FORAGE QUALITY OF CROSS TIMBERS RANGE PLANTS

By

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FORAGE QUALITY OF CROSS

TIMBERS RANGE PLANTS

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PREFACE

Forage quality components, crude protein, digestibility, and water content were analyzed for range plants from two range sites (sandy savannah and prairie) within two brush treatments (tebuthiuron plus fire and check). Samples were analyzed to determine the effects of season, brush treatment and range site on forage quality.

Chapter I will be submitted to the Journal of Range Management for publication; Chapter II will be submitted to the Southwestern Naturalist for publication; and Chapter III will be published as a research report for the Oklahoma State University Experiment Station.

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CHAPTER I

FORAGE QUALITY OF THREE GRASSES IN THE CROSS TIMBERS AFTER BRUSH CONTROL

Abstract

Big bluestem (Andropogon gerardii Vitman), little bluestem (Schizachyrium scoparium (Michx.) Nash), and indiangrass (Sorghastrum nutans (L.) Nash) were hand-plucked to simulate selection by stocker cattle in the Cross Timbers of Oklahoma. Samples were collected from three treatment conditions: 1) sandy savannah with tebuthiuron plus spring burning 2) revegetating prairie and eroded shallow savannah with tebuthiuron plus spring burning, and 3) revegetating prairie and eroded shallow savannah with no brush treatment. The samples were analyzed for crude protein, in vitro dry matter digestibility, and water content as measures of forage quality. Indiangrass was more digestible than big bluestem and little bluestem; but big bluestem had greater water content than indiangrass and little bluestem. Quality of all species declined throughout the grazing season. Tebuthiuron plus spring burning provided higher quality forage than the untreated check. Forage quality varied more among species and within the grazing season, however, than among treatment conditions. Species composition and season are likely the overriding factors affecting diet quality of

cattle on Cross Timbers rangelands dominated by the three species included in this study.

Introduction

The vegetation of the Cross Timbers range type in Oklahoma is post oak-blackjack oak upland forest intermixed with tallgrass prairie (Dyksterhuis 1948). This range type does not produce important timber or wood products, but is otherwise similar to the forested ranges of the southeastern United States (Byrd et al. 1984). The primary use of the Cross Timbers is livestock grazing. Livestock grazing capacity is limited because of a suppressed herbage layer under the forest canopy and the inaccessibility of forage to livestock because of vines and low branches. The application of herbicides to remove the overstory hardwood competition can increase forage on some range sites from less than 100 kg/ha to as much as 5000 kg/ha (Elwell et al. 1974, Engle et al. 1987).

Methods of controlling competing overstory hardwoods in the Cross Timbers traditionally were one-time procedures such as mechanical brush removal (Scifres 1980) or herbicide application (Stritzke et al. 1975). Integrating two or more different brush management treatments will maximize long term benefits (Scifres 1980). Stritzke et al. (1975) found that periodic spring burning following initial herbicide application helped maintain herbicide benefits in the Oklahoma Cross Timbers.

The relationship of brush management to forage quality is not as clearly understood as the relationship of brush management to forage

quantity. No forage quality data is available for the Cross Timbers following brush management treatments. Knowledge of the relationship of forage quality to brush management treatments and range site in the Cross Timbers would guide resource managers in decision making in this resource type (i.e. livestock supplementation). Increased forage production is only one element of improved grazing value; increased or maintained forage quality is another. The objective of this study was to determine the effects of brush management and range site on seasonal forage quality for key species of the Cross Timbers.

Methods and Materials

This study was located on the Cross Timbers Experimental Range (CTER) located approximately 11 km southwest of Stillwater, Oklahoma. Annual precipitation averages 831 mm with the majority falling from April-October; mean average temperature is 15.5^{o} C with January averaging 2.3^{o} C and July averaging 27.6^{o} C. Precipitation was 349 mm and 338 mm above average in 1985 and 1986, respectively, with most of the departure from average coming in the form of summer and fall rain.

Common range sites found on the CTER are shallow savannah (Stephenville-Darnell soil complex, 1 to 8 % slopes), sandy savannah (Harrah-Pulaski soil complex, 0 to 8 % slopes) and shallow prairie (Grainola-Lucien soil complex, 5 to 12 % slopes) (Ewing et al. 1984). Overstory vegetation found on the shallow savannah is dominated by blackjack oak (Quercus marilandica Muenchh.) and post oak (Quercus stellata Wang.). Sandy savannah overstory dominants are a mixture of shallow savannah species and shumard oak (Quercus shumardii Buckl.), american elm (Ulmus american L.), green ash (Fraxinus pennsylvanica

Marsh.), black walnut (Juglans nigra L.), and hackberry (Celtis spp.). The shallow prairie is considered a tallgrass prairie (Ewing et al. 1984). Sizable portions of shallow savannah and prairie range sites are revegetating following abandonment from cropping.

This study was conducted on four pastures on the CTER. Two pastures were treated with 2.2 kg/ha of tebuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N N'-dimethylurea) plus annual spring burning and two were untreated checks. Herbicide was applied in March of 1983 and prescribed burning was initiated the spring of 1985. Pastures were moderately stocked with yearling cattle from mid-April through September. The brush treatments and range sites selected represented the extremes in brush control levels and site potential for CTER. The three treatment conditions selected for comparison were 1) sandy savannah range sites within pastures treated with tebuthiuron (1983) plus spring burning (1985 and 1986) (TFS), 2) prairie and eroded shallow savannah range sites revegetating following cultivation within pastures treated with tebuthiuron (1983) plus spring burning (1985 and 1986) (TFP), and 3) prairie and revegetating shallow savannah range sites with no brush treatment (Check). Sandy savannah range sites with no brush treatment were not included because of the lack of forage under the forest canopy on the sandy savannah range site.

Hand-plucked samples were collected for three key species, big bluestem (Andropogon gerardii Vitman), little bluestem (Schizachyrium scoparium (Michx.) Nash), and indiangrass (Sorghastrum nutans (L.) Nash), within each treatment condition (Huston et al. 1981, Society for Range Management 1986). Species and plant parts collected were determined by observing cattle selection of plants and plant parts, and

by observation of recently grazed plants. Within a range site and brush treatment samples of each species were composited across pastures. Plant phenology and fresh weight were recorded at the time of collection. Sampling was conducted during the normal stocker cattle grazing season. Sampling dates were approximately May 1, June 1, July 1, August 15, and September 19 in 1985 and 1986 (grazing day 15, 45, 75, 120, 150, respectively).

Plant samples were oven dried at 65° C for a minimum of 48 hours and then ground to pass through a 2 mm screen. Crude protein (CP) and water content were determined using methods described by the A.O.A.C. (1980). In vitro dry matter digestibility (IVDMD) was determined on triplicate samples by Tilley and Terry's (1963) two stage procedure. Ruminal fluid used in the in vitro analysis was collected from a rumen cannulated steer consuming prairie hay supplemented with soybean meal.

Crude protein, IVDMD, and water content data were subjected to analysis of variance with the SAS GLM procedure (SAS 1985) as a split-plot over time in a randomized complete block. Species and treatment condition (brush treatment and range site) were considered as main effects with grazing day as split-plots in time. Replication was by years (1985 and 1986). The sums of squares for grazing day were partitioned into linear, quadratic, and cubic effects to determine the nature of the response surface over time (Steel and Torrie 1980). Cubic effects were dropped because of the absence of significance except for one instance. Where appropriate, species and treatment condition means were separated by LSD at the 0.05 level of probability.

Results and Discussion

Crude Protein

Crude protein content of the three species responded similarly ($P>0.18$) to treatment condition and grazing date, so results were averaged over grass species (Table 1). However, seasonlong crude protein averaged 8.9 % in big bluestem, 7.7 % in little bluestem, and 8.7 % in indiangrass. Crude protein of these grasses decreased with time in a quadratic fashion on the TFS and TFP treatment conditions, but crude protein content of the grasses sampled on checks did not fit any of the models tested (Table 1). In comparison to TFS and TFP, crude protein values on the check were low early in the grazing season, but did not decline as noticeably during the season. Crude protein content of the grasses in TFS and TFP were higher early, but no different from crude protein in control grasses by mid-season.

Masters and Scifres (1984) and Biondini et al. (1986) concluded that measurable differences in crude protein concentration attributable to tebuthiuron treatment under field conditions occurred only during the growing season of application. Therefore, the increase in crude protein on the first sampling date is not likely the direct result of tebuthiuron application. Instead, the reduction in overstory canopy on TFS may increase crude protein content of grasses in spring since suppression of sunlight and reduced soil temperature from the tree canopy can reduce the quality of understory plants (Halls and Epps 1969). Little of the first sampling date increase can be attributed to burning because of the spotty burn in the savannah in both years (Engle et al. 1987).

In contrast, burning rather than the tebuthiuron treatment may have caused the grasses to be higher in crude protein on the first sampling date in the prairie (TFP). Although the effects of tebuthiuron and fire can not be separated, steer gains were higher on tebuthiuron plus fire pastures than on pastures treated with tebuthiuron alone (McCollum et al. 1987). Burning increased crude protein in big bluestem and little bluestem whole-plant samples (Allen et al. 1976) and in diets of esophageally fistulated steers grazing bluestem range (Woolfolk et al. 1975). Burning is generally considered to improve diet quality as a result of removing old dead and litter, thus improving quality of available forage (Grelen et al. 1967, McGinty et al. 1983). Powell et al. (1979) reported that burning appeared to prolong higher levels of forage quality only until mid-summer. Our data indicate an even briefer positive effect of burning on crude protein.

In all three treatment conditions, crude protein values remained relatively higher through the end of the grazing period compared to previous studies (Waller et al. 1972, Allen et al. 1976, Burzlaff 1971). Because whole-plants or plant parts were sampled in previous studies (Waller et al. 1972, Allen et al. 1976, Burzlaff 1971) and regrowth was sampled in the present study, the difference may be a result of sampling strategy.

A deep, well-drained soil with favorable soil-plant relationships, such as the sandy savannah range site in our study, might be expected to support more continuous plant growth and therefore higher quality forage through the growing season than shallow prairie sites. Everitt and Alaniz (1982) showed that crude protein from whole-plant grass

samples in the spring on gray sandy loam (a deep, well-drained soil) was higher than samples from a shallow range site which had poor plant-soil water relationship and shallow rooting depth. Yet crude protein differences occurred early and not late and there was no difference between TFP and TFS.

In Vitro Dry Matter Digestibility

Digestibility of all three species declined in a quadratic fashion through the grazing season but the rates of decline were different across species (Table 2). Similar rapid declines in mid-season digestibility have been documented (Burzlaff 1971, Meyer and Brown 1985). Whole-plants of little bluestem in seeded monocultures (Burzlaff 1971) were higher in digestibility through the growing season compared to this study, however. Esophageal and whole-plant samples of bluestem pasture forages (Rao et al. 1973) were similar in digestibility to the hand-plucked samples in this study in both average digestibility and seasonal decline of digestibility.

Digestibility responded in a linear fashion to grazing season day in the check and TFS, but in a quadratic fashion in TFP, probably because digestibility of TFP grasses was higher at the beginning of the grazing season (Table 3). Digestibility was not different among treatment conditions by early June. In contrast, burning in the Kansas Flint Hills increased digestibility of grazed forages through September (Smith et al. 1960). Lower digestibility on the TFS early in the season compared to TFP may have resulted from incomplete burning of the savannah sites (Engle et al. 1987).

Water Content

Treatment condition did not influence water content ($P>0.09$), but there was a trend of higher water content in the TFS treatment condition (62 %, 63 %, and 67 % for Check, TFP and TFS, respectively). The absence of a significant treatment condition effect is surprising. Of the three treatment conditions, TFS would be expected to produce forage greater in water content in late-season because of the deeper soils with greater water holding capacity and the release of grasses from competing brush. Also, tebuthiuron treatments have been shown previously to result in plants of higher water content (Sosebee 1979, Biondini et al. 1986).

