THE EFFECTS OF EARLY SPRING BURNING AND MESQUITE DENSITY ON PLANT SPECIES COMPOSITION, BIOMASS, AND STEM DENSITY IN HARDLAND RANGE

By

JOHN ALLEN RATZLAFF

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Thesis Approved:

Larry G. Talbot
Thesis Adviser

O. Eugene Maughan

Robert L. Lochmiller

Norman N. Durham
Dean of the Graduate College

PREFACE

The effects of early spring burning and mesquite density on plant species composition, biomass, and stem density in Hardland range were investigated at Ft. Sill Military Reservation during 1985. Results from this study showed that there are distinct differences in the effects of early spring burning on the plant communities associated with different densities of mesquite. The presence or absence of brome and/or litter appeared to be the major influencing factors. After burning, mesquite free areas had an increase in plant diversity and perennial grasses, and a decrease in brome. Mesquite free areas decreased in standing crop biomass and stem density at all heights after burning. In high mesquite density areas, burning increased plant diversity and the relative number of perennial grasses. Brome was reduced by burning. Burning decreased standing crop biomass and stem density early in the growing season and increased standing crop biomass and stem density late in the growing season, in comparison to unburned high mesquite density areas. The effects, however, were only temporary because brome recolonized the areas after two years. In low mesquite density areas, burning increased standing crop biomass, stem density, plant diversity, and to some degree, the relative number of perennial grasses.

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CHAPTER I

INTRODUCTION

Although the effects of fire on prairie grasslands and the role of fire in maintaining grasslands has been studied in many areas, there is still a paucity of information relating the effects of burning to the time of year the burning occurred and the influence brush (mesquite in the southwest) can have on the desired outcome. Native grasslands of the central United States evolved under a system of grazing and periodic, sometimes annual or sporadic, burning (Anderson 1976, Jackson 1965). Periodic burning has led some authors to contend that grasslands are not a climax community but an early successional stage maintained by fire (Sauer 1950, Stewart 1953). In contrast, Carpenter (1940) suggested that grasslands are a climax community maintained by a deficiency of rainfall during the latter portion of the dry season. Borchert (1950) contends that grasslands are climax communities maintained by climates which are simply more conducive to grass whether there is fire or not. Still others contend that grasslands are climax communities and that the extent of grasslands are maintained by climate; fire being only one of many environmental factors (Weaver and Albertson 1956). Malin (1956) disagreed with the idea of a fire climax because fire does not always retard woody growth or promote the invasion of grass at the expense of trees. Rather, each grassland is unique and the invasion of woody growth (every grassland contains non-grass species, some of which may be termed woody), the climate associated with a particular area and the variations and extremes experienced, plus a host of other variables including altitude, topography, geological structure, soil, and ground water.

Managers now realize the importance and usefulness of fire and frequently use fire as a management tool. Vogl (1965) and many other authors (Curtis and Partch 1948, Hadley and Keickhefer 1963, Old 1969, Anderson 1972, Wright 1972, Vogl 1974, Peet et al. 1975) found that early spring burning not only decreased the amount of dead herbage but also increased the amount of green herbage. However, in more arid regions the results are less clear. Fire can reduce vegetative growth where debris accumulations are considerable and xeric conditions follow burning (Hopkins et al. 1948, Launchbaugh 1964). However, Towne and Owensby (1984) found that burning tallgrass prairies in Kansas, even in dry years, had no affect on herbage production. Graber (1926) showed that vegetative production was decreased on grasslands burned either in late spring, late fall, or early spring, and Anderson et al. (1970) also noted that forage quality was higher on plots burned in late spring. Areas burned in late spring were closest to the vegetative production on unburned areas. However, plant populations were greatest on plots burned in late fall and least on those burned in late spring. Plots burned in late fall and early spring had greater plant populations than unburned areas. Anderson et al. (1970) and Towne and Owensby (1984) found similar results and attributed the higher production in late spring burns to the greater moisture retention capacity of such areas and to the dormancy of some plants. Thus, burning at a time to minimize surface exposure will prevent moisture loss and increase herbage production (Towne and Owensby 1984).

