The application of 50 pounds of nitrogen per acre increased production of big bluestem from 1,082 pounds per acre in the controls to 1,181 pounds. The addition of 100 pounds of nitrogen decreased big bluestem production to 1,153 pounds. At best, little change in forage production from fertilization alone was noted.

Little bluestem, indiangrass, and switchgrass showed decreases in forage production when fertilized with 50 pounds of nitrogen per acre. Little bluestem dropped from 637 pounds of forage to 436 pounds. There is no apparent reason for this decline. Indiangrass fell from 634 pounds to 456 pounds. And switchgrass decreased from 258 pounds of forage to 24 pounds.

Treatment with 100 pounds of nitrogen per acre tended to bring little bluestem, indiangrass, and switchgrass production to a level comparable with the controls. Of the three grasses, only indiangrass surpassed the control plots production figure. Indiangrass produced 718 pounds of forage, when treated with 100 pounds of nitrogen as compared to 634 pounds of forage in the control plots.

Other grasses and forbs decreased slightly in production when treated with 50 pounds of nitrogen. Both were increased when treated with 100 pounds of nitrogen.

Even though other grasses and forbs increased under the 100 pounds of nitrogen per acre treatment, their production was still proportional to the total forage. In the control plots, other grasses and forbs made up 15.5% of the total, and 18.6% of the total in the 100 pounds of nitrogen per acre.

Burning alone did not significantly change the forage production of species over the controls except in the case of indiangrass, other grasses, and forbs (Figure 8). Indiangrass increased production after burning from 637 pounds of forage to 935 pounds per acre. This was a 46.8% increase. Other grasses and forbs produced a total of 273 pounds of forage per acre when burned. This was a 74.7% decrease from the 477 pounds of production in the control plots.

Burning combined with 50 pounds of nitrogen increased production in all cases (Figure 8). Big bluestem produced 1,369 pounds, an increase of 26.6% over the controls, little bluestem produced 1,008 pounds, a 36.8% increase, indiangrass produced 967 pounds, and increase of 52.5%, and switchgrass increased 110% to a total of 542 pounds of forage.

Other grasses and forbs also showed increases in production. Other grasses produced 304 pounds of forage which is a 50 pound increase over the controls. Although forbs increased over the plots burned only, the 183 pounds per acre figure was still below the 223 pounds of forage produced by the control plots.

Apparently, big bluestem and indiangrass were the most efficient users of nitrogen of the species studied. These two grasses continued to increase in production when burned and treated with 100 pounds of nitrogen. Big bluestem reached a total figure of 2,199 pounds of forage per acre, a 103% increase over the control plots. Indiangrass increased to 1,305 pounds per acre, 105% over the control.

Both little bluestem and switchgrass appeared to reach their most efficient use of nitrogen at the 50 pound level under burning. Little bluestem's production dropped when treated with 100 pounds of nitrogen