There was a significant species by grazing day interaction, and little bluestem was lowest among the three species in water content on several dates (Table 4). Water content in little bluestem declined rapidly from June 1 to August 15 and then slightly improved between August 15 and September 15. Water content in big bluestem and indiangrass, on the other hand, declined in a linear fashion during the season, but remained higher in water content than little bluestem at the end of the grazing season. This difference in water content may partially explain the well known lower relative palatability of little bluestem (Dyksterhuis 1948, Dwyer 1961).

Conclusions

Results of this study suggest that for the three species evaluated under the three treatment conditions of this study, quality varies more among species and within the grazing season than among treatment conditions. Treatment condition had little effect except for the early

portion of the grazing season. Therefore, species composition and season are likely the overriding factors affecting diet quality of cattle on Cross Timbers rangelands dominated by the three species included in this study.

The recommended nutritional management for livestock in Oklahoma tallgrass prairies is for protein supplementation to begin in mid-summer (about July 1) when crude protein in forage drops between 7 and 8 % and forage intake declines. Protein supplementation increases forage intake of low quality forage (McCollum and Galyean, 1985). Based on the results of this study, this supplementation practice would also pertain to Cross Timbers rangelands and may be necessary even earlier than mid-summer on prairie sites that have not been burned.

Table 1. Average seasonal crude protein content (%) of key grass species on Cross Timbers rangeland in response to treatment condition (brush treatment and range site) and date within grazing season.

	Days within grazing season[1]						Response Surface	
Treatment condition	15	45	75	120	150	Mean	Linear	Quad.
	----------%----------						------OSL[2]-----	
Check	9.0[3]	7.3	7.0	8.2	7.7	7.8	0.47	0.13
Tebuthiuron + Fire, Prairie	12.0	8.7	7.0	7.1	7.4	8.4	0.01	0.01
Tebuthiuron + Fire, Savannah	12.7	9.2	7.6	7.6	7.8	9.0	0.01	0.01
			LSD=2.7[4]					

[1]Grazing season was April 15 - Sept. 15; Day 15=May 1, Day 45=June 1, Day 75=July 1, Day 120=Aug. 15, Day 150=Sept. 15.

[2]Observed significance level

[3]Means of 1985 and 1986 pooled from three species: little bluestem, big bluestem, and indiangrass.

[4]Least significant difference among treatments within date.

Table 2. Average seasonal in vitro dry matter digestibility (%) of three key grass species on Cross Timbers rangelands.

Species	Days within grazing season[1]					Mean	Response Surface	
	15	45	75	120	150		Linear	Quad.
	----------%----------						------OSL[2]-----	
Little bluestem	58.7[3]	53.3	44.9	37.2	37.7	46.4	0.01	0.06
Big bluestem	64.6	57.4	52.1	47.3	47.5	53.8	0.01	0.01
Indiangrass	68.6	60.7	58.5	53.8	52.8	58.9	0.01	0.01
			LSD=4.8[4]					

[1]Grazing season was April 15 - Sept.15; Day 15=May 1, Day 45=June 1, Day 75=July 1, Day 120=Aug. 15, Day 150=Sept 15.

[2]Observed significance Level

[3]Means of 1985 and 1986 across three treatment conditions (brush treatment and range site): Check; Tebuthiuron + fire, prairie; Tebuthiuron + fire, savannah.

[4]Least significant difference among species within date.

Table 3. Seasonal in vitro dry matter digestibility (%) of key grass species on Cross Timbers rangelands in response to treatment condition (brush treatment and range site).

Treatment condition	Days within grazing season[1] 15	45	75	120	150	Mean	Response Surface Linear	Quad.
	----------%----------						------OSL[2] -----	
Check	59.9[3]	55.4	50.0	45.7	46.5	51.5	0.01	0.25
Tebuthiuron + Fire, Prairie	68.0	59.4	52.8	47.0	46.4	54.7	0.01	0.05
Tebuthiuron + Fire, Savannah	64.1	56.7	52.7	46.6	45.1	53.0	0.01	0.19
	LSD=4.8[4]							

[1]Grazing season was April 15-Sept. 15; Day 15=May 1, Day 45=June 1, Day 75=July 1, Day 120=Aug. 15, Day 150=Sept. 15.

[2]Observed significance level

[3]Means of 1985 and 1986 pooled from three species: little bluestem, big bluestem, and indiangrass.

[4]Least Significant difference among treatments within date.

Table 4. Seasonal water content (% dry weight) of three key grass species on Cross Timbers rangelands.

	Days within grazing season[1]						Response Surface	
Species	15	45	75	120	150	Mean	Linear	Quad.
	----------%----------						------OSL[2]-----	
Little bluestem	70.8[3]	65.8	57.0	48.7	51.5	58.8	0.01	0.01
Big bluestem	74.7	73.7	66.7	62.8	62.0	68.0	0.01	0.18
Indiangrass	72.8	69.7	64.7	61.3	58.5	65.4	0.01	0.31
			LSD=4.7[4]					

[1]Grazing season was April 15-Sept. 15; Day 15=May 1, Day 45=June 1, Day 75= July 1, Day 120=Aug. 15, Day 150=Sept.15.

[2]Observed significance level

[3]Means of 1985 and 1986 across three treatment conditions (brush treatment and range site): Check; Tebuthiuron + fire, prairie; Tebuthiuron + fire, savannah.

[4]Least significant difference among species within date.

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CHAPTER II

NUTRITIVE VALUE OF FORBS AND BROWSE AFTER BRUSH CONTROL IN THE CROSS TIMBERS

ABSTRACT--Forb and browse species were hand-plucked in 1985 and 1986 to simulate herbivory in the Cross Timbers of northcentral Oklahoma. Samples were collected from two range sites (sandy savannah and prairie) within two brush treatments, tebuthiuron plus spring burning and an untreated check. Plant samples were analyzed for crude protein, digestibility, and water content. Forbs maintained high quality throughout the summer. Vines and american elm (Ulmus americana L.) were higher in quality than other browse species and maintained quality later in the season. Quality differences were more common among species than within species between treatments.

Brush manipulation in the Cross Timbers vegetation type is a potential management tool to increase availability of forb and browse species for deer use. Forb and browse species are suppressed under the dense upland forest canopy, whereas forest edges and openings offer a greater variety of forbs and browse. Before settlement, the Cross Timbers was likely a mosaic of grassland and oak thickets (Johnson and Risser, 1975; Rice and Penfound, 1959) which would be an ideal habitat for deer (Inglis, 1983). Seasonal fires on upland sites maintained the mosaic pattern by

stimulating resprouting which increased densities of oak stems (Dyksterhuis, 1948; Harlan, 1958). With heavy cattle stocking and fire suppression by European man, a closed canopy of trees occurred, reducing fuel for fire (Box, 1967; Ehrenreich and Crosby, 1960). Prairie openings of old cultivated fields or cleared pastures are typical of the present day Cross Timbers (Ewing et al., 1984) but they offer limited edge habitat for deer. Preferred deer food items are scarce under the closed forest canopy, dominated by post oak (Quercus stellata Wang.) and blackjack oak (Quercus marilandica Muenchh.), and in grass-dominated prairie openings.

Methods of brush management for opening up the woody overstory canopy include chaining (Rollins and Bryant, 1986), herbicide applied in patterns to increase fringe cover (Inglis, 1983; Scifres and Koerth, 1986), prescribed burning (Elwell et al., 1970; Adams et al., 1982), and combinations of herbicides with repeated prescribed burning to prevent reestablishing of the overstory canopy (Scifres et al., 1987).

No deer forage quality data is available for the Cross Timbers following brush management. Knowledge of forb and browse quality are needed to evaluate the value of brush management practices for improving deer habitat. The objective of this study was to determine the effects of brush management and range site on seasonal quality of key forb and browse species in the Cross Timbers.

STUDY AREA--This study was located on the Cross Timbers Experimental Range (CTER) located approximately 11 km southwest of Stillwater, Oklahoma. Annual precipitation averages 831 mm with the majority falling from April-October; mean average temperature is 15.5 C with

January averaging 2.3 C and July averaging 27.6 C. Precipitation was 349 mm and 338 mm above average in 1985 and 1986, respectively, with most of the departure from average coming in the form of summer and fall rain.

Common range sites found on the CTER are shallow savannah (Stephenville-Darnell soil complex, 1 to 8 % slopes), sandy savannah (Harrah-Pulaski soil complex, 0 to 8 % slopes), and shallow prairie (Grainola-Lucien soil complex, 5 to 12 % slopes) (Ewing et al., 1984). Overstory vegetation found on the shallow savannah is dominated by blackjack oak and post oak. Sandy savannah overstory dominants are a mixture of shallow savannah species and shumard oak (Quercus shumardii Buckl.), american elm, green ash (Fraxinus pennsylvanica L.), black walnut (Juglans nigra L.), and hackberry (Celtis) spp. The shallow prairie is considered a tallgrass prairie (Ewing et al., 1984). Sizable portions of shallow savannah and prairie range sites are revegetating following abandonment from cropping.

METHODS AND MATERIALS--This study was conducted on four pastures on the CTER. Two pastures were treated with 2.2 kg/ha of tebuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N, N'-dimethylurea) plus annual spring burning and two were untreated checks. Herbicide was applied in March of 1983 and prescribed burning was initiated the spring of 1985. Pastures were moderately stocked with yearling cattle from mid-April through September. The brush treatments and range sites selected represented the extremes in brush control levels and site potential for CTER. The two treatment conditions selected for comparison of forbs and browse were 1) sandy savannah range sites within

pastures treated with tebuthiuron (1983) plus spring burning (1985 and 1986) (TFS), and 2) prairie and revegetating shallow savannah range sites with no brush treatment (Check). Sandy savannah range sites with no brush treatment (Check) were not included because of the lack of forbs and browse under the forest canopy on the sandy savannah range site. Sampling was conducted during the growing season.

Hand-plucked samples were collected for key species of forbs (marestail (Conyza canadensis (L.) Cronq.), pokeweed (Phytolacca americana L.), and prickly lettuce (Lactuca spp.) and browse (greenbriar (Smilax spp.), virginia creeper (Parthenocissus quinquefolia (L.) Planch.), oak, elm, buckbrush (Symphoricarpos orbiculatus Moench), and blackberry (Rubus spp.) within each treatment condition (Huston et al., 1981; Society for Range Management, 1986). The three forb species are considered to be preferred deer food items that are abundant after brush treatment. Three of the six browse species (buckbrush, oak, and blackberry) are not generally preferred but are abundant, productive species, especially following brush treatment. Species and plant parts were collected to match those plants and plant parts which had been recently selected by herbivores. Within a range site and brush treatment, samples of each species were composited across pastures. Plant phenology and fresh weight were recorded at the time of collection. Sampling dates were approximately May 1, June 1, July 1, August 15, and September 19 in 1985 and 1986.

Plant samples were oven dried at 65 C for a minimum of 48 hours and then ground to pass through a 2 mm screen. Crude protein (CP) and water content were determined using methods described by the A.O.A.C. (1980).

In vitro dry matter digestibility (IVDMD) was determ ned on triplicates by Tilley and Terry's (1963) two stage procedure.

Crude protein, IVDMD, and water content data were ubjected to analysis of variance with the SAS GLM procedure (SAS 1985) as a split-plot over time in a randomized complete block. Spec es and treatment condition (brush treatment and range site) were cons dered as main effects with sample date as split-plots in time and ears (1985 and 1986) as blocks. The sums of squares for sample dat were partitioned into linear, quadratic, and cubic effects to determ e the nature of the response surface over time (Steel and Torrie, 1980). Cubic effects were dropped because of the absence of significance excep for one instance. Where appropriate, species and treatment condition m ans were separated by LSD.

