Central Oklahoma Rangeland Response to Fire, Fertilization and Grazing by Sheep

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Abstract

Species composition and herbage production responses to burning and fertilization were studied on poor condition, naturally revegetated Oklahoma rangeland. The April, 1973 burn reduced early spring herbage production, but the difference was less by July. Fertilization increased herbage yield in the spring. By December, there was no difference in forage yield in response to either burning or fertilization. The effect of burning on individual species density varied according to the species, but none of the differences were highly significant. Fertilization did increase the density of total desirable grasses and total desirable forage and decreased density of certain undesirable grasses.

Burned areas were utilized more heavily by grazing sheep than were unburned areas. Total herbage on burned areas in June, 1974, was reduced by 70% in contrast to 123% increase on fertilized areas. The effect of burning declined with advanced plant maturity and the effect of fertilization became more evident. On fertilized areas, organic matter was higher and soil pH was lower on certain sampling dates. Dry matter and crude protein contents were highly variable in vegetation from all treatment areas, but generally higher on burned or fertilized areas. Digestible dry matter content was higher on fertilized areas.

Central Oklahoma Rangeland Response to Fire, Fertilization and Grazing by Sheep

J. Powell, H. T. Zawi, J. J. Crockett, L. I. Croy and R. D. Morrison*

Oklahoma has over eight million ha. of native grasslands (Gay and Dwyer 1965). Large portions of this land were plowed 50 to 75 years ago for crops and have been abandoned since. As a result, the land has become eroded with shallower topsoil and reduced organic matter content. Consequently, the productivity of this rangeland has been very much reduced.

In a study in the Southern Great Plains, Savage and Runyon (1937) found that none of the abandoned fields possessed a cover comparable in composition with the climax of the region, even after 40 years. In central Kansas, the climax composition was not attained in a field which had been abandoned for 33 years (Tomanek et al. 1955).

Booth (1941) found succession in abandoned fields in central Oklahoma included four stages: (1) weeds, (2) annual grass, (3) perennial bunchgrass and (4) true prairie. The weed stage lasted from 9 to 13 years and was dominated by prairie threeawn (*Aristida oligantha*). The perennial bunchgrass stage was dominated by little bluestem (*Schizachyruim scoparium*), and this stage was still present 30 years after abandonment.

Penfound (1964) conducted a study on succession in a moderately grazed tallgrass prairie and found, with complete protection, the vegetation changed from midgrass to midgrass-tallgrass to midgrass-tallgrass-woody plants in 13 years. This would indicate this tallgrass prairie might be succeeded by a woody plant climax.

Grasses occurring early in succession may have a competitive advantage over climax grasses because nitrogen requirements of early succession grasses are relatively low (Roux and Warren 1963). In central Oklahoma, nitrogen and phosphorus requirements of prairie threeawn, little bluestem and switchgrass (*Panicum virgatum*) increase in that order (Rice et al. 1960). This is also the relative order in which these species invade abandoned cropland and occur in succession on depleted rangeland. Soils in abandoned cropland and depleted ranges in Oklahoma are usually low in nitrogen and phosphorus. Soils in later stages of succession contain higher amounts of these elements (Roux and Warren 1963).

The use of fertilizer on ranges is a practical means of increasing forage production in certain situations. However, some range fertilization studies have shown inconsistent or undesirable effects. In Oklahoma, Huffine and Elder (1960) found fertilized rangeland produced two to five times more weeds than unfertilized rangeland. On the other hand, McMurphy (1970) reported nitrogen fertilized areas produced significant

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increases in forage yield over that from unfertilized areas. He also found the nitrogen plus phosphorus treatment often produced an additional increase compared to nitrogen alone. Similar results were obtained by Elder and Murphy (1958).

In a Northern Great Plains study by Casper et al. (1967), a single application of nitrogen fertilizer on a deteriorated range site changed the botanical composition from predominantly forbs and shortgrass species to a western wheatgrass (*Agropyron smithii*) and shortgrass composition. Nitrogen also increased both the forage yield and crude protein content. Forage yields were increased by the increased number of midgrasses as well as with the nitrogen application. Two years of fertilization with 90 pounds of nitrogen did more to improve range condition and increase production than six years of complete deferment (Rogler and Lorenz 1957).

Controlled burning is considered an effective range improvement tool and is frequently used by ranchers to improve herbage quantity and quality. For many years, prescribed burning has been suggested as a major factor in promoting and maintaining high forage yields in the South (Duval 1962). Fire often benefits plant growth by increasing organic matter and mineral elements in the soil (Ahlgren and Ahlgren 1960). However, Grelen and Epps (1967) concluded that litter removal on bluestem range, either by mowing and raking or burning, was the major cause of increased yields and improved quality of forage.

Fire also improves botanical composition (Graves and McMurphy 1969). In Oklahoma, the reduction of prairie threeawn and rapid recovery of decreaser species were the most obvious improvements.

Aldous (1934) observed that succession was affected by burning. There are fewer plants in the plots burned in late spring than those burned in the fall. With late spring burning, the number of grasses remained fairly constant, but there was a measurable decrease in the number of weeds and sedges present.

Gay and Dwyer (1965) noted that burning in combination with nitrogen fertilization increased forage production significantly more than any other treatment including fertilization only. They also found that burning, fertilization and their combination promoted grasses more than forbs.

Increases in herbage yield following fire also occur in more humid sections of true prairie (Hadley and Kieckhefer 1963). This is contrary to results obtained in the drier Kansas Flint Hills where herbage yields have been lower on ungrazed areas burned annually than on adjacent ungrazed, unburned areas (McMurphy and Anderson 1963). During a 30-year burning study of Kansas Flint Hills bluestem range, burned areas yielded significantly less herbage than unburned areas regardless of the time of burning. However, areas burned in the late spring yielded more than those burned earlier.

In a long-term fertilization of a tallgrass range near Stillwater, Oklahoma, the combination of nitrogen, phosphorus and potassium fertilizers produced the greatest herbage yield compared to the application of nitrogen, phosphorus or potassium alone (Harper 1957). However, McMurphy (1970) reported that in spite of forage production increases in Harper's study, it was not economical to fertilize at that time considering the existing value of forage and cost of fertilization. The economic feasibility of a practice naturally depends on the existing value: cost ratio and the total range management plan.

Very little information is available on the effects of sheep grazing on rangeland vegetation in central Oklahoma. Rangeland research on improvement of naturally revegetated, abandoned cropland is also limited. Therefore, the objective of this study was to determine the rangeland improvement potential of burning, fertilization and sheep grazing on the range condition, quality and production of naturally revegetated, abandoned cropland in central Oklahoma.

Figure 1. View of the study area.

Study Area

The study area is on abandoned cropland last plowed about 40 years ago and allowed to revegetate naturally (Fig. 1). It is located about 7 km southeast of Stillwater, Oklahoma. The area has a continental climate with the annual precipitation (820 mm) distribution being 34% (November-March), 21% (April-May), 28% (June-August) and 17% (September-October). The 82-year monthly average ranged from 29 mm in January to 117mm in May (Fig. 2). The absolute minimum precipitation value during this two-year study was 13 mm in January, 1974. The absolute temperatures during this study (Fig. 3) ranged from -20°C in January, 1973, to 43°C in July, 1974.

The primary vegetation in the area consisted of an open grassland with an overstory of oaks (*Quercus* spp.) in some places. The ground cover ranged from bare ground and litter accumulations to tall and midgrasses. The most common grass species in the area included prairie threeawn, bermudagrass (*Cynodon dactylon)*, little bluestem and splitbeard bluestem (*Andropogon ternarius)*. The most common forbs in the area included common yarrow (*Achillea lanulosa)*, western ragweed (*Ambrosia psilostachya)* and goldenrod (*Solidago* spp).