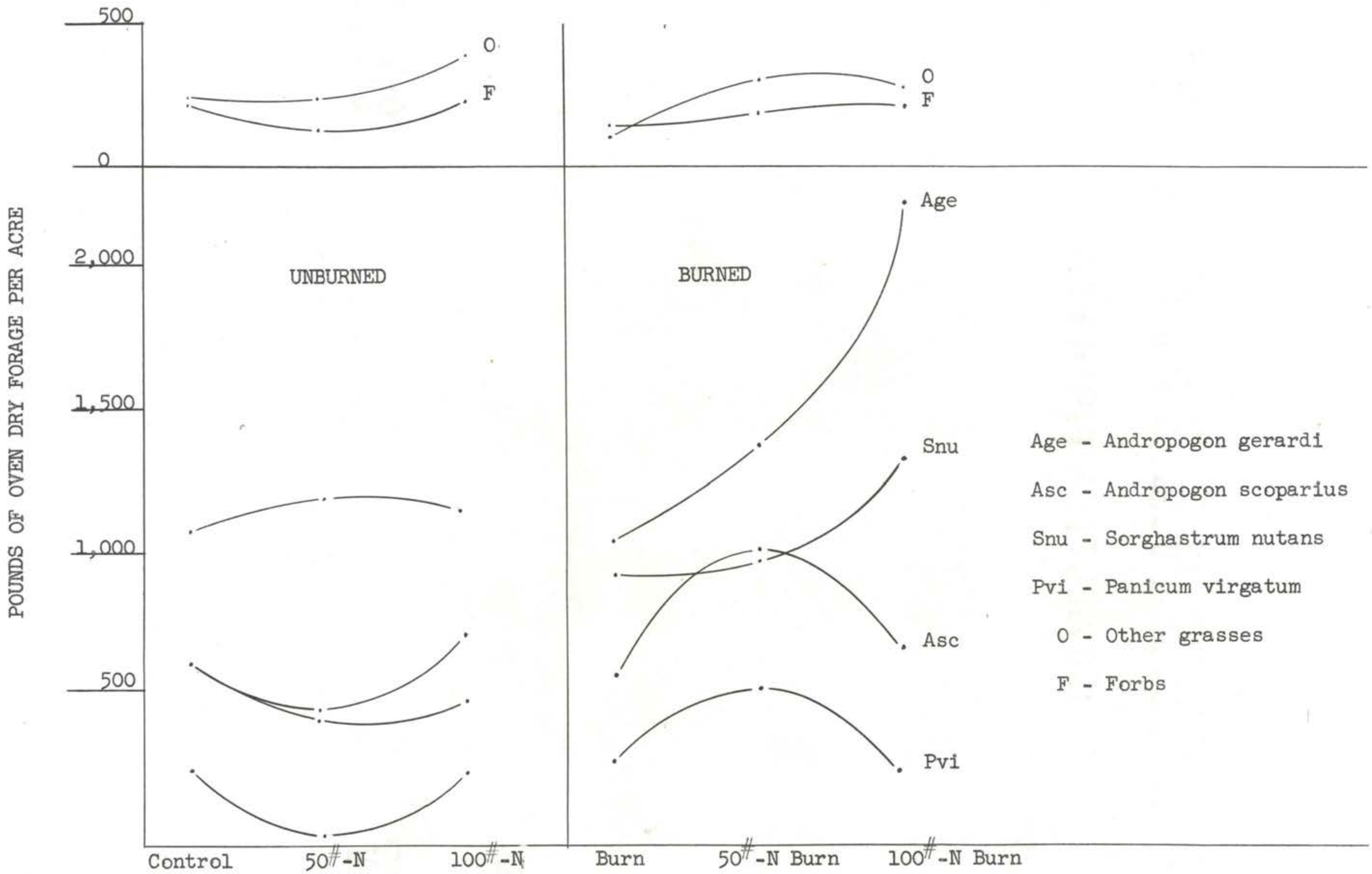

Figure 8. Forage Production Response of Species to Treatments.

and burned. The 676 pounds of forage produced was still a 6.1% increase over the control. Switchgrass responded similarly with forage production of 237 pounds for the 100 pounds of nitrogen and burned treatment. Perhaps these decreases are due to increased competition from big bluestem and indiangrass at the 100 pound level.

Other grasses remained approximately equal in production for the 100 pounds of nitrogen treatment as the 50 pound treatment under burning. Forbs increased slightly with a total figure of 207 pounds of forage per acre. This figure was still below the 223 pounds of forage produced by forbs in the control plots. Other grasses and forbs in the plots treated with 100 pounds of nitrogen and burned composed only 10.2% of the total forage compared to 15.5% in the control plots.

Soil Analysis

The analysis of the soils showed no correlation with treatments (Table II). The value of the analysis was the uniformity shown within the treatments.

TABLE II

SOIL ANALYSIS OF THE FORAGE PRODUCTION PLOTS

Treat.	pH	Per cent Organic Matter	Phosphorus pounds/acre	Potassium pounds/acre	Per cent Nitrogen
Check	5.9	4.9	6.0	330.0	0.226
50#N	6.2	4.8	6.0	350.0	0.218
100#N	6.0	4.7	8.0	280.0	0.204
Burn	6.0	4.8	8.0	300.0	0.204
50#N Burn	6.0	4.7	6.0	340.0	0.212
100#N Burn	6.0	4.9	8.0	410.0	0.216

Forage Utilization

Species Composition

Big bluestem was the most abundant species in both the fertilized and unfertilized areas composing 25.8% and 23.4%, respectively (Tables III and IV). Tall dropseed was second in abundance comprising 25.2% of the vegetation in the fertilized strip and 20.8% in the unfertilized areas. Little bluestem, indiangrass, hairy grama, buffalograss, and switchgrass followed in that order of importance. The transects used to determine species composition crossed both loamy prairie and claypan range sites so the percentages shown in Tables III and IV are a composite of the two sites.

Cattle Preference

The fact that cattle prefer and selectively graze certain native grasses over others was shown by Dwyer (1961) working in this same pasture. Cattle preference was measured by formulating a preference value for each species in both the fertilized and unfertilized areas (Tables III and IV). This value was determined by multiplying the percent grazed times the difference between the ungrazed and grazed height for each species.