RESULTS AND DISCUSSION--Forbs--Crude protein conte t differed greatly among forb species (Table 1), but this magnitude of ifference among forb species has been shown from work in other veget tion types (Blair et al., 1977). Crude protein fluctuated throughout he season with no surface response model being significant (Table 2). Crude protein was quite high in these three species even in late summe and early fall, in contrast to an expected normal seasonal decline in c ude protein content (Meyer and Brown, 1985).

Forbs are selected primarily in spring and early s mmer because of higher quality and availability in these seasons (Mc ahan, 1964; Thill, 1984). Crude protein requirements for large herbivc es such as white-tailed deer (Odocoileus virginianus Rafinesque) are 3% to 16% for optimum growth and 6% to 7% for maintenance (French t al. 1956).

Present study values of forbs averaged over treatment condition and species exceed these requirements throughout most of the study period. However, prickly lettuce may provide crude protein levels below white-tailed deer growth requirements at times within the growing season. Overall, forbs in TFS had higher levels of crude protein than the check, but no herbivory occurred on forbs after the second date on the checks so there is no comparative data for the last portion of the season (Table 3).

Digestibility of marestail was lower than pokeweed or prickly lettuce (Table 1). Forb quality is generally considered to rapidly decline with time in the growing season (Blair et al., 1977), but forb digestibility in this study decreased in a linear fashion with time until the last sample date when it increased (Table 2).

Forb water content remained above 85% until mid-season, and then dropped to about 75% for the last 30 to 60 days, a cubic response curve (Table 2). This water content is relatively high for herbaceous plants in general, especially in late summer when seasonal drought stress is a common environmental phenomenon in this area of Oklahoma (Hake et al. 1984).

Browse--Crude protein content of browse generally declined with sample date but the sample date effect interacted with species (Table 4). Although the expected seasonal declines occurred, crude protein remained high, probably as a result of regrowth following earlier browsing (Blair and Halls, 1968). Crude protein content in greenbriar, american elm and blackberry markedly decreased with time, which may explain the absence of herbivory on greenbriar and blackberry by the last sample period. In

contrast, crude protein in virginia creeper increased in the last half of season while oak and buckbrush remained at a comparatively low level throughout the season. Crude protein content of the TFS browse species averaged over sampling date was significantly greater than crude protein in browse species of the check (13.7 and 12.4, respectively).

Vine species, greenbriar and virginia creeper, and american elm averaged nearly 60% digestibility, whereas buckbrush averaged 48% and oak and blackberry were less digestible (37% and 40%, respectively). Treatment condition interacted with sampling date for digestibility, but differences in digestibility between treatment condition were surprisingly small on all sampling dates (Table 5). Seasonal changes in digestibility in both treatment conditions were similar.

A three-way interaction ($P< 0.08$) for water content in browse occurred between treatment condition (brush treatment and range site), species, and sample date (Table 6). Browse water content generally declined through the season in both treatment conditions, but the vines contained substantially more water throughout the season than other species (Figure 1). Greenbriar, american elm, and virginia creeper (a preferred species) contained over 70% water on the first date but only greenbriar and virginia creeper remained above 70% water by the last two dates. Buckbrush, oak, and blackberry contained over 60% water the first date then dropped considerably by the third date, after which herbivory ceased. Browse in TFS tended to have higher water content, especially in the more preferred species in the latter part of the season. Because palatability of browse is associated with water content (Blair and Halls, 1968; Stoddart et al., 1975), this response may partially explain

the deer preference for brush treatment areas and the higher deer production from these areas compared to untreated areas in oak-dominated systems (Inglis, 1983).

CONCLUSIONS--Forbs in the Cross Timbers are important food items that remain high in quality throughout the season. Vines and american elm, which increase in abundance after brush treatment, are higher quality than other browse species and maintain their quality later into the growing season.

Because there were more quality differences among species than between treatments, differences in quality of deer diets will depend largely on availability of preferred food items. Species availability, however, can be dramatically altered by brush treatment. Forb production, including the species in this study, increases manyfold for three to four years after the initial herbicide treatment (Engle et al., 1987). Thus, the greater effect of brush treatment with herbicides and fire on quality of deer diets in the Cross Timbers is from increased availability of preferred food items rather than from direct effects of the brush treatments on the forage already present.

Table 1. Mean crude protein (%) and in vitro dry matter digestibility (%) for three forb species in 1985 and 1986 on the Cross Timbers Experimental Range. Values are averages of 5 collection dates.

Species	CP	IVDMD
Conyza canadensis	17.9	63.0
Phytolacca americana	23.1	78.6
Lactuca spp.	13.6	73.3
$LSD_{.05}$[1]	4.8	5.6

[1]Least significant difference for species

Table 2. Quality of forbs[1] over time on the Cross Timbers Experimental Range in 1985 and 1986. Values are means over species.

Quality factors	Sample date					Respose Surface	
	5-1	6-1	7-1	8-15	9-19	Linear	Quad.
	%					OSL[2]	
Crude protein	20.1	16.6	19.0	15.8	17.5	0.17	0.40
IVDMD	76.4	71.3	68.3	60.1	72.2	0.08	0.13
Moisture content	89.4	87.9	82.5	75.5	73.5	0.01	0.39

[1]*Conyza canadensis*, *Phytolacca americana*, *Lactuca* spp.

[2]Observed significance level

Table 3. Seasonal crude protein content (%) of forbs[1] by treatment condition (brush treatment and range site) on the Cross Timbers Experimental Range in 1985 and 1986. Values are means averaged over species.

Treatment	Sample date					Mean
	5-1	6-1	7-1	8-15	9-19	
	%					
Check	14.3	10.4	----[2]	----	----	12.4
Tebuthiuron + fire, Savannah	22.1	18.7	19.0	15.8	17.8	19.4
$LSD_{.05}$[3]	7.8	7.8				

[1] *Conyza canadensis*, *Phytolacca americana*, *Lactuca* spp.

[2] No observed herbivory for the sample date.

[3] Least significant difference for treatment within sample date.

Table 4. Crude protein content (%) of browse on the Cross Timbers Experimental Range in 1985 and 1986. Values are sample date X species means averaged over treatment condition (brush treatment and range site).

Species	Sample date					Response Surface	
	5-1	6-1	7-1	8-15	9-19	Linear	Quad.
	----------%----------					-------OSL[1] -------	
Parthenocissus quinquefolia	----[2]	12.8	10.5	13.8	13.2	0.77	0.13
n[3]		4	4	4	2		
Quercus spp	13.0	10.8	12.0	----	----	0.69	0.47
n	4	4	4				
Rubus spp	15.2	12.0	10.3	----	----	0.03	0.65
n	3	4	2				
Smilax spp	23.4	18.7	13.8	18.1	----	0.01	0.01
n	4	4	4	4			
Symphoricarpos orbiculatus	11.5	9.6	10.5	----	9.9	0.15	0.84
n	4	4	4		2		
Ulmus americana	14.3	11.7	9.2	12.6	13.2	0.68	0.01
n	4	4	4	2	4		

[1]Observed significance level

[2]No observed herbivory for the sample date.

[3]Sample size; MSE=8.43, 33 d.f.

Table 5. In vitro dry matter digestibility (%) of browse species[1] on the Cross Timbers Experimental Range in 1985 and 1986. Values are sample date X treatment condition (brush treatment and site) means averaged over species.

	Sample date					Response Surface	
Treatment condition	5-1	6-1	7-1	8-15	9-19	Linear	Quad.
	----------%----------					-------OSL -------	
Check	53.9	49.8	50.0	58.4	55.1	0.92	0.24
Tebuthiuron + fire Savannah	55.2	49.9	52.6	60.6	56.1	0.22	0.40
$LSD_{.10}$[3]	7.9	7.4	7.4	14.4	14.4		

[1] *Symphoricarpos orbiculatus*, *Smilax* spp, *Ulmus americana*, *Rubus* spp, *Quercus* spp, *Parthenocissus quinquefolia*

[2] Observed significance level

[3] Least significant difference for treatment condition within sample date.

Table 6. Water content (%) of browse on the Cross Timbers Experimental Range in 1985 and 1986. Values are treatment condition (brush treatment and range site) X species X sample date means.

	Sample Date				
	5-1	6-1	7-1	8-15	9-19
Parthenocissus quinquefolia					
Tebuthiuron + fire, savannah	---[1]	78	73	74	74
Check	---	82	75	---	---
$LSD_{.05}$[2]		7	7		
Quercus spp.					
Tebuthiuron + fire, savannah	72	63	54	---	---
Check	65	59	56	---	---
$LSD_{.05}$	7	7	7		
Rubus spp.					
Tebuthiuron + fire, savannah	78	73	69	---	---
Check	74	71	64	---	---
$LSD_{.05}$	9	7	10		
Smilax spp.					
Tebuthiuron + fire, savannah	85	84	81	80	---
Check	87	86	84	84	---
$LSD_{.05}$	7	7	7	7	
Symphoricarpos orbiculatus					
Tebuthiuron + fire, savannah	65	60	51	---	53
Check	64	62	55	---	---
$LSD_{.05}$	7	7	7		
Ulmus americana					
Tebuthiuron + fire, savannah	74	72	69	64	66
Check	72	68	61	---	57
$LSD_{.05}$	7	7	7		7

[1]No observed herbivory for the sample date.

[2]Least significant difference between treatments within sample date.

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CHAPTER III

NUTRITIVE VALUE OF RANGE PLANTS IN THE CROSS TIMBERS

Introduction

The vegetation of the Cross Timbers range type in Oklahoma is post oak-blackjack oak upland forest intermixed with tallgrass prairie (Dyksterhuis 1948). This range type does not produce important timber or wood products, but is otherwise similar to the forested ranges of the southeastern United States (Byrd et al. 1984). The primary use of the Cross Timbers is livestock grazing. Livestock grazing capacity is limited because of a suppressed herbage layer under the forest canopy and the inaccessibility of forage to livestock because of vines and low branches. The application of herbicides to remove the overstory hardwood competition can increase forage on some range sites from less than 100 kg/ha to as much as 5000 kg/ha (Elwell et al. 1974, Engle et al. 1987).

Methods of controlling competing overstory hardwoods in the Cross Timbers traditionally have been one-time procedures such as mechanical brush removal (Scifres 1980) or herbicide application (Stritzke et al. 1975). Integrating two or more different brush management treatments, however, will maximize long-term benefits (Scifres 1980). Stritzke et al. (1975) found that periodic spring burning following initial

herbicide application helped maintain herbicide benefits in the Oklahoma Cross Timbers.

Increased forage production is only one element of improved grazing value; increased or maintained forage quality is another. The relationship of brush management to forage quality is not as clearly understood as the relationship of brush management to forage quantity. No forage quality data is available for the Cross Timbers following brush management treatments. Knowledge of the relationship of forage quality to brush management treatments and range site in the Cross Timbers would guide resource managers in decision making in this resource type (i.e. livestock supplementation). The objective of this study was to determine the effects of brush management and range site on seasonal forage quality of forage species of the Cross Timbers.

Methods and Materials

This study was located on the Cross Timbers Experimental Range (CTER) located approximately 11 km southwest of Stillwater, Oklahoma. Annual precipitation averages 831 mm with the majority falling from April-October; mean average temperature is 15.5^{o} C with January averaging 2.3^{o} C and July averaging 27.6^{o} C. Precipitation was 349 mm and 338 mm above average in 1985 and 1986, respectively, with most of the departure from average coming in the form of summer and fall rain.