Four different soil types occurred in the study area. The most common is Zaneis loam-a member of the fine-loamy, mixed, thermic family of Udic Argiustolls. The surface layer is dark-brown loam with a granular structure about 23 cm thick. The subsoil is about 99 cm thick.

The second most common in the Stephenville fine sandy loam-a member of the fine-loamy, siliceous, thermic family of Ultic Haplustalfs. The surface layer is about 36 cm thick and consists of fine sandy loam that is neutral to medium acid. The subsoil is about 66 cm thick.

Of lesser abundance is Lucien sandy loam-a member of loamy, mixed, thermic, shallow family of Typic Haplustolls. The surface layer is reddish-brown, slightly acid, fine sandy loam about 10 cm thick. The subsoil is about 28 cm thick.

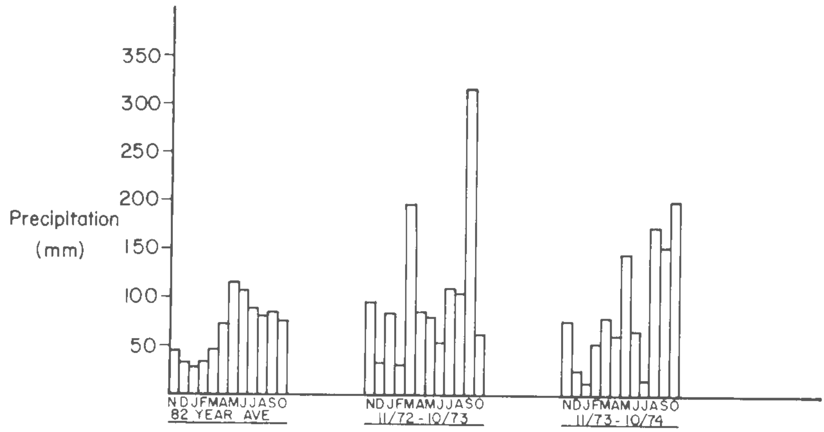

Figure 2. Monthly precipitation (mm) for study area.

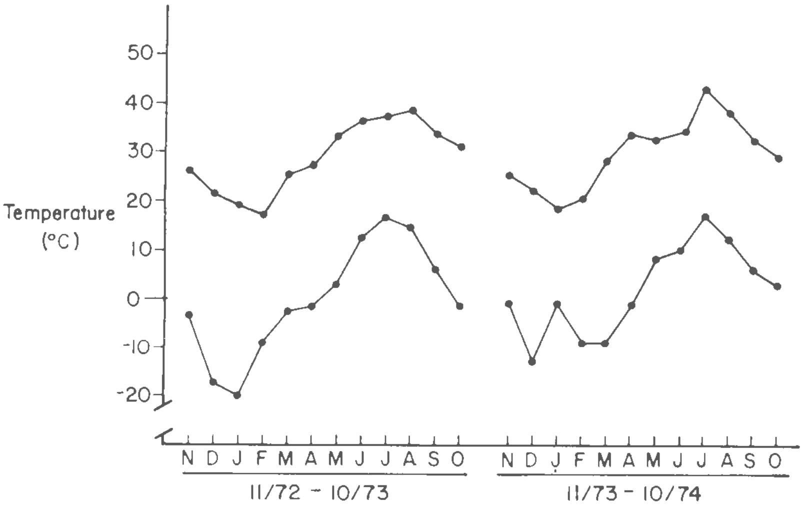

Figure 3. Monthly absolute maximum temperatures (°C) during study.

The least common is Vernon clay loam-a member of the fine, mixed, thermic family of Typic Ustochrepts. The surface layer is reddish-brown, calcareous clay loam about 15 cm thick. The subsoil consists of red clay about 23 cm thick. The Lucien and Vernon soils in this study area were commonly intermingled as a complex mapping unit.

Analysis of soil samples from the study area showed that organic matter, phosphorus and potassium contents of the soil were low (Table 1). The average phosphate content of the soil was 3 ppm, while the critical level of phosphate for optimum crop production as determined by Baker and Tucker (1973) is 32 ppm. The average potash content of the soil was 62 ppm in contrast to the optimum of 125 ppm.

Table 1. Average Values for Study Area Soil Characteristics, 0-30 cm.

	pH	Organic Matter (%)	Extractable Nutrients (ppm) Phosphate	Potash	Calcium	Magnesium	Sodium
$\bar{X}$ ± sd	5.8 ± 0.25	1.21 ± 0.15	3 ± 2	62 ± 17	700 ± 188	235 ± 109	80 ± 95
Range	4.6-7.6	0.3-2.0	1-12	30-140	250-1200	100-600	30-600

Methods and Materials

A randomized block experimental design was employed using four replications, NW, NE, SW and SE. Each replication was randomly subdivided into four treatments: fertilized, burned, burned-fertilized and untreated (Fig. 4). The treatment areas were 0.25 ha each in the NE and SE replications; 0.18 ha in the NW and 0.34 ha in the SW replication. The treatment areas in the SW replication were larger to compensate for the reduction in herbage yield due to a relatively dense overstory of trees in this area.

On the first week of April, 1973, fertilizer was applied at the rate of 200 kg of ammonium nitrate (33-0-0) per ha and 73 kg of superphosphate (0-45-0) per ha to all treatment areas to be fertilized in the NE and SE replications. Fire was applied prior to fertilization to all treatment areas to be burned at the same date. The same fertilization treatments were applied to the NW and SW replications one month later.

On April 2, five conical-shaped cages, 0.75m² at the base, were placed at five different systematically selected locations within each plot in the NE and SE replications. A band of 20 lambs with an average weight of 23 kg grazed the area. On May 11, the NE and SE replications were sampled for grass and forb production by the weight-estimate method (Pechanec and Pickford 1937). A 0.5 m² circular quadrat located 3 m away from a cage was used to estimate production of grasses and forbs on grazed areas. Herbage was clipped at a 5 cm stubble height at one randomly selected location in each treatment area to establish estimation accuracy. Clipped samples were weighed in the field, dried at 60°C, reweighed for dry matter content and analyzed for Kjeldahl nitrogen and in vitro digestible dry matter (Tilley and Terry 1963) contents.

On May 11, cages and sheep were moved to the NW and SW replications. Caged and grazed vegetation on these replications was sampled on July 20 using the weight-estimate method. The sheep were then moved to the NE and SE replications. The NE and SE replications were sampled on December 9, for herbage production, dry matter and Kjeldahl nitrogen contents.

In December, 1973, each treatment area was sampled for species composition using five 50 m transect lines located about 8.5 m apart and 8.5 m inward from the sides of each area. Five points, spaced 10 m apart, were located along each transect line. Using the 10-pin, point quadrat method (Levt and Madden 1933, Becker and Crockett 1973) at each point, ten hits were determined to be litter, bare ground or vegetation (by species).

On April 28, 1974, nitrogen fertilizer (33-0-0) was again applied at the rate of 67 kg/N/ha to treatments on all four replications. None of the areas, however, were burned in 1974.

Grazing on all four replications started on May 2. Sheep grazing had to be eliminated by June 3 due to dog predation which resulted in the death of 10 sheep by that time.