Switchgrass was the most preferred in both areas at the time of the June sampling (Table III). Switchgrass had a preference value of 6.6 in the fertilized strip and 3.2 in the unfertilized areas. Indiangrass was the second most preferred grass with a preference value of 4.3 in the fertilized strip and ranked third in the unfertilized areas with a 1.5 value. The positions of indiangrass and switchgrass changed at the August sampling (Table IV). Indiangrass showed the highest preference values, 5.2 for fertilized and 3.3 for unfertilized. Switchgrass fell to sixth with a 3.2 value in the fertilized area.

TABLE III

SPECIES COMPOSITION AND CATTLE PREFERENCE AT THE TIME OF THE FIRST SAMPLING, JUNE 25, 1963

Species	% Composition		% Grazed		Avg. Ungrazed Height Inches		Avg. Grazed Height Inches		Preference Value[1]	
	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.
Andropogon gerardi	25.8	23.4	71.2	41.4	12.6	13.1	7.5	6.8	3.6	2.6
Andropogon scoparius	11.8	14.5	45.3	21.9	12.6	11.7	7.0	6.3	2.5	1.2
Sorghastrum nutans	6.3	6.4	67.6	43.9	13.6	13.3	7.2	9.8	4.3	1.5
Panicum virgatum	5.0	5.3	68.6	32.3	16.2	17.6	6.6	7.8	6.6	3.2
Sporobolus asper	25.2	20.8	12.4	5.9	14.4	22.0	8.4	5.5	0.7	0.9
Bouteloua curtipendula	3.1	4.2	50.0	30.4	11.5	7.8	7.1	5.0	2.2	0.8
Bouteloua hirsuta	5.4	6.7	20.0	0.0	6.2	5.5	4.5	0.0	0.3	0.0
Bouteloua gracilis	4.3	5.1	0.0	25.0	6.6	5.4	0.0	2.5*	0.0	0.5*
Buchloe dactyloides	4.8	5.8	10.7	11.8	3.7	3.7	3.0*	1.5*	0.1*	0.2*
Schedonnardus paniculatus	2.4	2.0	17.6	25.0	5.3	3.4	3.8*	1.4*	0.3*	0.5*
Panicum scribnerianum	2.3	2.2	0.0	0.0	6.5	6.2	0.0	0.0	0.0	0.0
Andropogon saccharoides	1.3	1.2	100.0*	0.0	6.1*	3.0*	0.0	0.0	0.0	0.0
Agropyron smithii	1.0	0.8	30.0*	50.0*	6.2*	7.5*	3.4*	4.7*	0.8*	1.4*

[1]Preference Value = % Grazed x (Ungrazed Height - Grazed Height).

*Values based on five or fewer samples.

TABLE IV

SPECIES COMPOSITION AND CATTLE PREFERENCE AT THE TIME OF THE SECOND SAMPLING, AUGUST 20, 1963

Species	% Composition		% Grazed		Avg. Ungrazed Height Inches		Avg. Grazed Height Inches		Preference Value[1]	
	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.
Andropogon gerardi	25.8	23.4	64.8	44.4	12.4	11.4	5.1	6.6	4.7	2.1
Andropogon scoparius	11.8	14.5	66.7	40.6	11.9	12.2	5.3	5.2	4.4	2.8
Sorghastrum nutans	6.3	6.4	69.4	58.4	15.6	12.0	8.1	6.6	5.2	3.3
Panicum virgatum	5.0	5.3	72.2	13.0	10.3	11.6	5.9	≠	3.2	≠
Sporobolus asper	25.2	20.8	27.9	17.8	23.6	26.8	7.2	8.0	4.6	3.3
Bouteloua curtipendula	3.1	4.2	70.5	25.0	6.6*	6.4	3.6	4.1	2.1*	0.6
Bouteloua hirsuta	5.4	6.7	59.0	32.6	5.4	5.4	2.7	3.0	1.6	0.8
Bouteloua gracilis	4.3	5.1	75.0	62.5	7.2	4.4	2.3	3.3	3.7	0.7
Buchloe dactyloides	4.8	5.8	55.0	28.0	3.5	4.5	2.1	2.0	0.8	0.7
Schedonnardus paniculatus	2.4	2.0	57.2	15.4	4.7*	4.6	2.9	2.0	1.0*	0.4
Panicum scribnerianum	2.3	2.2	20.0	9.1	5.6	6.8	3.3*	5.0*	0.5*	0.8*
Aristida oligantha	0.3*	1.2	50.0	0.0	10.5*	9.5	8.6*	0.0	1.0*	0.0
Andropogon saccharoides	1.3	1.2	75.0	0.0	3.9*	5.9*	5.7	0.0	≠	0.0
Chloris verticillata	1.0	0.4*	40.0	50.0	5.8*	3.8*	3.2	4.5*	1.0*	≠
Agropyron smithii	1.0	0.8	0.0	30.0	0.0	9.4*	0.0	5.0*	0.0	1.3*

[1]Preference Value = % Grazed x (Ungrazed Height - Grazed Height).