Common range sites found on the CTER are shallow savannah (Stephenville-Darnell soil complex, 1 to 8 % slopes), sandy savannah (Harrah-Pulaski soil complex, 0 to 8 % slopes), and shallow prairie (Grainola-Lucien soil complex, 5 to 12 % slopes) (Ewing et al. 1984).

Overstory vegetation found on the shallow savannah is dominated by blackjack oak (Quercus marilandica Muenchh.) and post oak (Quercus stellata Wang). Sandy savannah overstory dominants are a mixture of shallow savannah species and shumard oak (Quercus shumardii Buckl.), american elm (Ulmus americana L.), green ash (Fraxinus pennsylvanica L.), black walnut (Juglans nigra L.), and hackberry (Celtis spp). The shallow prairie is considered a tallgrass prairie (Ewing et al. 1984). Sizable portions of shallow savannah and prairie range sites are revegetating following abandonment from cropping.

This study was conducted on four pastures on the CTER, two pastures treated with 2.2 kg\ha of tebuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N, N'-dimethylurea) plus annual spring burning and two untreated checks. The herbicide was applied in March of 1983 and prescribed burning was initiated the spring of 1985. All Pastures were moderately stocked with yearling cattle from mid-April through September. The brush treatments and range sites selected represented the extremes in brush control levels and site potential for CTER. Thus, the four treatment conditions selected for comparison were 1) sandy savannah range sites within pastures treated with tebuthiuron (1983) plus spring burning (1985 and 1986), 2) prairie and eroded shallow savannah range sites revegetating following cultivation (open grassland) within pastures treated with tebuthiuron (1983) plus spring burning (1985 and 1986), 3) revegetating prairie and eroded shallow savannah range sites (open grassland) with no brush treatment, and 4) sandy savannah range sites with no brush treatment.

Hand-plucked plant samples were collected (Huston et al. 1981, Society for Range Management 1986) for three forage classes:

graminoids, forbs, and browse. Species and plant parts collected were determined by observing cattle selection of plants and plant parts, and by observation of recently grazed plants for a given sampling date. Species were not sampled if they did not occur in a treatment site or if no evidence of recent grazing use was observed on a sampling date. Within a range site and brush treatment, samples of each species were composited across pastures. Plant phenology and fresh weight were recorded at the time of collection. Sampling was conducted during the normal stocker cattle grazing season. Sampling dates were approximately May 1, June 1, July 1, August 15, and September 19 in 1985 and 1986.

Plant samples were oven dried at 65^{o} C for a minimum of 48 hours and then ground to pass through a 2 mm screen. Crude protein (CP) and water content were determined using methods described by the A.O.A.C. (1980). In vitro dry matter digestibility (IVDMD) was determined on triplicate samples by Tilley and Terry's (1963) two stage procedure. Ruminal fluid used in the in vitro analysis was collected from a rumen cannulated steer consuming prairie hay supplemented with soybean meal.

Results and Discussion

Prairie range sites in both the treated and check pastures provided sufficient grazed plants from which to sample. The sandy savannah range site in the tebuthiuron plus fire treatment pastures also had sufficient plant species; but, plant species availability was limited on the sandy savannah range site within the check because of the closed overstory canopy of trees.

The tebuthiuron plus fire treatment provided higher quality forage than the check treatment (Tables 1, 2 and 3). The tebuthiuron plus fire

treatment on prairie range sites supported high quality forages the third and fourth year after application, possibly in response to spring burning rather than as a result of the tebuthiuron treatment applied two years before this study began. Burning tallgrass prairie has increased quality of grasses (Allen et al. 1976) and the diets of steers (Woolfolk et al. 1975). Steer gains were higher in the present study on pastures treated with tebuthiuron plus fire than on pastures treated with tebuthiuron only (McCollum et al. 1987). Burning is generally considered to improve diet quality by removing old dead herbage and litter, thus improving quality of available forage (Grelen and Epps 1967, McGinty et al. 1983).

The mechanism involved in the improvement in forage quality on sandy savannah range sites within the tebuthiuron plus fire pastures is unclear since the fires did not burn continuously through these sites in either year of the study (Engle et al. 1987). Tebuthiuron, applied for brush control, has been shown to increase crude protein content of forages, but the increase occurred only in the growing season of application (Masters and Scifres 1984, Biondini et al. 1986). The increase in crude protein and digestibility of grasses and forbs on the tebuthiuron-treated sandy savannah sites in the first half of the season may be the result of reduced overstory canopy. Reduced sunlight and soil temperature from an overstory canopy may reduce forage quality of understory plants (Halls and Epps 1969).

The sandy savannah range sites in the tebuthiuron plus fire treatment might be expected to produce higher quality late-season forages than the prairie sites because of the possibility more available late-season water after release from overstory competition. Neither CP,

IVDMD, or water content, however, were consistently higher in the later sampling dates on the sandy savannah range sites treated with tebuthiuron plus burning compared to prairie sites.

Forage quality generally declined with sample date, but remained relatively high through the end of the grazing period in all treatments compared to previous studies (Burzlaff 1971, Waller et al. 1972, Allen et al. 1976). Because whole-plants or plant parts were sampled in previous studies and regrowth was sampled in the present study, the difference may be a result of sampling strategy.

Grasses, forbs, and browse differed in quality and in the change in quality during the grazing period. Forbs and browse generally contained higher levels of crude protein than graminoids (Table 1). Forbs were generally higher in digestibility (Table 2) and water content (Table 3) than either graminoids or browse. These quality components were generally high in the early growing season and decreased as the season progressed. Some species, however, increased in quality as the season progressed. Forbs remained high in quality throughout the season. Vines and american elm, which increase in abundance after brush treatment (Engle et al. 1987), are higher quality than other browse species and maintained their quality later into the growing season than other browse species. Therefore, species composition and season are likely overriding factors affecting diet quality of herbivores on Cross Timbers rangeland.

In summary, although tebuthiuron and burning generally improved forage quality early in the grazing period, quality appeared to vary more among species and within grazing season than among treatments. Diet quality of livestock grazing the sandy savannah range sites within

tebuthiuron plus fire treatment pastures may be higher than on untreated sandy savannah range sites. The improved diet quality may result also from increased forage availability following release from overstory competition.

Table 1. Seasonal crude protein content (%) in range plants for 1985 and 1986 on the Cross Timbers Experimental Range.

Species	Brush treatment	Range site	Year	Sample date 5-1	6-1	7-1	8-15	9-19
GRAMINOIDS								
Andropogon gerardii Vitman	Check	Prairie	1985	10.7	8.9	7.2	8.8	8.3
	Check	Prairie	1986	9.6	7.4	7.4	9.5	9.7
	Teb + fire [1]	Prairie	1985	13.0	10.1	7.8	4.7	8.3
	Teb + fire	Prairie	1986	11.4	8.8	7.2	9.0	8.9
	Teb + fire	Savannah	1985	8.4	8.9	2.4	5.9	8.3
	Teb + fire	Savannah	1986	14.4	10.7	7.3	9.7	7.7
Aristida spp.	Check	Prairie	1985	---[2]	---	5.4	---	---
	Teb + fire	Prairie	1985	---	---	---	---	7.0
	Teb + fire	Prairie	1986	---	---	---	---	7.5
Bouteloua curtipendula (Michx.) Torr.	Check	Prairie	1985	---	---	4.0	---	---
	Teb + fire	Prairie	1985	9.5	10.1	7.7	7.0	7.8
	Teb + fire	Prairie	1986	11.2	14.4	5.9	8.8	7.5
Bromus spp.	Check	Prairie	1986	9.7	5.5	---	---	---
	Check	Savannah	1985	9.8	8.3	---	---	---
	Check	Savannah	1986	10.8	5.3	---	---	---
	Teb + fire	Savannah	1985	11.4	---	---	---	---
	Teb + fire	Savannah	1986	13.1	---	---	---	---
Carex spp.	Check	Prairie	1985	10.2	7.5	5.9	---	---
	Check	Prairie	1986	7.8	8.0	---	---	---
	Check	Savannah	1985	9.5	10.0	6.5	9.9	---
	Check	Savannah	1986	10.9	7.9	7.9	8.1	---

Carex spp. continued	Teb + fire	Prairie	1985	13.3	9.0	5.9	---	---
	Teb + fire	Prairie	1986	12.7	10.3	---	---	---
	Teb + fire	Savannah	1985	10.0	10.2	7.1	10.7	12.0
	Teb + fire	Savannah	1986	11.6	10.9	9.8	12.5	14.4
Cynodon dactylon (L.) Pers.	Check	Prairie	1985	---	---	---	---	10.2
	Check	Prairie	1986	---	---	---	---	8.1
Elymus virginicus L.	Check	Savannah	1985	9.6	6.7	---	---	---
	Check	Savannah	1986	10.6	7.1	---	---	---
	Teb + fire	Savannah	1985	15.0	10.8	---	---	---
	Teb + fire	Savannah	1986	17.7	13.0	---	---	---
Muhlenbergia spp.	Teb + fire	Savannah	1985	10.1	7.6	5.9	---	---
	Teb + fire	Savannah	1986	12.7	9.2	8.0	---	---
Panicum anceps Michx.	Teb + fire	Prairie	1985	---	---	---	10.2	---
	Teb + fire	Prairie	1986	---	---	---	8.8	---
	Teb + fire	Savannah	1985	---	---	---	9.6	---
	Teb + fire	Savannah	1986	17.2	---	---	11.9	---
Panicum oligosanthes Schultes	Check	Prairie	1985	10.7	9.1	6.6	---	---
	Check	Prairie	1986	9.4	8.3	6.6	---	---
	Teb + fire	Prairie	1985	15.0	18.0	---	---	---
	Teb + fire	Prairie	1986	12.5	10.7	---	---	---
	Teb + fire	Savannah	1985	16.8	11.4	11.4	---	---
	Teb + fire	Savannah	1986	11.9	9.6	9.0	---	---
Panicum virgatum L.	Check	Prairie	1985	14.1	9.4	1.2	---	8.3
	Check	Prairie	1986	12.6	8.5	7.9	---	10.6

Panicum virgatum L. continued	Teb + fire	Prairie	1985	13.0	8.8	9.4	7.7	8.3
	Teb + fire	Prairie	1986	14.6	9.1	---	6.3	9.4
	Teb + fire	Savannah	1985	13.6	10.0	9.4	---	---
	Teb + fire	Savannah	1986	14.6	9.7	---	---	---
Paspalum spp.	Teb + fire	Savannah	1985	---	---	---	9.4	10.2
	Teb + fire	Savannah	1986	---	---	---	11.9	10.6
Schizachyrium scoparium (Michx.) Nash	Check	Prairie	1985	8.3	7.1	5.9	4.2	3.5
	Check	Prairie	1986	7.7	5.9	7.8	8.8	9.1
	Teb + fire	Prairie	1985	11.9	8.3	5.9	4.3	5.9
	Teb + fire	Prairie	1986	10.4	7.8	6.5	6.2	6.2
	Teb + fire	Savannah	1985	13.0	9.5	6.6	6.0	6.7
	Teb + fire	Savannah	1986	13.3	9.0	6.6	9.6	9.8
Sorghastrum nutans (L). Nash	Check	Prairie	1985	9.5	8.2	6.5	10.3	6.5
	Check	Prairie	1986	8.5	6.6	7.2	7.8	8.9
	Teb + fire	Prairie	1985	13.2	9.0	7.8	10.6	5.9
	Teb + fire	Prairie	1986	12.5	8.4	6.6	7.8	9.5
	Teb + fire	Savannah	1985	13.8	9.6	8.9	7.0	6.5
	Teb + fire	Savannah	1986	13.3	7.8	7.3	7.5	7.9
Sporobolus asper (Michx.) Kunth	Check	Prairie	1985	9.7	9.1	5.9	---	---
	Check	Prairie	1986	9.6	8.4	5.4	---	---
	Teb + fire	Prairie	1985	11.4	7.7	6.6	7.8	8.5
	Teb + fire	Prairie	1986	12.6	8.4	6.0	5.0	4.4
Tridens flavus (L.) Hitchc.	Check	Prairie	1985	12.4	9.3	6.9	---	---
	Check	Prairie	1986	9.8	7.9	8.5	---	---