Soil samples (0-30 cm) were collected at each clipping location with a soil auger. The gravimetric soil water content of each soil sample was determined before pH and

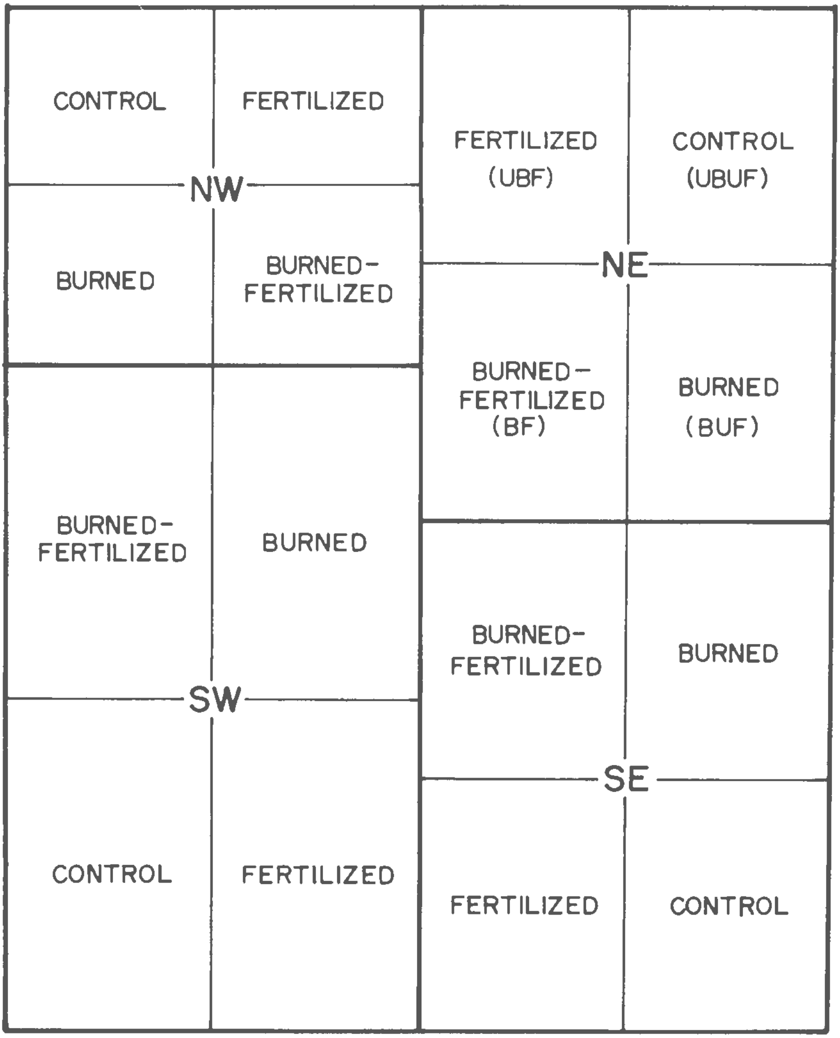

Figure 4. Experimental replications and treatments.

organic matter were determined by the O.S.U. Department of Agronomy Soil and Water Testing Laboratory.

Crude protein content of herbage was determined by multiplying nitrogen content (%) by 6.25. Percent utilization was determined by dividing the difference in caged and grazed production by the caged production. The proportion of each species class in the diets was computed as the ratio of the amount of each species class utilized to the total herbage utilized.

All statistical analyses were conducted using the Statistical Analysis System (Barr and Goodnight 1972) and the O.S.U. IBM 370/158 computer. Unless otherwise indicated, all differences discussed were significant at the 5% probability level or less.

Results and Discussion

1973 Herbage Production and Chemical Composition

Spring. On May 11, 1973, 40 days after the areas were burned, production by all species classes was 30-60% less on burned areas than on unburned areas (Fig. 5). Production of annual grasses was reduced ($P < .18$) relatively more than for perennial grasses or forbs. The deleterious effect of burning on spring production was in contrast to fertilization which increased herbage production. The increase in herbage production on fertilized areas was due to primarily to a large increase ($P < .18$) in forb production. However, the increase due to fertilization occurred only on the unburned areas and not on the burned and fertilized areas. Production was 15 to 20% lower on the burned and fertilized or burned and unfertilized areas than on the untreated areas.

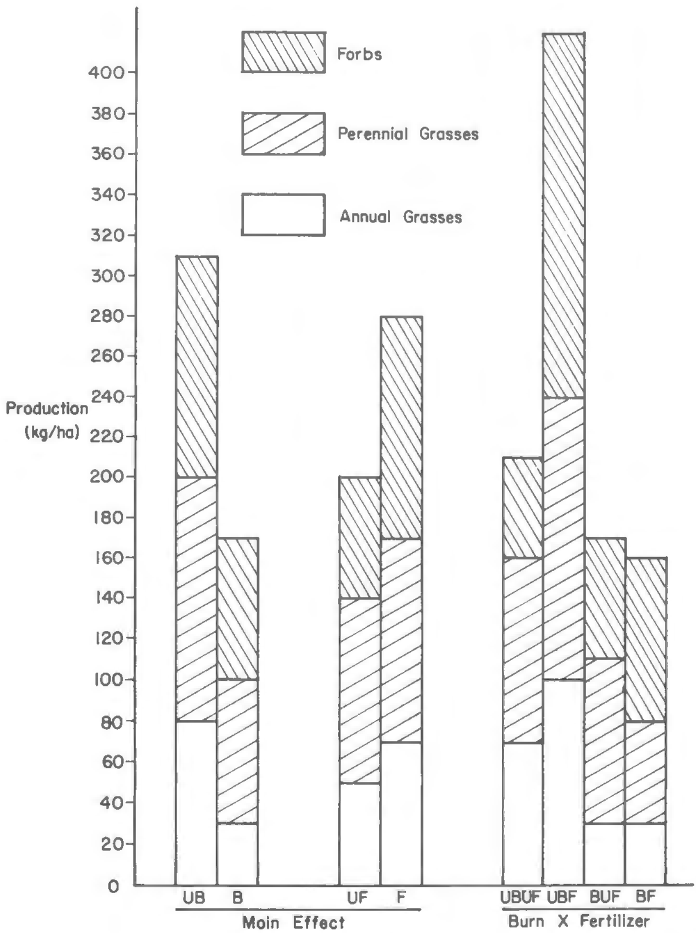

Figure 5. Dry matter production (kg/ha) on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, May, 1973.

Dry matter and crude protein contents were highly variable in vegetation from all treated areas (Fig. 6). Consequently, differences shown are inconclusive. Digestible dry matter content, however, was 11% higher on unburned, fertilized areas as compared to burned, fertilized areas($P< .13$). This may have been caused by a difference in species composition on unburned, fertilized areas as compared to burned, fertilized areas. After an extensive review of nutritive values resulting from pasture fertilization, Blaser (1964) suggested that total digestible nutrients changed little with nitrogen fertilization because increases in crude protein digestibility offset decreases in soluble carbohydrates.