*Values based on five or fewer samples.

≠Values are void because of insufficient samples.

Big bluestem ranked third when fertilized and second unfertilized in June. Big bluestem also ranked third in fertilized area at the August sampling date with a value of 4.7 (Table IV). In the unfertilized strip, however, big bluestem rated fourth.

Little bluestem, at the time of first sampling, ranked fourth in both the fertilized and unfertilized areas with respective values of 2.5 and 1.2 (Table III). The second sampling showed that little bluestem had not changed positions in the fertilized strip, but the preference value had increased to 4.4 (Table IV). In the unfertilized area at second sampling, little bluestem dropped to fifth position with a 2.8 value.

The response which cattle showed toward tall dropseed in the late season was interesting. Preference values in the early season for both fertilized and unfertilized areas was 0.7 and 0.9, respectively (Table III). However, at the August sampling, the preference value climbed to 4.6, number three in the fertilized strip, and to 3.3, which shared the number one position with indiangrass, in the unfertilized area. Apparently tall dropseed became more palatable as the season progressed since large amounts of the major four had been removed by grazing.

On the claypan sites, blue grama showed a remarkable preference increase in the fertilized strip during the growing season (Tables III and IV). Blue grama had a preference value of 0 when first sampled, but this value increased to 3.7 at the second sampling. Preference value for blue grama in the unfertilized area did not change.

In all cases, except switchgrass, preference values increased from the first sampling date to the second as shown by Tables III and IV. This was apparently due to increased grazing pressure placed upon all grasses as forage from the more palatable species diminished in the late season. Switchgrass probably declined because its apparent zenith of palatability was reached early in the season (Dwyer, 1961). Switchgrass has a coarse, fibrous habit in late season.

Grazing activities of the cattle were observed in the fertilized area. Regardless of the direction that an animal entered the fertilized strip, some factor registered the animal's attention and they always turned to the right into the strip. The animal would graze parallel to the strip's length, and then turn to the left and continue in the original direction.

Grazing patterns within the fertilized strip were varied, but defined. Some areas of the strip were grazed to ground level in large blocks (Figure 9). In these spots grazing ceased at the fertilized, unfertilized interface. These blocks appeared to be where the established trails crossed. Other portions of the strip showed definite trails (as many as twelve) running side by side parallel to the strip's length. These trails usually extended from the grazed blocks.

Figure 9. View of the fertilized strip showing increased utilization in the foreground.

CHAPTER VI

SUMMARY

The effects of nitrogen fertilization on native vegetation under the conditions of clipping, grazing, and burning were studied on the Adams Ranch in Osage County, Oklahoma. Forage production plots were established in a native grass hay meadow in excellent range condition. One-half of the plots were burned. Plots were fertilized at rates of 50 pounds and 100 pounds of nitrogen per acre with ammonium nitrate. In another study, a 50 foot wide fertilized strip across a 1,500 acre pasture was used to study the effect of fertilizer on forage utilization and preference of cattle. Fifty pounds of nitrogen were applied as ammonium sulfate.

Unburned plots clipped twice during the season produced more forage than unburned plots clipped once. Plots that were burned and fertilized with 100 pounds of nitrogen and clipped once, at the end of the season, produced significantly (1% confidence level) more forage than any other treatment.

Big bluestem was the most efficient user of fertilizer. Indiangrass ranked second. Little bluestem and switchgrass increased when 50 pounds of nitrogen fertilizer were used, but were unable to utilize 100 pounds of nitrogen probably because of increased competition from big bluestem and indiangrass. Both burning, fertilization, and combinations of the two were effective in reducing forbs.

Big bluestem and tall dropseed were codominants within the fertilized strip and the unfertilized areas. Little bluestem, indiangrass, hairy grama, and switchgrass ranked next in composition. All grasses studied were grazed more often when fertilized. The percent grazed increased for each species from the first sampling to the second. Cattle preference also increased for all species between sampling dates. Indiangrass, big bluestem, tall dropseed, little bluestem, and blue grama, in that order, were most preferred when fertilized.