Tridens flavus (L.) Hitchc. continued	Teb + fire	Prairie	1985	16.2	8.4	6.7	22.1	8.0
	Teb + fire	Prairie	1986	12.3	9.6	7.9	10.0	12.5
	Teb + fire	Savannah	1985	15.1	8.3	8.5	11.0	12.9
	Teb + fire	Savannah	1986	14.0	7.9	9.7	13.8	10.6
Mean of graminoids	Check	Prairie		10.0	7.9	6.6	8.2	8.3
	Check	Savannah		10.2	7.6	7.2	9.0	---
	Teb + fire	Prairie		12.6	9.8	7.0	6.5	7.9
	Teb + fire	Savannah		13.4	9.7	8.3	8.5	9.8
FORBS								
Achillea lanulosa Nutt.	Check	Prairie	1985	13.6	10.2	9.5	---	---
	Check	Prairie	1986	12.7	9.8	9.6	---	---
	Teb + fire	Prairie	1985	15.2	10.7	9.0	---	---
	Teb + fire	Prairie	1986	12.9	8.9	8.4	---	---
Ambrosia psilostachya DC.	Check	Prairie	1985	16.6	12.9	11.0	---	---
	Check	Prairie	1986	13.7	13.5	11.8	---	---
	Teb + fire	Prairie	1985	22.2	16.0	14.2	12.4	---
	Teb + fire	Prairie	1986	17.2	17.7	13.1	15.8	---
Artemisia ludoviciana Nutt.	Check	Prairie	1985	13.8	12.0	10.4	---	---
	Check	Prairie	1986	13.7	12.0	9.6	---	---
	Teb + fire	Prairie	1985	15.4	12.4	---	---	---
	Teb + fire	Prairie	1986	9.5	13.1	---	---	---
Conyza canadensis (L.) Cronq.	Teb + fire	Savannah	1985	21.9	19.9	16.2	13.8	---
	Teb + fire	Savannah	1986	18.4	17.8	17.4	17.8	---
Erigeron spp.	Check	Prairie	1986	19.9	8.7	---	---	---
	Teb + fire	Prairie	1986	12.9	9.7	---	---	---

Gutierrezia dracunculoides (DC.) Blake	Teb + fire	Prairie	1985	17.2	13.0	8.9	---	---
	Teb + fire	Prairie	1986	15.5	13.1	11.3	---	---
Lactuca spp.	Check	Savannah	1985	15.0	12.4	---	---	---
	Check	Savannah	1986	13.7	8.3	---	---	---
	Teb + fire	Savannah	1985	19.6	8.9	---	---	---
	Teb + fire	Savannah	1986	16.8	13.8	---	---	---
Phytolacca americana L.	Teb + fire	Savannah	1985	28.2	30.0	23.4	---	13.3
	Teb + fire	Savannah	1986	27.4	21.4	19.0	---	22.3
Psoralea tenuiflora Pursh	Check	Prairie	1985	21.9	17.4	10.7	---	---
	Check	Prairie	1986	22.7	14.3	11.5	---	---
	Teb + fire	Prairie	1985	22.6	16.2	---	---	---
	Teb + fire	Prairie	1986	19.6	12.9	12.6	---	---
Tragia betonicifolia Nuttall	Teb + fire	Prairie	1985	---	---	---	9.4	---
Mean of forbs	Check	Prairie		16.5	12.3	10.5	---	---
	Check	Savannah		14.4	10.4	---	---	---
	Teb + fire	Prairie		16.4	13.1	11.1	12.5	---
	Teb + fire	Savannah		22.1	18.6	19.0	15.8	17.8
BROWSE								
Celtis spp.	Check	Savannah	1985	16.4	10.7	---	---	7.1
	Check	Savannah	1986	14.0	9.5	8.8	---	10.0
	Teb + fire	Savannah	1985	19.2	16.0	---	12.6	13.8
	Teb + fire	Savannah	1986	17.4	14.4	14.7	17.5	16.3
Cercis canadensis (L.) Cronq.	Check	Savannah	1985	16.8	13.5	10.2	---	---
	Check	Savannah	1985	17.2	12.4	12.6	---	---

Cercis candanensis (L.) Cronq. continued	Teb + fire	Savannah	1985	15.5	13.8	15.6	11.9	15.8
	Teb + fire	Savannah	1986	19.7	14.7	15.6	19.4	15.0
Cornus drummondii Meyer	Check	Savannah	1985	11.0	9.7	7.5	10.2	8.2
	Check	Savannah	1986	12.0	7.6	8.9	9.4	10.0
	Teb + fire	Savannah	1985	18.4	9.8	2.4	9.1	10.2
	Teb + fire	Savannah	1986	14.1	11.2	9.5	10.6	11.3
Parthenocissus quinquefolia (L.) Planch.	Check	Savannah	1985	---	12.6	10.7	---	---
	Check	Savannah	1986	---	10.3	8.6	---	---
	Teb + fire	Savannah	1985	---	13.6	12.5	14.4	12.0
	Teb + fire	Savannah	1986	---	14.6	10.3	13.1	14.4
Quercus spp.	Check	Savannah	1985	11.4	10.2	19.7	---	---
	Check	Savannah	1986	12.6	9.6	8.2	---	---
	Teb + fire	Savannah	1985	12.0	12.6	10.4	---	---
	Teb + fire	Savannah	1986	16.1	10.6	9.6	---	---
Rhus copallina L.	Teb + fire	Prairie	1985	---	---	---	7.2	---
Rubus spp.	Check	Savannah	1985	12.3	11.0	---	---	---
	Check	Savannah	1986	17.0	10.2	8.6	---	---
	Teb + fire	Savannah	1985	15.8	12.6	---	---	---
	Teb + fire	Savannah	1986	---	14.0	12.0	---	---
Smilax spp.	Check	Savannah	1985	22.8	22.1	15.0	17.4	---
	Check	Savannah	1986	21.4	17.2	12.9	16.9	---
	Teb + fire	Savannah	1985	20.4	19.0	11.4	15.5	---
	Teb + fire	Savannah	1986	28.8	16.5	16.1	22.5	---

Symphoricarpos orbiculatus Moench	Check	Savannah	1985	11.1	9.7	7.3	---	---
	Check	Savannah	1986	10.4	7.4	9.1	---	---
	Teb + fire	Savannah	1985	12.7	10.8	14.6	---	8.6
	Teb + fire	Savannah	1986	11.6	10.4	11.0	---	11.3
Ulmus americana L.	Check	Savannah	1985	12.6	10.2	9.5	---	9.7
	Check	Savannah	1986	12.8	12.5	10.0	---	10.6
	Teb + fire	Savannah	1985	17.0	10.7	6.0	10.3	14.1
	Teb + fire	Savannah	1986	14.8	13.5	11.2	15.0	18.1
Vitis spp.	Check	Savannah	1985	12.5	10.0	8.9	9.5	9.0
	Check	Savannah	1986	15.8	9.7	9.8	10.0	8.8
	Teb + fire	Savannah	1985	15.4	11.7	5.9	11.3	13.0
	Teb + fire	Savannah	1986	18.0	11.5	10.3	12.5	11.9
Mean of browse	Check	Prairie		---	---	---	---	---
	Check	Savannah		14.5	11.3	10.4	12.2	9.2
	Teb + fire	Prairie		---	---	---	7.2	---
	Teb + fire	Savannah		16.9	13.1	11.1	14.0	13.3

[1]Tebuthiuron plus spring burning.
[2]Not observed as being grazed for that sample date; therefore, not sampled.

Table 2. Seasonal digestibility (%) of range plants for 1985 and 1986 on the Cross Timbers Experimental Range.

Species	Brush treatment	Range site	Year	Sampling date 5-1	6-1	7-1	8-15	9-15
GRAMINOIDS								
Andropogon gerardii Vitman	Check	Prairie	1985	64.4	58.5	53.3	46.7	51.7
	Check	Prairie	1986	59.8	53.5	46.8	48.0	51.8
	Teb + fire[1]	Prairie	1985	72.8	62.7	57.2	43.9	49.3
	Teb + fire	Prairie	1986	62.4	58.1	51.0	50.4	43.5
	Teb + fire	Savannah	1985	63.5	58.7	52.7	43.5	46.8
	Teb + fire	Savannah	1986	64.9	53.0	51.8	51.5	41.7
Aristida spp.	Check	Prairie	1985	---[2]	---	51.2	---	---
	Teb + fire	Prairie	1985	---	---	---	---	41.7
	Teb + fire	Prairie	1986	---	---	---	---	45.1
Bouteloua curtipendula (Michx.) Torr.	Check	Prairie	1985	---	---	39.5	---	---
	Teb + fire	Prairie	1985	69.6	52.4	46.5	43.4	38.4
	Teb + fire	Prairie	1986	62.2	57.7	48.6	45.5	44.9
Bromus spp.	Check	Prairie	1986	55.9	45.6	---	---	---
	Check	Savannah	1985	57.1	41.6	---	---	---
	Check	Savannah	1986	59.4	45.2	---	---	---
	Teb + fire	Savannah	1985	61.9	---	---	---	---
	Teb + fire	Savannah	1986	60.1	---	---	---	---
Carex spp.	Check	Prairie	1985	59.2	51.4	45.0	---	---
	Check	Prairie	1986	56.1	43.4	---	---	---
	Check	Savannah	1985	65.4	58.3	50.2	40.3	---
	Check	Savannah	1986	61.9	51.9	48.5	40.7	---

Carex spp. continued	Teb + fire	Prairie	1985	68.8	47.3	44.5	---	---
	Teb + fire	Prairie	1986	63.0	57.6	---	---	---
	Teb + fire	Savannah	1985	67.9	62.4	59.7	50.6	57.2
	Teb + fire	Savannah	1986	66.1	56.9	55.0	52.9	61.4
Cynodon dactylon (L.) Pers.	Check	Prairie	1985	---	---	---	---	44.4
	Check	Prairie	1986	---	---	---	---	41.6
Elymus virginicus L.	Check	Savannah	1985	60.7	47.0	---	---	---
	Check	Savannah	1986	56.7	46.9	---	---	---
	Teb + fire	Savannah	1985	58.0	49.7	---	---	---
	Teb + fire	Savannah	1986	63.6	44.8	---	---	---
Muhlenbergia spp.	Teb + fire	Savannah	1985	49.5	49.7	---	---	---
	Teb + fire	Savannah	1986	56.0	47.6	43.4	---	---
Panicum anceps Michx.	Teb + fire	Prairie	1985	---	---	---	50.8	---
	Teb + fire	Prairie	1986	---	---	---	54.2	---
	Teb + fire	Savannah	1985	---	---	---	46.5	---
	Teb + fire	Savannah	1986	64.7	---	---	48.0	---
Panicum oligosanthes Schultes	Check	Prairie	1985	70.2	54.4	53.8	---	---
	Check	Prairie	1986	63.7	58.2	51.0	---	---
	Teb + fire	Prairie	1985	74.0	64.4	---	---	---
	Teb + fire	Prairie	1986	68.2	59.4	---	---	---
	Teb + fire	Savannah	1985	63.1	53.9	51.2	---	---
	Teb + fire	Savannah	1986	64.7	55.4	49.8	---	---
Panicum virgatum L.	Check	Prairie	1985	66.9	57.2	41.8	---	39.6
	Check	Prairie	1986	65.5	55.7	48.1	---	51.3