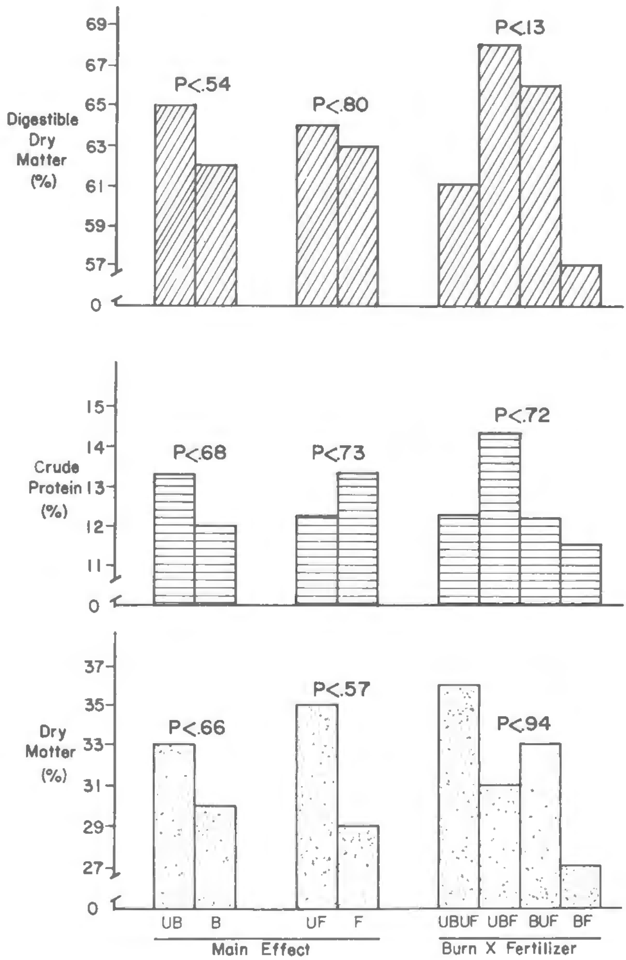

Figure 6. Plant chemical composition on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, May, 1973.

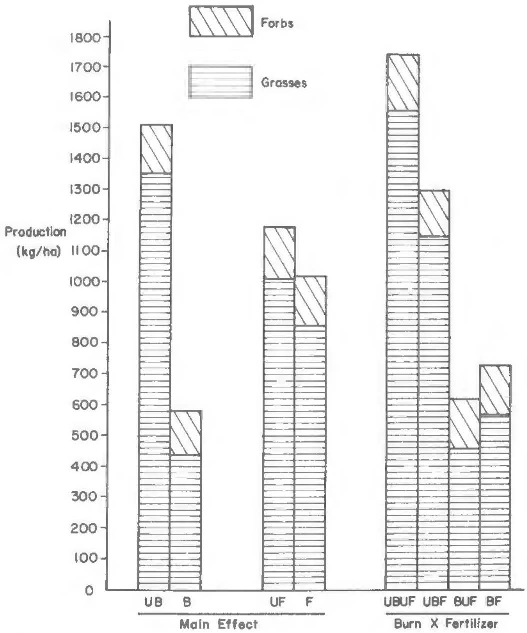

Figure 7. Dry matter production (kg/ha) on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, July, 1973.

Summer. The summer sample was collected from the NW and SW replications. Herbage production on burned areas sampled in July had less grass production, but about the same forb production (Fig. 7). The effect of fertilization was small and inconsistent in areas fertilized in April and sampled in July.

Crude protein content was greater ($P < .17$) on fertilized areas and was unaffected by burning (Fig. 8). Percent dry matter digestibility was slightly greater both on burned areas and on fertilized areas, but results were highly variable. The percent dry matter digestibility appears to be inversely related to dry matter content. Burning reduced the dry matter content in herbage, probably due to retarded maturity and increased succulence in plants.

Fall. By December 9, grasses on burned areas had recovered from burning and yielded as much as the unburned areas (Fig. 9). Differences in grass production and in forb production due to fertilization were also negligible by December. Forb production was much less in the fall than in the spring as a result of the advance in the growing season and maturity of spring and summer forbs which constituted the majority of the forbs in the area. Also, sheep utilization of forbs was relatively high. Crude protein content was less ($P < .11$) on burned than on unburned areas (Fig. 10) and declined from 12.0% on burned areas in May to 4.2% in December due to advanced plant maturity.

Ground Cover

The main effects of burning and fertilization shown in Fig. 11 are somewhat misleading because of differences due to the interaction between burning and fertiliza-

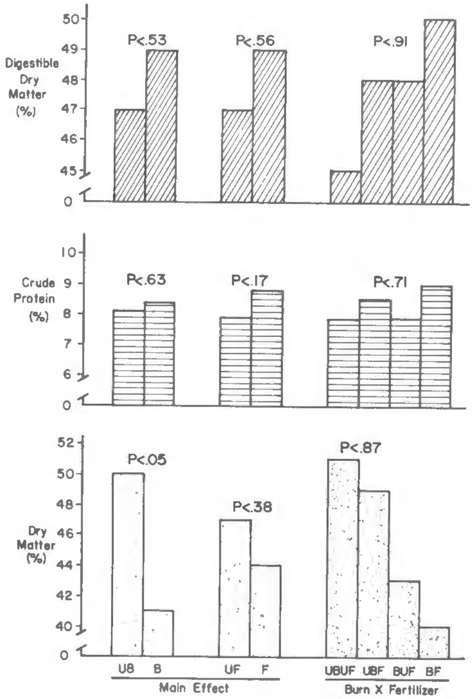

Figure 8. Plant chemical composition on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, July, 1973.

tion. On unfertilized areas, the number of point-contacts for bare ground, litter and live plants was very similar. However, on unburned areas, fertilization increased the number of live plants and decreased the percent bare ground. On burned and fertilized areas, the number of bare ground hits were much greater and litter hits much less than on untreated areas or on unburned and fertilized areas. The combination of burning and fertilization may have caused more concentrated grazing and trampling by sheep on these areas.

The effect of fire varied from one species to another. Some grasses showed a slight increase in density in response to fire, while the other species decreased (Table 2). Lower successional species, such as Japanese brome (*Bromus japonicus)*, splitbeard bluestem and prairie threeawn were the most reduced in abundance by burning. Most of the desirable grass species were increased by fertilization; whereas, the lower successional species were reduced. Bermudagrass was the grass species most increased by fertilization. Lower successional stage species, such as prairie threeawn, prevailed on low fertility soils on old fields in central Oklahoma, and hence, retarded the invasion of higher successional stages species which require more nitrogen and phosphorus (Rice 1976). Rice suggested that nitrogen and phosphorus fertilization enhances succession on abandoned fields. Prairie threeawn density was very much reduced on fertilized areas in this study. It should be emphasized that responses of the different species to fertilization may have been greatly modified by grazing preferences of the sheep. However, except on hay meadows, grazing on rangelands is to be expected and range improvement research should be conducted under grazing conditions.

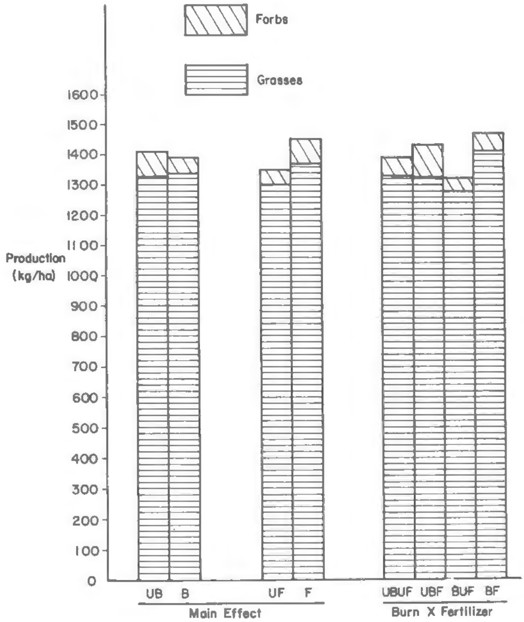

Figure 9. Dry matter production (kg/ha) on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, December, 1973.