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APPENDIX A

ANALYSIS OF VARIANCE FOR THE FORAGE PRODUCTION PLOTS

Source	df	Sum of Squares	Mean Squares	F
Total	59	65,311,892.5		
Mean	1	798,056,963.3		
Blocks	4	9,325,615.1	2,331,403.8	3.602*
Treat.	11	27,507,051.1	2,500,641.0	3.863**
Fert.	2	8,541,143.4	4,270,571.7	6.598**
Burn	1	5,981,504.8	5,981,504.8	9.241**
Clip	1	714,168.6	714,168.6	1.034
F x B	2	3,860,306.4	1,930,153.2	2.987
F x C	2	345,083.2	172,541.6	0.267
B x C	1	5,693,811.4	5,693,811.4	8.797**
FxBxC	2	12,270,234.3	6,135,117.2	9.479**
Error	44	28,479,226.3	647,255.1	

* Significant at the 0.05 level.

** Significant at the 0.01 level.

THE B x C INTERACTION

Burned	Two Clips (C.1)	One Clip (C.2)	C.1 - C.2
No Burn (B.1)	56,226.9	43,712.3	-12,514.6
Burned (B.2)	56,457.5	62,426.1	5,968.6

C within B.1 = (12,514.6)/30 = 5,220,507.0**

C within B.2 = (5,968.6)/30 = 1,187,472.8 ns

THE UNBURNED EFFECTS WITHIN

FERTILIZER LEVELS

(B.1 within F.1, F.2, and F.3)

Fertilizer Level	Two Clips (C.1)	One Clip (C.2)	C.1 - C.2
None (F.1)	16,645.9	15,441.4	1,204.5
50#-N (F.2)	19,374.5	12,284.1	7,090.4
100#-N (F.3)	20,206.5	15,986.7	4,219.8

C within F.1 = 1,449,616/10 = 144,961.6 ns

C within F.2 = 50,268,100/10 = 5,026,810.0**

C within F.3 = 17,808,400/10 = 1,780,840.0 ns

APPENDIX B

POUNDS OF OVEN-DRY FORAGE PER ACRE FOR PLOTS WITH TWO SEASONAL CLIPPINGS

Blocks	Control	50#-N	100#-N	Burned	Burn 50#-N	Burn 100#-N
		Clipped June 18, 1963				
1	2,816.4	3,165.6	2,857.1	2,314.9	3,421.5	3,656.9
2	3,541.1	2,912.9	2,884.8	2,335.4	3,451.7	3,101.9
3	2,044.1	3,540.0	2,377.2	2,985.0	3,017.0	4,397.4
4	2,644.9	3,861.9	3,688.3	2,749.9	3,290.7	3,505.4
5	2,502.5	2,574.5	3,505.5	2,617.5	2,989.0	2,816.0
$\bar{x}$	2,709.8	3,211.0	3,262.6	2,600.5	3,234.0	3,495.5
		Clipped August 25, 1963				
1	652.7	692.4	638.2	544.6	697.3	700.0
2	521.6	663.9	763.5	581.9	724.7	650.4
3	483.5	543.3	675.5	808.8	637.7	851.6
4	712.1	815.4	891.3	317.9	823.4	762.2
5	727.0	606.6	925.1	636.2	538.3	532.3
$\bar{x}$	619.4	663.9	778.2	577.9	684.3	699.3
$\Sigma\bar{x}$'s	3,329.2	3,874.9	4,040.9	3,178.4	3,918.3	4,194.8

APPENDIX C

POUNDS OF OVEN DRY FORAGE PER ACRE BY SPECIES

FOR PLOTS WITH ONE SEASONAL CLIPPING

Species	Control	50#-N	100#-N	Burned	Burn 50#-N	Burn 100#-N
Age	1,082.0	1,180.8	1,153.1	1,037.2	1,369.0	2,199.2
Asc	637.0	436.3	484.4	535.1	1,008.0	675.6
Snu	633.6	456.3	718.5	935.3	967.1	1,305.4
Pvi	258.3	24.4	245.0	291.5	542.3	237.1
O	254.1	230.7	374.7	126.0	304.3	297.1
F	223.4	136.9	221.6	146.8	182.8	206.9
Total	3,08813	2,456.8	3,197.4	3,071,8	4,492.0	4,921.4

Age - *Andropogon gerardi*

Asc - *Andropogon scoparius*

Snu - *Sorghastrum nutans*

Pvi - *Panicum virgatum*

O - Other Grasses

F - Forbs

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