Panicum virgatum L. continued	Teb + fire	Prairie	1985	74.0	56.7	46.4	33.2	35.9
	Teb + fire	Prairie	1986	74.8	60.4	---	39.7	46.8
	Teb + fire	Savannah	1985	70.3	59.4	55.2	---	---
	Teb + fire	Savannah	1986	72.7	60.1	---	---	---
Paspalum spp.	Teb + fire	Savannah	1985	---	---	---	45.4	38.8
	Teb + fire	Savannah	1986	---	---	---	42.8	46.6
Schizachyrium scoparium (Michx.) Nash	Check	Prairie	1985	54.8	68.2	48.8	35.9	33.1
	Check	Prairie	1986	53.2	39.0	39.3	35.0	35.4
	Teb + fire	Prairie	1985	68.2	56.5	50.7	37.6	38.0
	Teb + fire	Prairie	1986	60.7	53.5	39.5	41.2	38.4
	Teb + fire	Savannah	1985	55.4	52.9	51.2	33.8	38.4
	Teb + fire	Savannah	1986	59.8	49.9	39.7	40.0	43.9
Sorghastrum nutans (L.) Nash	Check	Prairie	1985	66.2	61.1	55.6	55.2	52.5
	Check	Prairie	1986	61.0	52.1	56.7	53.2	54.3
	Teb + fire	Prairie	1985	74.5	66.4	61.0	55.6	54.7
	Teb + fire	Prairie	1986	69.2	59.3	57.3	53.2	55.6
	Teb + fire	Savannah	1985	70.6	64.9	60.9	54.4	52.0
	Teb + fire	Savannah	1986	70.4	60.8	59.9	51.2	47.8
Sporobolus asper (Michx.) Kunth	Check	Prairie	1985	54.9	45.1	48.7	---	---
	Check	Prairie	1986	48.2	40.5	43.1	---	---
	Teb + fire	Prairie	1985	68.7	57.2	53.4	46.0	48.8
	Teb + fire	Prairie	1986	62.7	53.7	47.9	43.7	38.5
Tridens flavus (L.) Hitchc.	Check	Prairie	1985	61.7	46.9	51.6	---	---
	Check	Prairie	1986	64.2	54.9	44.9	---	---

Tridens flavus (L.) Hitchc. continued	Teb + fire	Prairie	1985	68.4	53.9	52.8	45.4	40.9
	Teb + fire	Prairie	1986	68.1	55.0	46.3	45.9	49.6
	Teb + fire	Savannah	1985	66.3	50.1	44.3	45.5	39.3
	Teb + fire	Savannah	1986	68.7	48.2	50.9	52.6	46.2
Mean of graminoids	Check	Prairie		60.3	52.1	45.2	45.7	45.6
	Check	Savannah		60.2	48.5	49.4	40.5	---
	Teb + fire	Prairie		68.4	57.3	50.2	45.6	44.4
	Teb + fire	Savannah		63.7	54.4	48.4	41.2	46.7
FORBS								
Achillea lanulosa Nutt.	Check	Prairie	1985	68.0	55.4	57.2	---	---
	Check	Prairie	1986	67.8	56.2	56.9	---	---
	Teb + fire	Prairie	1985	71.7	60.4	57.4	---	---
	Teb + fire	Prairie	1986	68.0	52.1	59.6	---	---
Ambrosia psilostachya DC.	Check	Prairie	1985	76.8	69.5	68.5	---	---
	Check	Prairie	1986	76.1	60.3	56.1	---	---
	Teb + fire	Prairie	1985	79.8	75.6	70.3	66.1	---
	Teb + fire	Prairie	1986	81.4	68.1	58.1	63.1	---
Artemisia ludoviciana Nutt.	Check	Prairie	1985	67.1	62.9	60.8	---	---
	Check	Prairie	1986	66.3	54.9	39.6	---	---
	Teb + fire	Prairie	1985	72.8	64.9	---	---	---
	Teb + fire	Prairie	1986	62.6	54.0	---	---	---
Conyza canadensis (L.) Cronq.	Teb + fire	Savannah	1985	73.6	65.0	65.4	61.4	---
	Teb + fire	Savannah	1986	63.3	60.0	56.3	58.9	---
Erigeron spp.	Check	Prairie	1986	82.3	58.8	---	---	---
	Teb + fire	Prairie	1986	80.7	59.1	---	---	---

Gutierrezia dracunculoides (DC.) Blake	Teb + fire	Prairie	1985	75.8	57.4	62.8	---	---
	Teb + fire	Prairie	1986	74.4	59.2	56.4	---	---
Lactuca spp.	Check	Savannah	1985	78.3	71.1	---	---	---
	Check	Savannah	1986	77.1	65.8	---	---	---
	Teb + fire	Savannah	1985	78.6	72.2	---	---	---
	Teb + fire	Savannah	1986	72.5	70.1	---	---	---
Phytolacca americana L.	Teb + fire	Savannah	1985	86.2	85.0	74.7	---	69.5
	Teb + fire	Savannah	1986	80.9	81.0	76.7	---	74.9
Psoralea tenuiflora Pursh	Check	Prairie	1985	71.9	61.7	62.8	---	---
	Check	Prairie	1986	66.5	63.5	49.7	---	---
	Teb + fire	Prairie	1985	72.0	64.3	---	---	---
	Teb + fire	Prairie	1986	67.3	56.0	56.7	---	---
Tragia betonicifolia Nuttall	Teb + fire	Prairie	1985	---	---	---	63.2	---
Mean of forbs	Check	Prairie		71.4	60.4	56.5	---	---
	Check	Savannah		77.7	68.5	---	---	---
	Teb + fire	Prairie		73.3	61.0	60.2	64.1	---
	Teb + fire	Savannah		75.9	72.2	68.3	60.2	72.2
BROWSE								
Celtis spp.	Check	Savannah	1985	67.6	55.0	---	---	54.3
	Check	Savannah	1986	70.0	59.6	44.9	---	41.9
	Teb + fire	Savannah	1985	29.8	58.7	---	60.7	57.1
	Teb + fire	Savannah	1986	74.5	68.1	67.4	58.5	60.9
Cercis canadensis L.	Check	Savannah	1985	50.2	38.5	29.9	---	---
	Check	Savannah	1986	48.2	36.4	36.3	---	---

Cercis canadensis L. continued	Teb + fire	Savannah	1985	41.1	28.8	30.8	28.7	40.5
	Teb + fire	Savannah	1986	51.9	38.6	36.7	41.7	42.9
Cornus drummondii Meyer	Check	Savannah	1985	57.0	53.5	40.1	50.0	51.7
	Check	Savannah	1986	58.1	51.9	47.7	51.9	52.4
	Teb + fire	Savannah	1985	56.8	49.6	46.9	56.2	51.1
	Teb + fire	Savannah	1986	48.4	45.0	43.0	44.9	46.9
Parthenocissus quinquefolia (L.) Planch.	Check	Savannah	1985	---	63.1	60.4	---	---
	Check	Savannah	1986	---	59.2	57.9	---	---
	Teb + fire	Savannah	1985	---	62.0	63.9	64.4	59.4
	Teb + fire	Savannah	1986	---	59.7	56.4	56.2	62.3
Quercus spp.	Check	Savannah	1985	35.3	31.0	30.4	---	---
	Check	Savannah	1986	48.0	30.8	35.8	---	---
	Teb + fire	Savannah	1985	40.3	33.5	37.1	---	---
	Teb + fire	Savannah	1986	45.7	35.3	35.4	---	---
Rhus copallina L.	Teb + fire	Prairie	1985	---	---	---	53.2	---
Rubus spp.	Check	Savannah	1985	52.8	42.3	---	---	---
	Check	Savannah	1986	40.1	37.2	38.2	---	---
	Teb + fire	Savannah	1985	46.3	34.9	---	---	---
	Teb + fire	Savannah	1986	---	35.9	36.8	---	---
Smilax spp.	Check	Savannah	1985	66.3	63.9	54.6	56.5	---
	Check	Savannah	1986	66.3	59.5	60.0	60.3	---
	Teb + fire	Savannah	1985	53.9	58.2	62.9	57.5	---
	Teb + fire	Savannah	1986	70.5	54.5	54.5	63.7	---

Symphoricarpos orbiculatus Moench	Check	Savannah	1985	46.6	41.5	39.2	---	---
	Check	Savannah	1986	57.0	51.0	48.7	---	---
	Teb + fire	Savannah	1985	56.7	38.9	44.9	---	39.0
	Teb + fire	Savannah	1986	54.8	58.1	47.3	---	50.4
Ulmus americana L.	Check	Savannah	1985	66.0	55.9	56.5	---	55.5
	Check	Savannah	1986	60.4	62.1	56.2	---	54.7
	Teb + fire	Savannah	1985	57.0	61.5	60.5	61.3	58.9
	Teb + fire	Savannah	1986	63.0	65.7	62.7	60.4	66.7
Vitis spp.	Check	Savannah	1985	67.6	63.8	61.6	62.5	60.5
	Check	Savannah	1986	63.4	63.6	55.3	58.3	56.6
	Teb + fire	Savannah	1985	61.3	61.1	64.4	63.5	61.8
	Teb + fire	Savannah	1986	65.7	61.1	59.1	59.2	60.5
Mean of browse	Check	Prairie		---	---	---	---	---
	Check	Savannah		56.7	51.0	47.4	56.6	53.5
	Teb + fire	Prairie		---	---	---	53.2	---
	Teb + fire	Savannah		54.0	53.5	50.6	55.5	54.2

[1]Tebuthiuron plus spring burning.
[2]Not observed as being grazed for that sample date; therefore, not sampled.

Table 3. Seasonal water content (%) of range plants for 1985 and 1986 on the Cross Timbers Experimental Range.

Species	Brush treatment	Range site	Year	Sampling date 5-1	6-1	7-1	8-15	9-15
GRAMINOIDS								
Andropogon gerardii Vitman	Check	Prairie	1985	74	69	68	64	59
	Check	Prairie	1986	70	79	65	64	62
	Teb + fire[1]	Prairie	1985	73	72	66	58	62
	Teb + fire	Prairie	1986	71	71	64	63	62
	Teb + fire	Savannah	1985	82	76	68	62	68
	Teb + fire	Savannah	1986	78	75	69	66	59
Aristida spp.	Check	Prairie	1985	---[2]	---	51	---	---
	Teb + fire	Prairie	1985	---	---	---	---	44
	Teb + fire	Prairie	1986	---	---	---	---	51
Bouteloua curtipendula (Michx.) Torr.	Check	Prairie	1985	---	---	43	---	---
	Teb + fire	Prairie	1985	57	52	50	46	48
	Teb + fire	Prairie	1986	59	58	51	49	43
Bromus spp.	Check	Prairie	1986	71	64	---	---	---
	Check	Savannah	1985	80	67	---	---	---
	Check	Savannah	1986	79	66	---	---	---
	Teb + fire	Savannah	1985	76	---	---	---	---
	Teb + fire	Savannah	1986	75	---	---	---	---
Carex spp.	Check	Prairie	1985	71	58	60	---	---
	Check	Prairie	1986	63	62	---	---	---
	Check	Savannah	1985	75	71	61	69	---
	Check	Savannah	1986	74	70	68	55	---