Herbage Utilization and Sheep Diet

Forbs were an important component of the diet, but declined in importance as the season progressed. The average percentage of forbs in the diet was about 50% in early spring, 20% during late spring and early summer and 10% during late summer and fall (Fig. 12). This decline coincided with the decline in forb availability, but the percentage in the diet was consistently higher than the percentage in total herbage. Like most animals, sheep are selective in their grazing (Van Dyne and Heady 1965), and selectivity by sheep was exhibited in this study.

The effect of treatments on sheep diet was much more pronounced in early spring than later in the year. Differences in percent forbs in the diet due to the burning and fertilization interaction were significant at the .2% level in early spring, 21% in summer and 60% in fall. During early spring, forbs comprised a much higher percentage of the diet on burned and fertilized areas than on other areas.

In the early spring utilization period (Fig. 13), sheep utilized relatively greater percentages of forbs than grasses on most areas with no difference in utilization due to treatments. The major difference in utilization occurred on the burned and fertilized areas with forbs being utilized at a much greater percentage of available herbage. By late spring and early summer, forb utilization differences increased ($P < .13$) on burned areas, while grass utilization differences increased ($P < .09$) on fertilized areas (Fig. 14). Grass and total herbage utilization was higher on all treated areas than on the untreated areas.

ble 2. Average Number of Species Class Point-Contacts Per Treatment, December, 1973

	Treatment										
	Main Effect										
	Burn			Fertilizer			Burn X Fertilizer				
	UB [1]	B [2]	P [3]	UF [4]	F [5]	P	UBUF	UBF	BUF	BF	P
al Grasses	172	156	.12	157	172	.15	156	189	157	155	.10
esirable Grasses	101	108	.70	77	133	.01	72	130	81	136	.91
Sedge spp.	5	3	.55	4	4	.95	7	3	1	5	.09
Bermudagrass	56	68	.50	38	86	.05	29	83	47	89	.73
Scribner's panicium	11	13	.63	12	13	.76	11	12	12	14	.85
Little bluestem	15	12	.52	11	16	.67	17	14	6	18	.72
Bristlegrass	1	2	.59	0	3	.12	0	3	1	3	.80
Dropseed	8	6	.54	7	8	.62	4	12	9	4	.01
ess Desirable Grasses	12	8	.52	11	8	.58	10	12	12	4	.33
Silver bluestem	1	1	.98	2	1	.72	5	3	3	0	.05
Japanese brome	5	1	.15	3	3	.93	6	5	0	1	.80
Fall witchgrass	4	5	.68	6	3	.30	4	4	8	2	.23
ndesirable Grasses	59	39	.22	68	30	.05	73	45	63	15	.53
Splitbeard bluestem	17	7	.11	16	9	.22	23	11	9	6	.60
Prairie threeawn	40	30	.58	51	18	.01	49	30	53	7	.27
bs	11	8	.64	9	10	.60	10	12	8	8	.71

nburned; 2 Burned; 3 Probability level; 4 Unfertilized; 5 Fertilized.

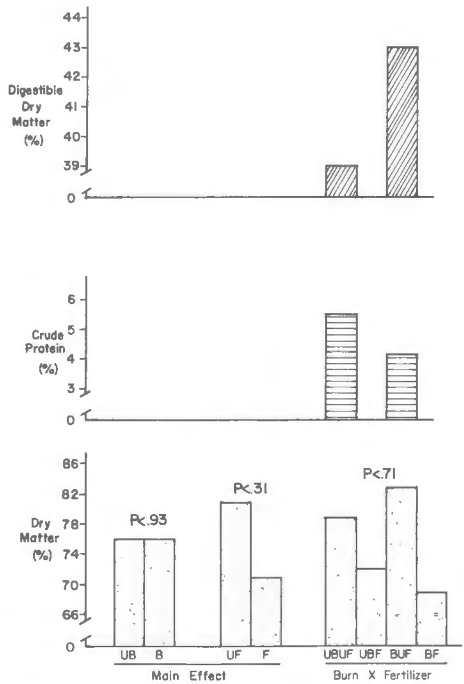

Figure 10. Plant chemical composition unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, December, 1973.

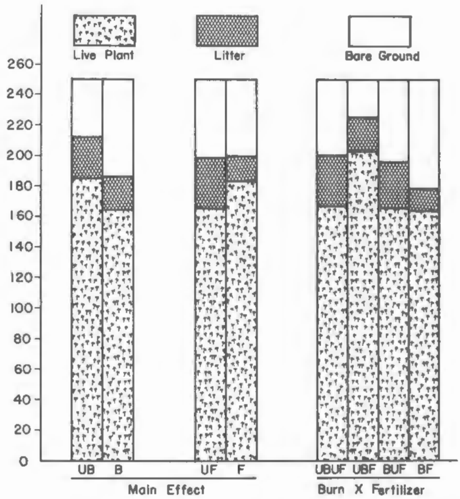

Figure 11. Average number of ground cover point-contacts per treatment, December, 1973.

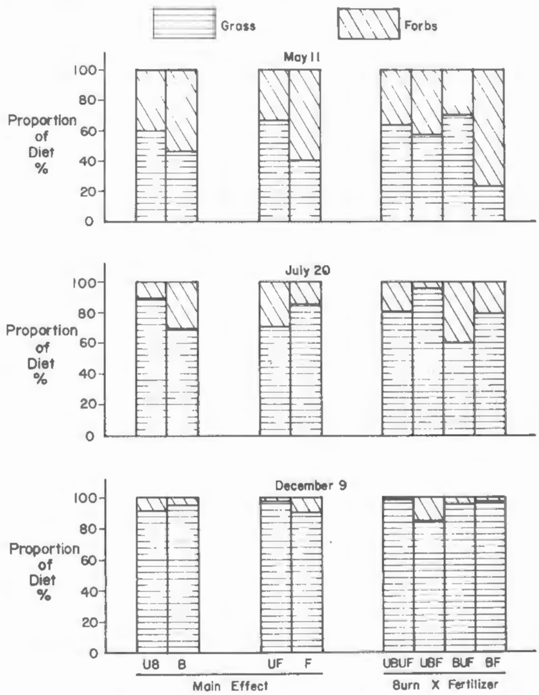

Figure 12. Proportion (%) of grass and forbs in diet of grazing sheep on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, 1973.

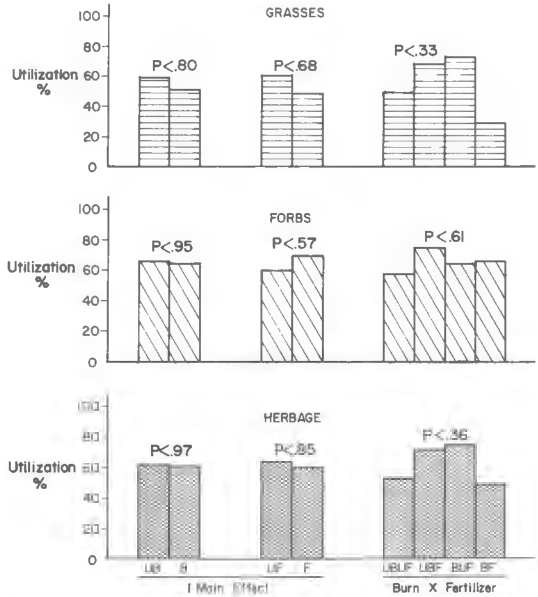

Figure 13. Early spring utilization (%) of grasses, forbs and herbage by grazing sheep on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, 1973.

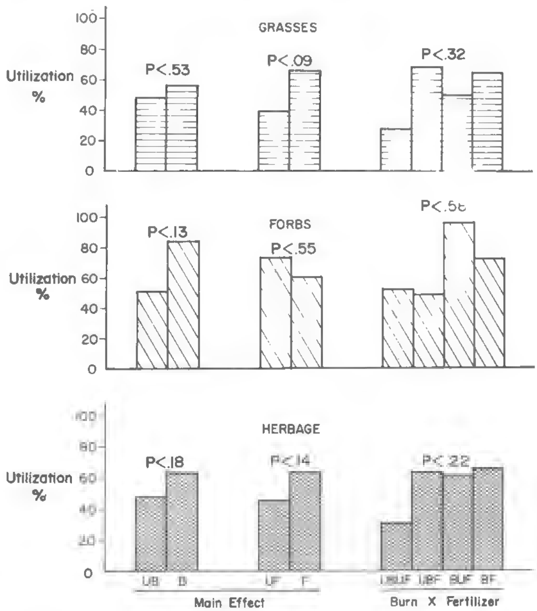

Figure 14. Late spring - early summer utilization (%) of grasses, forbs and herbage by grazing sheep on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, 1973.

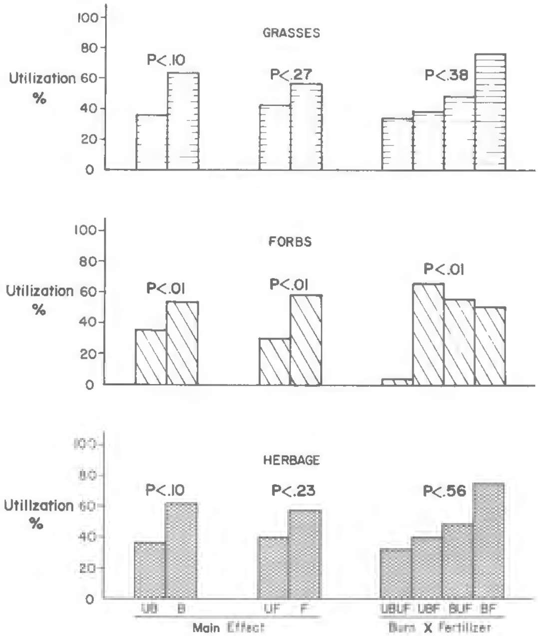

Figure 15. Late summer - fall utilization (%) of grasses, forbs and herbage by grazing sheep on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, 1973.

During late summer and fall, differences in forb utilization due to treatments were much greater than during earlier seasons (Fig. 15). Forb utilization varied from 50 to 60% on treated areas, but was only about 5% on untreated areas. Apparently, the treatments produced an effect on species composition or palatability which greatly influenced animal preference. Forb utilization was similar on all areas in the spring, and forb production was similar at the end of the fall season.

1974 Herbage Production and Chemical Composition

Late Spring. Grass and total herbage production was lower on burned areas on June 9 than on unburned areas (Fig. 16). Most of this difference was due to the low production on burned and unfertilized areas. Since production was similar on all areas in December, 1973, this difference in production might have been the result of greater utilization of burned areas by the sheep which grazed the area from early May to early June, 1974. Tallgrass production on fertilized areas was about twice that on unfertilized areas. Tallgrasses included big bluestem (*Andropogon gerardii)*, broom sedge (*Andropogon virginicus*), switchgrass, and indiangrass (*Sorghastrum nutans*). Production of midgrasses increased on burned and fertilized areas, but the difference was negligible. Midgrasses included splitbeard bluestem, sand paspalum (*Paspalum stramineum*), sideoats grama (*Bouteloua curtipendula*), silver bluestem (*Bothriochloa saccharoides*), dropseed (*Sporobolus asper*) and fall witchgrass (*Leptolma cognatum*). Shortgrasses produced 370 kg/ha by July in contrast to 110 kg/ha in June. Shortgrasses included hairy grama (*Bouteloua hirsuta*), bermudagrass and Scribner's panicum (*Panicum oligosanthes* var. *scriberianum*).

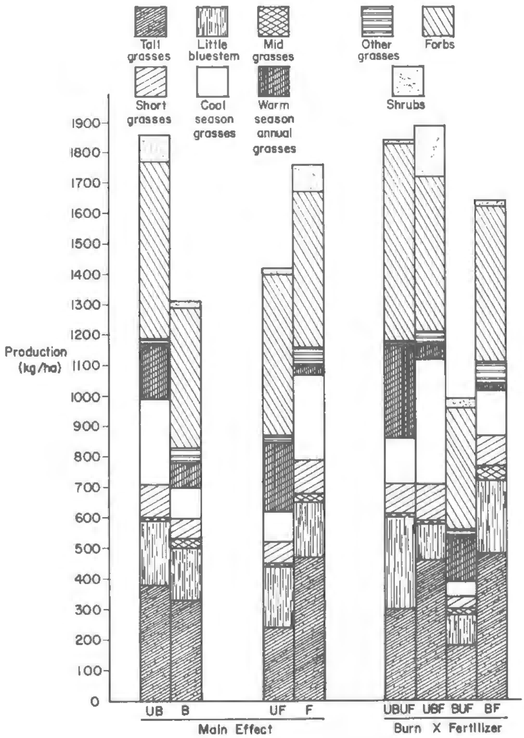

Figure 16. Dry matter production (kg/ha) on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, June, 1974.

Fertilization of the true prairie increases herbage production by stimulating cool-season species, undersirable forbs or both, usually at the expense of warm-season species (Huffine and Elder 1960; Gay and Dwyer 1965; Powell and Box 1967). Burning under proper conditions helps control cool-season annual grasses (McMurphy and Anderson 1965). In this study, burning reduced the production of cool-season grasses from 280 to 100 kg/ha. On the other hand, fertilization increased the production of cool-season grasses to 280 kg/ha compared to 100 kg/ha on unfertilized areas. Cool-season grasses included Canada wildrye (*Elymus canadensis*), Japanese brome and sedges (*Carex* spp).

Differences in soil water and organic matter contents due to treatments were not highly significant, but soil pH on fertilized areas decreased ($P < .06$) from 6.2 to 5.7 (Fig. 17) as a result of the acidic effect of the applied ammonium nitrate fertilizer. Soil pH is commonly lower on nitrogen fertilized areas, but this decrease seems unusually large for the second year of fertilization.

Herbage produced on fertilized areas was 14% lower in dry matter content as compared to that on unfertilized areas (Fig. 18). Fertilization usually increases succulence in vegetation. Digestible dry matter was about 3% greater ($P < .12$) in herbage on fertilized areas. Nitrogen fertilization was credited for the 2% higher crude protein content of herbage on fertilized areas. The highest ($P < .11$) crude protein content (8.8%) and lowest ($P < .12$) dry matter content (34%) were on the unburned, fertilized areas.

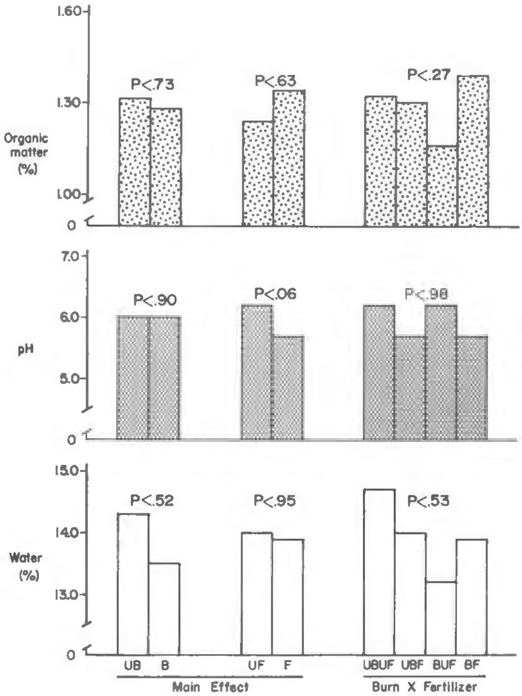

Figure 17. Levels of soil factors on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, June, 1974.