Carex spp. continued								
	Teb + fire	Prairie	1985	78	70	31	---	---
	Teb + fire	Prairie	1986	75	79	---	---	---
	Teb + fire	Savannah	1985	78	76	66	70	67
	Teb + fire	Savannah	1986	75	72	68	66	68
Cynodon dactylon (L.) Pers.	Check	Prairie	1985	---	---	---	---	60
	Check	Prairie	1986	---	---	---	---	60
Elymus virginicus L.	Check	Savannah	1985	74	67	---	---	---
	Check	Savannah	1986	72	70	---	---	---
	Teb + fire	Savannah	1985	77	66	---	---	---
	Teb + fire	Savannah	1986	75	60	---	---	---
Muhlengergia spp.	Teb + fire	Savannah	1985	70	66	54	---	---
	Teb + fire	Savannah	1986	71	67	60	---	---
Panicum anceps Michx.	Teb + fire	Prairie	1985	---	---	---	66	---
	Teb + fire	Prairie	1986	---	---	---	66	---
	Teb + fire	Savannah	1985	---	---	---	72	---
	Teb + fire	Savannah	1986	83	---	---	76	---
Panicum oligosanthes Schultes	Check	Prairie	1985	76	70	60	---	---
	Check	Prairie	1986	75	76	63	---	---
	Teb + fire	Prairie	1985	75	79	---	---	---
	Teb + fire	Prairie	1986	78	76	---	---	---
	Teb + fire	Savannah	1985	83	73	65	---	---
	Teb + fire	Savannah	1986	79	73	64	---	---
Panicum virgatum L.	Check	Prairie	1985	78	66	63	---	47
	Check	Prairie	1986	71	74	64	---	65

Panicum virgatum L. continued	Teb + fire	Prairie	1985	72	72	68	56	55
	Teb + fire	Prairie	1986	73	71	---	54	57
	Teb + fire	Savannah	1985	76	74	65	---	---
	Teb + fire	Savannah	1986	75	78	---	---	---
Paspalum spp.	Teb + fire	Savannah	1985	---	---	---	76	74
	Teb + fire	Savannah	1986	---	---	---	80	75
Schizachyrium scoparium (Michx.) Nash	Check	Prairie	1985	66	62	56	41	44
	Check	Prairie	1986	66	59	57	46	57
	Teb + fire	Prairie	1985	74	69	56	48	52
	Teb + fire	Prairie	1986	69	66	59	49	48
	Teb + fire	Savannah	1985	75	70	54	49	50
	Teb + fire	Savannah	1986	75	69	60	59	58
Sorghastrum nutans (L.) Nash	Check	Prairie	1985	68	64	64	62	54
	Check	Prairie	1986	68	71	66	59	63
	Teb + fire	Prairie	1985	74	70	66	62	58
	Teb + fire	Prairie	1986	73	69	58	59	60
	Teb + fire	Savannah	1985	77	72	67	64	63
	Teb + fire	Savannah	1986	77	72	67	62	53
Sporobolus asper (Michx.) Kunth	Check	Prairie	1985	62	60	56	---	---
	Check	Prairie	1986	60	59	52	---	---
	Teb + fire	Prairie	1985	66	62	62	62	61
	Teb + fire	Prairie	1986	65	50	54	48	31
Tridens flavus (L.) Hitchc.	Check	Prairie	1985	69	66	67	---	---
	Check	Prairie	1986	68	68	64	---	---

Tridens flavus (L.) Hitchc. continued								
	Teb + fire	Prairie	1985	70	68	62	66	53
	Teb + fire	Prairie	1986	70	68	61	65	53
	Teb + fire	Savannah	1985	74	72	64	65	57
	Teb + fire	Savannah	1986	71	68	65	68	56
Mean of graminoids	Check	Prairie		69	66	60	56	57
	Check	Savannah		76	69	65	62	---
	Teb + fire	Prairie		71	68	58	57	52
	Teb + fire	Savannah		76	71	64	58	62
FORBS								
Achillea lanulosa Nutt.	Check	Prairie	1985	78	70	64	---	---
	Check	Prairie	1986	76	72	64	---	---
	Teb + fire	Prairie	1985	80	74	62	---	---
	Teb + fire	Prairie	1986	76	78	62	---	---
Ambrosia psilostachya DC.	Check	Prairie	1985	78	76	68	---	---
	Check	Prairie	1986	75	79	71	---	---
	Teb + fire	Prairie	1985	82	79	80	70	---
	Teb + fire	Prairie	1986	78	80	68	74	---
Artemisia ludoviciana Nutt.	Check	Prairie	1985	78	74	63	---	---
	Check	Prairie	1986	75	73	63	---	---
	Teb + fire	Prairie	1985	87	78	---	---	---
	Teb + fire	Prairie	1986	78	75	---	---	---
Conyza canadensis (L.) Cronq.	Teb + fire	Savannah	1985	89	87	83	77	---
	Teb + fire	Savannah	1986	86	86	82	74	---
Erigeron spp.	Check	Prairie	1986	75	74	---	---	---

Erigeron spp. continued	Teb + fire	Prairie	1986	79	73	---	---	---
Gutierrezia dracunculoides (DC.) Blake	Teb + fire	Prairie	1985	80	76	61	---	---
	Teb + fire	Prairie	1986	80	76	74	---	---
Lactuca spp.	Check	Savannah	1985	90	84	---	---	---
	Check	Savannah	1986	91	90	---	---	---
	Teb + fire	Savannah	1985	92	90	---	---	---
	Teb + fire	Savannah	1986	89	91	---	---	---
Phytolacca americana L.	Teb + fire	Savannah	1985	90	88	81	---	70
	Teb + fire	Savannah	1986	88	87	84	---	77
Psoralea tenuiflora Pursh	Check	Prairie	1985	79	71	61	---	---
	Check	Prairie	1986	79	73	63	---	---
	Teb + fire	Prairie	1985	77	71	---	---	---
	Teb + fire	Prairie	1986	75	72	64	---	---
Tragia betonicifolia Nuttall	Teb + fire	Prairie	1985	---	---	---	60	---
Mean of forbs	Check	Prairie		77	74	65	---	---
	Check	Savannah		91	87	---	---	---
	Teb + fire	Prairie		72	76	67	68	---
	Teb + fire	Savannah		89	88	83	76	74
BROWSE								
Celtis spp.	Check	Savannah	1985	76	65	---	---	50
	Check	Savannah	1986	76	72	51	---	49
	Teb + fire	Savannah	1985	73	72	---	66	62
	Teb + fire	Savannah	1986	75	74	69	62	57

Cercis canadensis L.	Check	Savannah	1985	75	72	59	---	---
	Check	Savannah	1986	76	72	70	---	---
	Teb + fire	Savannah	1985	76	67	60	70	66
	Teb + fire	Savannah	1986	79	71	70	71	61
Cornus drummondii Meyer	Check	Savannah	1985	68	66	59	60	57
	Check	Savannah	1986	64	62	61	57	57
	Teb + fire	Savannah	1985	69	64	58	65	59
	Teb + fire	Savannah	1986	70	65	60	59	55
Parthenocissus quinquefolia (L.) Planch.	Check	Savannah	1985	---	84	76	---	---
	Check	Savannah	1986	---	80	74	---	---
	Teb + fire	Savannah	1985	---	80	76	76	72
	Teb + fire	Savannah	1986	---	76	69	72	75
Quercus spp.	Check	Savannah	1985	62	57	53	---	---
	Check	Savannah	1986	68	60	58	---	---
	Teb + fire	Savannah	1985	70	65	57	---	---
	Teb + fire	Savannah	1986	73	61	50	---	---
Rhus copallina L.	Teb + fire	Prairie	1985	---	---	---	50	---
Rubus spp.	Check	Savannah	1985	72	70	---	---	---
	Check	Savannah	1986	76	71	64	---	---
	Teb + fire	Savannah	1985	78	72	---	---	---
	Teb + fire	Savannah	1986	---	74	69	---	---
Smilax spp.	Check	Savannah	1985	86	86	84	84	---
	Check	Savannah	1986	88	86	83	84	---

Smilax spp. continued	Teb + fire	Savannah	1985	82	84	80	75	---
	Teb + fire	Savannah	1986	87	84	82	84	---
Symphoricarpos orbiculatus Moench	Check	Savannah	1985	66	66	52	---	---
	Check	Savannah	1986	62	57	57	---	---
	Teb + fire	Savannah	1985	65	62	50	---	53
	Teb + fire	Savannah	1986	64	57	51	---	53
Ulmus americana L.	Check	Savannah	1985	72	66	59	---	58
	Check	Savannah	1986	72	70	62	---	55
	Teb + fire	Savannah	1985	72	69	60	66	65
	Teb + fire	Savannah	1986	75	74	77	62	66
Vitis spp.	Check	Savannah	1985	78	74	69	71	65
	Check	Savannah	1986	81	77	71	67	65
	Teb + fire	Savannah	1985	79	76	71	70	66
	Teb + fire	Savannah	1986	81	76	69	64	63
Mean of browse	Check	Prairie		---	---	---	---	---
	Check	Savannah		73	71	65	71	57
	Teb + fire	Prairie		---	---	---	50	---
	Teb + fire	Savannah		75	71	65	69	62

[1]Tebuthiuron plus spring burning.
[2]Not observed as being grazed for that sample date; therefore, not sampled.

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APPENDIXES

Appendix A. Phenology of range plants for 1985 and 1986 on pastures 2,4,6, and 14 on the Cross Timbers Experimental Range.

Species	Brush treatment	Range site	Year	Sample date 5-1	6-1	7-1	8-15	9-19
GRAMINOIDS								
Andropogon gerardii Vitman	Check	Prairie	1985	1.25	1.50	2.25	2.25	2.50
	Check	Prairie	1986	1.25	1.50	1.75	2.50	2.75
	Teb + fire[2]	Prairie	1985	1.25	1.50	2.25	2.25	2.50
	Teb + fire	Prairie	1986	1.25	1.50	1.75	2.50	2.75
	Teb + fire	Savannah	1985	1.25	1.50	2.25	2.25	2.50
	Teb + fire	Savannah	1986	1.25	1.50	1.75	2.50	2.75
Aristida spp.	Check	Prairie	1985	---[3]	---	1.75	---	---
	Teb + fire	Prairie	1985	---	---	---	---	2.75
	Teb + fire	Prairie	1986	---	---	---	---	2.75
Bouteloua curtipendula (Michx.) Torr.	Check	Prairie	1985	---	---	2.50	---	---
	Teb + fire	Prairie	1985	1.50	1.25	2.50	2.75	3.00
	Teb + fire	Prairie	1986	1.25	2.25	2.75	3.00	3.00
Bromus spp.	Check	Prairie	1986	2.25	3.33	---	---	---
	Check	Savannah	1985	2.25	2.25	---	---	---
	Check	Savannah	1986	2.25	3.33	---	---	---
	Teb + fire	Savannah	1985	2.25	---	---	---	---
	Teb + fire	Savannah	1986	2.25	---	---	---	---
Carex spp.	Check	Prairie	1985	2.75	2.75	2.75	---	---
	Check	Prairie	1986	1.25	2.50	---	---	---
	Check	Savannah	1985	2.75	2.75	2.75	3.00	---
	Check	Savannah	1986	1.25	2.50	2.75	2.75	---