Summer. By July 11, herbage production on all treatment areas (Fig. 19) was 90 to 470 kg/ha less than the corresponding values on June 9. This decrease in production was attributed to the high temperatures and limited rainfall during late June and early July. Differences in grass production between burned and unburned areas were smaller in July, possibly due to more rapid growth on burned areas or the elimination of sheep grazing in early June. Burning, fertilization and a combination of the two were effective in reducing forbs in Osage County, Oklahoma (Gay and Dwyer 1965). The cool season annual grasses produced 32% less herbage on fertilized areas than in June. However, the cool season annual grass production was still greater on fertilized than on unfertilized areas.

A fertilization study by Elder and Murphy (1958) indicated that areas infested with cool-season annual grasses prevented the growth of warm season annuals. In this study, fertilized areas produced greater yields of cool season annuals, but significantly lower yields of warm season annual grasses. The warm season annuals included prairie threeawn, lovegrass (*Eragrostis spp.*) and foxtail (*Setaria* spp). Some perennial grass species were able to maintain appreciable amounts of growth on fertilized areas in spite of the drought conditions, probably due to their well established root systems.

An increase in organic matter on burned areas (Fig. 20) was attributed to a possible increase in roots and a more rapid decomposition of litter and other plant materials. The same factors may have caused the higher soil organic matter on fertilized areas.

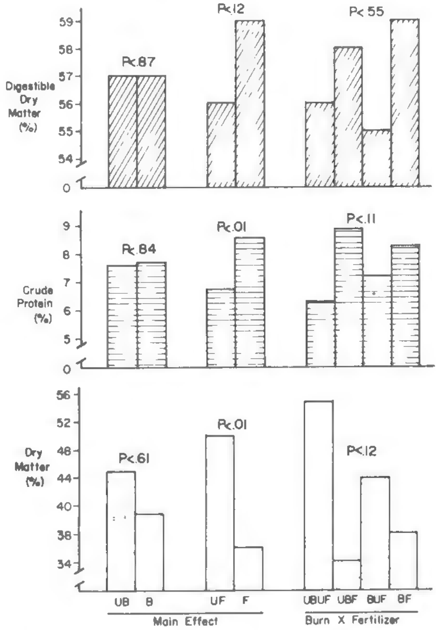

Figure 18. Plant chemical composition on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, June, 1974.

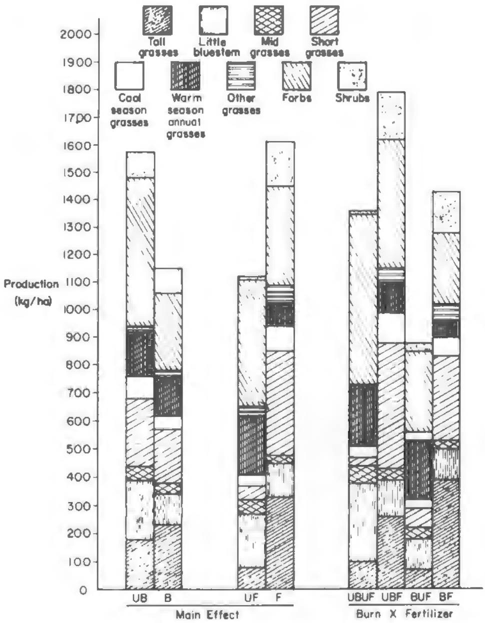

Figure 19. Dry matter production (kg/ha) on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, July, 1974.

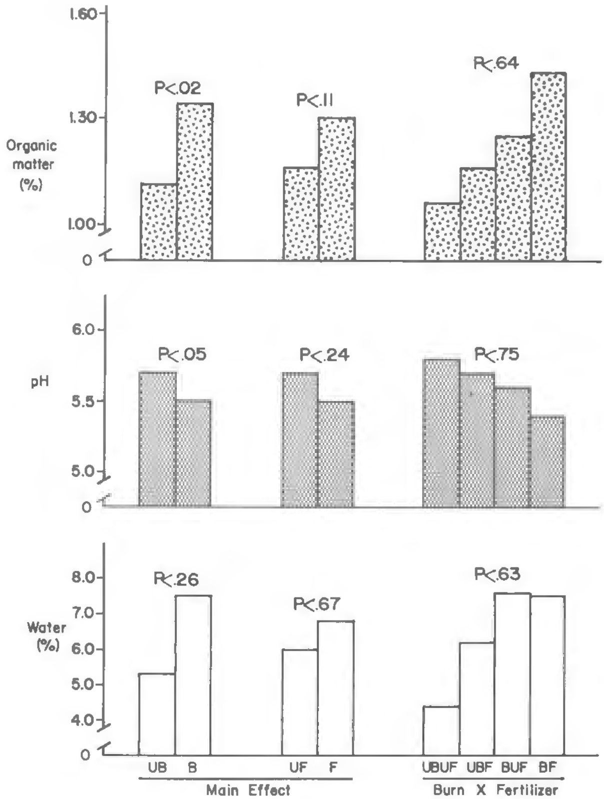

Figure 20. Levels of soil factors on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, July, 1974.

Soils in burned grasslands usually have slightly higher pH values due to the release of alkaline earth metals (Baldanzi 1961; Daubenmire 1968). In this study, the pH decreased from 5.7 on unburned areas to 5.5 on burned areas. This trend was not evident on other sampling dates. The decrease in pH may have been due to local weather conditions or to a possible relationship between soil pH and soil water. Soil water content was higher on all treated areas than on the untreated areas. In June, the opposite situation existed. In July, the highest soil water contents occurred on the burned areas where forb production was lowest. A difference in soil water use efficiency by different species may have caused the soil water differences.

Differences in digestible dry matter and crude protein contents due to treatments were small and highly variable (Fig. 21). However, both digestible dry matter and crude protein were higher on all treated areas than on untreated areas. Conversely, dry matter content was lower on all treated areas and as on other sampling dates was inversely related to digestible dry matter and crude protein.

Late Summer. Differences in grass production on unburned and burned areas were small by August 14 (Fig. 22). However, shortgrass production on burned areas was higher than on unburned. This could be attributed to their possible higher

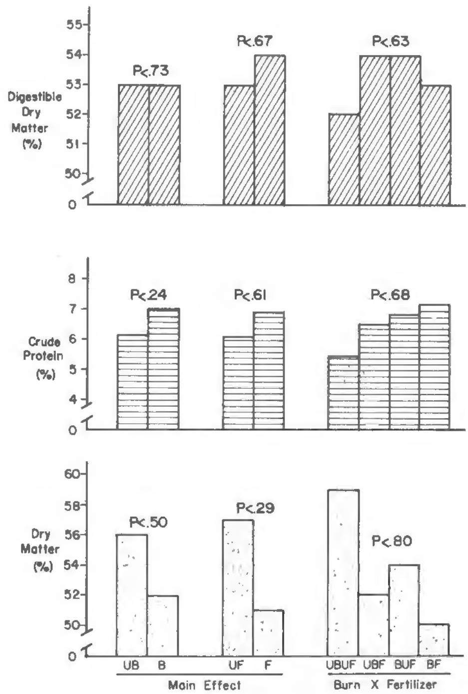

Figure 21. Plant chemical composition on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, July, 1974.

resistance to drought under burning conditions than were other species classes. Tall and shortgrasses increased yield on fertilized areas which could be related to a possible greater efficiency in utilizing nitrogen fertilizer. Production of each species class except warm season annual grasses was higher on fertilized areas than on unfertilized areas.

Soil pH on fertilized areas was lower ($P < .07$) than on unfertilized areas (Fig. 23) in August as it has been on the preceding sampling dates. Treatments had no significant effect on the organic matter and soil water at this sampling date.

The digestible dry matter content in the August vegetation was about 3% less ($P < .07$) on fertilized areas than on unfertilized areas (Fig. 24). This was influenced primarily by the large differences on the burned-unfertilized and burned-fertilized areas. At this time, the ranking of values for the digestible dry matter in vegetation on the four treatment areas was the same as the ranking for dry matter content. Since the effect of fertilizer on chemical composition was probably minor by August, the differences in digestible dry matter content were apparently influenced most by the differences in species composition.

Conclusions and Management Implications

Burning, fertilization and grazing by sheep on central Oklahoma rangeland proved to be effective management tools in manipulating range vegetation. Herbage production was temporarily reduced after the spring burn, but recovered by late summer. The temporary reduction from burning was in contrast to an immediate increase in herbage yield and quality on fertilized areas. Crude protein content and dry

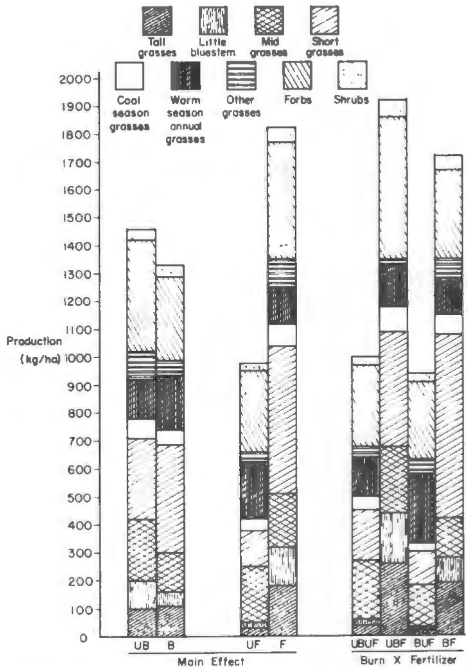

Figure 22. Dry matter production (kg/ha) on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, August, 1974.

matter digestibility were highly variable in vegetation from all treated areas, but generally higher on burned or fertilized areas.

Burning and deferment from grazing appears to improve range condition and prolong higher levels of forage quality later into the summer when forage quality is relatively low. Fertilized areas should be grazed first and burned areas later in a rotation system using a combination of practices.

The effect of fire varied from one species to another. Some grasses showed a slight increase in density in response to fire, while other species decreased. Generally, lower successional species were the most reduced by fire and most of the desirable grass species were favored by burning. Bermudagrass ground cover was greatly increased by fertilization. Fertilization increased herbage production by stimulating growth of all species except warm season annual grasses.

Burning and fertilization appears to be feasible practices for increasing forage quality on poor condition rangeland. These practices, used on rangeland in combination with introduced spring pastures, could extend the period of higher quality forage for lamb production in central Oklahoma.

Fertilization increased soil organic matter on most fertilized areas. Soil water content was higher on treated areas only in July. Soil pH was decreased on most fertilized areas. The combination of fire, fertilization, sheep grazing and probably liming offer effective means for improving soil conditions on depleted rangelands.

Additional research using fire, fertilization and more comprehensive grazing systems with detailed range condition analyses deserves consideration.

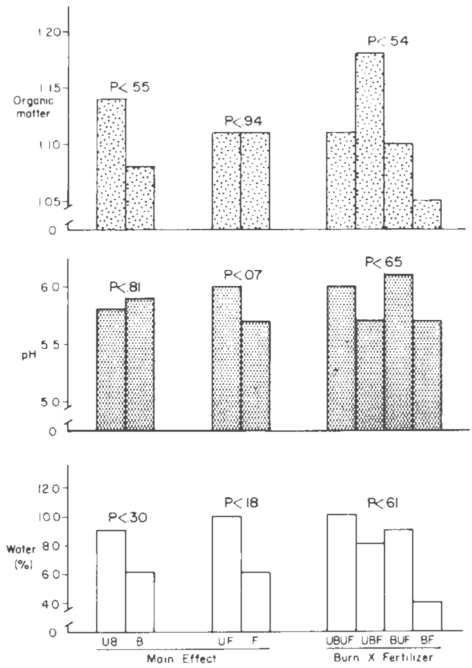

Figure 23. Levels of soil factors on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, August, 1974.

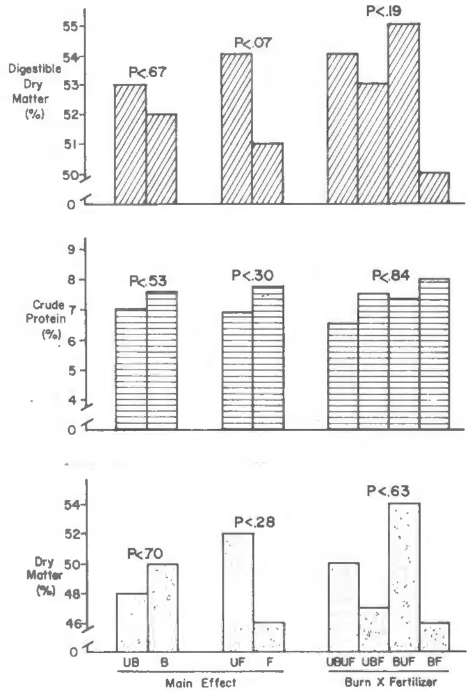

Figure 24. Plant chemical composition on unburned (UB), burned (B), unfertilized (UF) and fertilized (F) areas, August, 1974.

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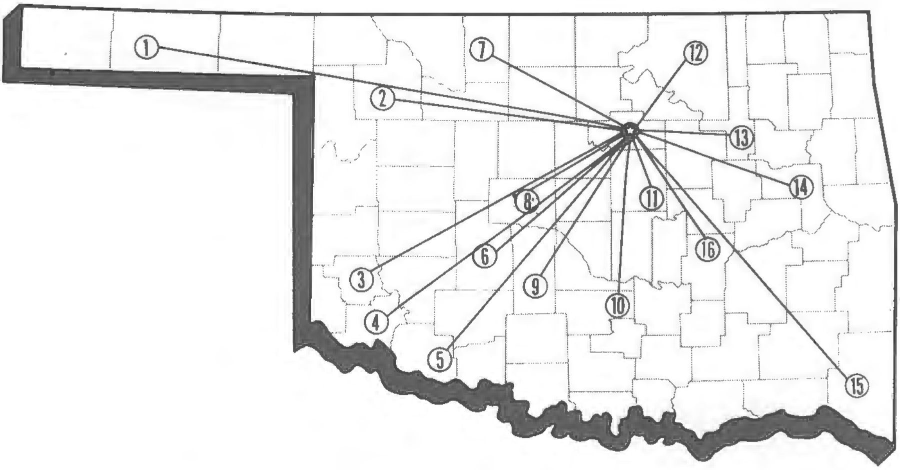

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