Carex spp. continued	Teb + fire	Prairie	1985	2.75	2.75	2.75	---	---
	Teb + fire	Prairie	1986	1.25	2.50	---	---	---
	Teb + fire	Savannah	1985	2.75	2.75	2.75	3.00	2.75
	Teb + fire	Savannah	1986	1.25	2.50	2.75	2.75	2.75
Cynodon dactylon (L.) Pers.	Check	Prairie	1985	---	---	---	---	2.75
	Check	Prairie	1986	---	---	---	---	2.75
Elymus virginicus L.	Check	Savannah	1985	1.25	2.75	---	---	---
	Check	Savannah	1986	1.25	2.50	---	---	---
	Teb + fire	Savannah	1985	1.25	2.75	---	---	---
	Teb + fire	Savannah	1986	1.25	2.50	---	---	---
Muhlenbergia spp.	Teb + fire	Savannah	1985	1.75	1.75	2.00	---	---
	Teb + fire	Savannah	1986	1.25	1.75	2.00	---	---
Panicum anceps Michx.	Teb + fire	Prairie	1985	---	---	---	2.75	---
	Teb + fire	Prairie	1986	---	---	---	2.75	---
	Teb + fire	Savannah	1985	---	---	---	2.75	---
	Teb + fire	Savannah	1986	1.25	---	---	2.75	---
Panicum oligosanthes Schultes	Check	Prairie	1985	2.25	2.75	2.75	---	---
	Check	Prairie	1986	2.00	2.75	2.75	---	---
	Teb + fire	Prairie	1985	2.25	2.75	---	---	---
	Teb + fire	Prairie	1986	2.00	2.75	---	---	---
	Teb + fire	Savannah	1985	2.25	2.75	2.75	---	---
	Teb + fire	Savannah	1986	2.00	2.75	2.75	---	---
Panicum virgatum L.	Check	Prairie	1985	1.25	1.50	2.00	---	2.75
	Check	Prairie	1986	1.25	1.50	2.00	---	2.75

Panicum virgatum L. continued	Teb + fire	Prairie	1985	1.25	1.50	2.00	2.50	2.75
	Teb + fire	Prairie	1986	1.25	1.50	---	2.25	2.75
	Teb + fire	Savannah	1985	1.25	1.50	2.00	---	---
	Teb + fire	Savannah	1986	1.25	1.50	---	---	---
Paspalum spp.	Teb + fire	Savannah	1985	---	---	---	2.25	2.50
	Teb + fire	Savannah	1986	---	---	---	1.75	2.00
Schizachyrium scoparium (Michx.) Nash	Check	Prairie	1985	1.25	1.50	1.75	2.00	2.50
	Check	Prairie	1986	1.25	1.25	1.75	2.00	2.25
	Teb + fire	Prairie	1985	1.25	1.50	1.75	2.00	2.50
	Teb + fire	Prairie	1986	1.25	1.25	1.75	2.00	2.25
	Teb + fire	Savannah	1985	1.25	1.50	1.75	2.00	2.50
	Teb + fire	Savannah	1986	1.25	1.25	1.75	2.00	2.25
Sorghastrum nutans (L.) Nash	Check	Prairie	1985	1.25	1.50	1.75	2.00	2.50
	Check	Prairie	1986	1.25	1.25	1.75	2.00	2.50
	Teb + fire	Prairie	1985	1.25	1.50	1.75	2.00	2.50
	Teb + fire	Prairie	1986	1.25	1.25	1.75	2.00	2.50
	Teb + fire	Savannah	1985	1.25	1.50	1.75	2.00	2.50
	Teb + fire	Savannah	1986	1.25	1.25	1.75	2.00	2.50
Sporobolus asper (Michx.) Kunth	Check	Prairie	1985	1.25	1.25	1.75	---	---
	Check	Prairie	1986	1.25	1.25	1.75	---	---
	Teb + fire	Prairie	1985	1.25	1.25	1.75	2.00	2.00
	Teb + fire	Prairie	1986	1.25	1.25	1.75	1.75	3.00
Tridens flavus (L.) Hitchc.	Check	Prairie	1985	1.25	1.50	1.75	---	---
	Check	Prairie	1986	1.25	1.50	1.75	---	---

Tridens flavus (L.) Hitchc. continued								
	Teb + fire	Prairie	1985	1.25	1.50	1.75	2.25	2.75
	Teb + fire	Prairie	1986	1.25	1.50	1.75	2.25	2.75
	Teb + fire	Savannah	1985	1.25	1.50	1.75	2.25	2.75
	Teb + fire	Savannah	1986	1.25	1.50	1.75	2.50	2.75
FORBS								
Achillea lanulosa Nutt.	Check	Prairie	1985	3	5	7	---	---
	Check	Prairie	1986	4	5	7	---	---
	Teb + fire	Prairie	1985	3	5	7	---	---
	Teb + fire	Prairie	1986	4	5	7	---	---
Ambrosia psilostachya DC.	Check	Prairie	1985	3	3	3	---	---
	Check	Prairie	1986	3	3	3	---	---
	Teb + fire	Prairie	1985	3	3	3	4	---
	Teb + fire	Prairie	1986	3	3	3	4	---
Artemisia ludoviciana Nutt.	Check	Prairie	1985	3	3	3	---	---
	Check	Prairie	1986	3	3	3	---	---
	Teb + fire	Prairie	1985	3	3	---	---	---
	Teb + fire	Prairie	1986	3	3	---	---	---
Conyza canadensis (L.) Cronq.	Teb + fire	Savannah	1985	3	3	3	4	---
	Teb + fire	Savannah	1986	3	3	3	4	---
Erigeron spp.	Check	Prairie	1986	4	5	---	---	---
	Teb + fire	Prairie	1986	4	5	---	---	---
Gutierrezia dracunculoides (DC.) Blake	Teb + fire	Prairie	1985	3	3	3	---	---
	Teb + fire	Prairie	1986	3	3	3	---	---
Lactuca spp.	Check	Savannah	1985	3	4	---	---	---
	Check	Savannah	1986	3	3	---	---	---

Lactuca spp. continued								
	Teb + fire	Savannah	1985	3	4	---	---	---
	Teb + fire	Savannah	1986	3	3	---	---	---
Phytolacca americana L.	Teb + fire	Savannah	1985	3	4	5	---	6
	Teb + fire	Savannah	1986	3	5	6	---	7
Psoralea tenuiflora Pursh	Check	Prairie	1985	5	5	7	---	---
	Check	Prairie	1986	4	5	7	---	---
	Teb + fire	Prairie	1985	5	5	---	---	---
	Teb + fire	Prairie	1986	4	5	7	---	---
Tragia betonicifolia Nuttall	Teb + fire	Prairie	1985	---	---	---	6	---
BROWSE								
Celtis spp.	Check	Savannah	1985	11	12	---	---	12
	Check	Savannah	1986	4	7	12	---	12
	Teb + fire	Savannah	1985	11	12	---	12	12
	Teb + fire	Savannah	1986	4	7	12	12	12
Cercis canadensis L.	Check	Savannah	1985	6	12	12	---	---
	Check	Savannah	1986	4	12	12	---	---
	Teb + fire	Savannah	1985	6	12	12	12	12
	Teb + fire	Savannah	1986	4	12	12	12	12
Cornus drummondii Meyer	Check	Savannah	1985	10	11	12	12	12
	Check	Savannah	1986	10	12	12	12	12
	Teb + fire	Savannah	1985	10	11	12	12	12
	Teb + fire	Savannah	1986	10	12	12	12	12

Parthenocissus quinquefolia (L.) Planch.	Check	Savannah	1985	---	6	7	---	---
	Check	Savannah	1986	---	7	7	---	---
	Teb + fire	Savannah	1985	---	6	7	12	12
	Teb + fire	Savannah	1986	---	7	7	12	12
Quercus spp.	Check	Savannah	1985	2	6	7	---	---
	Check	Savannah	1986	2	6	7	---	---
	Teb + fire	Savannah	1985	2	6	7	---	---
	Teb + fire	Savannah	1986	2	6	7	---	---
Rhus copallina L.	Teb + fire	Prairie	1985	---	---	---	12	---
Rubus spp.	Check	Savannah	1985	5	12	---	---	---
	Check	Savannah	1986	11	12	13	---	---
	Teb + fire	Savannah	1985	5	12	---	---	---
	Teb + fire	Savannah	1986	---	12	13	---	---
Smilax spp.	Check	Savannah	1985	4	5	12	12	---
	Check	Savannah	1986	4	12	12	12	---
	Teb + fire	Savannah	1985	4	5	12	12	---
	Teb + fire	Savannah	1986	4	12	12	12	---
Symphoricarpos orbiculatus Moench	Check	Savannah	1985	7	7	11	---	---
	Check	Savannah	1986	7	7	11	---	---
	Teb + fire	Savannah	1985	7	7	11	---	9
	Teb + fire	Savannah	1986	7	7	11	---	9
Ulmus americana L.	Check	Savannah	1985	6	6	7	---	7
	Check	Savannah	1986	6	6	7	---	7
	Teb + fire	Savannah	1985	6	6	7	7	7
	Teb + fire	Savannah	1986	5	6	7	7	7

Vitis spp.	Check	Savannah	1985	5	5	12	12	13
	Check	Savannah	1986	5	12	12	12	14
	Teb + fire	Savannah	1985	5	5	12	12	13
	Teb + fire	Savannah	1986	5	12	12	12	14

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[1]Phenology scales:

GRASSES

1.00	1-3 leaves
1.25	4-6 leaves
1.50	7-8 leaves
1.75	> 8 leaves
2.00	Boot stage
2.25	Inflorescence
2.50	Anthesis (pollen)
2.75	Anthesis complete
3.00	< 50% of leaves yellow
3.33	> 50% of leaves yellow
3.66	top growth all dead

FORBS

0	Winter rosette
1	Shoots without leaves
2	2-4 leaves
3	> 4 leaves
4	Flowering buds present
5	Flowering
6	Post flowering
7	> 50% top growth dead
8	Top growth all dead

BROWSE

0	Winter dormancy, deciduous
1	Buds with green tips, starting to open
2	Green leaves out but not fully unfolded
3	< 25% leafing
4	20-50% leafing
5	50-75% leafing
6	> 75% leafing
7	Full leaf
8	< 50% leaf yellowing
9	> 50% leaf yellowing
10	Flower buds swelling
11	Flowering
12	Post flowering
13	Fruit ripe
14	Fruit dropping

[2]Tebuthiuron plus spring burning.
[3]Not observed as being grazed for that sample date; therefore, not sampled.

APPENDIX B

List of common names for plant species

GRAMINOIDES

Andropogon gerardii Vitman	Big bluestem
Aristida spp.	Threeawn
Bouteloua curtipendula (Michx.) Torr.	Sideoats grama
Bromus spp.	Brome
Carex spp.	Sedge
Cynodon dactylon (L.) Pers.	Bermuda grass
Elymus virginicus L.	Virginia wildrye
Muhlenbergia spp.	Muhly
Panicum anceps Michx.	Beaked panicum
Panicum oligosanthes Schultes	Rosette panicgrass
Panicum virgatum L.	Switchgrass
Paspalum spp.	Paspalum
Schizachyrium scoparium (Michx.) Nash	Little bluestem
Sorghastrum nutans (L.) Nash	Indiangrass
Sporobolus asper (Michx.) Kunth	Tall dropseed
Tridens flavus (L.) Hitchc.	Purpletop

FORBS

Achillea lanulosa Nutt.	Yarrow
Ambrosia psilostachya DC.	Western ragweed
Artemisia ludoviciana Nutt.	Louisiana sagewort
Conyza canadensis (L.) Cronq.	Marestail
Erigeron spp.	Fleabane
Gutierrezia dracunculoides (DC.) Blake	Broomweed
Lactuca spp.	Prickly lettuce
Phytolacca americana L.	Pokeweed
Psoralea tenuiflora Pursh	Slimflower scurfpea
Tragia betonicifolia Nuttall	Nettleleaf noseburn

BROWSE

Celtis spp.	Hackberry
Cercis canadensis (L.) Cronq.	Redbud
Cornus drummondii Meyer	Roughleaf dogwood
Parthenocissus quinquefolia (L.) Planch.	Virginia creeper
Quercus spp.	Oak
Rhus copallina L.	Winged sumac
Rubus spp.	Blackberry
Smilax spp.	Greenbriar
Symphoricarpos orbiculatus Moench	Buckbrush
Ulmus americana L.	American elm
Vitis spp.	Grape

VITA 2

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