The invasion of woody growth into grasslands effect the diversity and species composition of prairie plants in some areas (Gruell 1983). However, evaluating the effect of associated vegetative changes depends on the management objectives for an area, e.g., is the goal to produce more forage for cattle or seeds and cover for wildlife. In grazed prairies, dense woody vegetation suppresses grass production and available forage (Dalrymple et al. 1964), i.e. as hardwood crown area increases, herbage decreases (Ehrenreich and Crosby 1960, Crouch 1986). For example, Dalrymple et al. (1964) found that control of winged elm (Ulmus alata) could double and sometimes triple forage production. Darrow and McCully (1959) attributed increased herbage production after brush control to the release of moisture, light, and nutrients.

In the southwestern United States, mesquite (Prosopis juliflora) is one of the most common woody invaders into prairie areas. Mesquite growth forms vary from a many stemmed bushy plant less than 1.5 m tall to a large single trunk tree that can reach 15 m in height and 0.6 m in diameter. The variation in growth habits is influenced by moisture, soil, weather, and injury to the plant (Fisher 1948). The extensive root system of mesquite allows it to withstand drought, competition with other plant species, and prolonged overgrazing. Roots may reach depths of 6 to 18 m and extend laterally as much as 15 m from the base of the tree (Dayton 1931).

The origin, extent, rate, and degree of mesquite "infestation" into the southwestern United States has been a much debated subject. Many authors contend that the mesquite invasion is of recent origin, stemming from either drought, cattle drives, overgrazing, a decrease in wildfires, or a combination of several of these factors. However, there is a preponderance of evidence showing that mesquite has been in the southwest since long before the events that some claim are the cause of its eruption. Malin (1956) examined reports from both the Long and Marcy expeditions of the early to mid 1800's and found that mesquite not only occurred in the southwest during the early 1800's but covered vast areas in dense uninterrupted stands. Malin also noted that the misconceptions about the origin and past extent of mesquite are not nearly as important as the apparent change in the growth form of mesquite and accompanying vegetation. Mesquite in the tree form, once occupied an area that, from the descriptions of early explorers, would be considered savanna. Today, some of these same areas are covered with a near impenetrable jungle of the brushy form of mesquite. There are areas, however, where mesquite has recently invaded, not simply increased in density. In Texas alone, mesquite now occupies over 138 million hectares, 4.9 million of which have only become infested in the past 20 years (Thomas et al. 1968).

Mesquite causes considerable problems for ranchers because it reduces the density and herbage yields of grasses and thus increases the cost and difficulty of handling range cattle (Martin 1975). In Arizona, as few as 62 trees per hectare have cut herbage production in half (Martin 1975). Generally, however, sites with annual rainfall of at least 0.64 m and sites of higher quality with less rainfall, have enough moisture to support mesquite with only a slight reduction in grass production (Fisher 1948). Mesquite has also been shown to accelerate or induce erosion. Mesquite requires three to four times much water to produce one unit of dry matter as do native perennial grasses (McGinnies and Arnold 1939). The long lateral roots of mesquite remove moisture from the soil between the trees. This moisture reduction results in relatively barren areas that are susceptible to wind and water erosion (Martin 1975).

Many methods of mesquite removal and their effects on herbage production have been and are being investigated. Wright (1968) found that fires with surface temperatures of 538 C or greater show potential to kill mesquite and increase tobosa grass (Hilaria mutica) production. However, Weaver and Clements (1938) stated that fire increases mesquite at the expense of grasses. Shredding of mesquite can also increase herbage production but timing is essential to prevent a loss of grasses (Schuster 1968). Box (1968) monitored herbaceous vegetation responses to roller chopping, scalping, root plowing, and shredding of mesquite. All methods increased herbage production. Cable and Tschirley (1961) found that spraying mesquite with 2,4,5-T resulted in an average of twice as much herbage over the six years following spraying as produced on untreated areas. Martin (1975) stated that mesquite infested range could be restored to full productivity if all mesquite was removed and noted that grass response following removal was excellent on sites that received 20 cm or more of summer rainfall, if a good crop of remnant perennial grasses was present.

There are, however, discrepancies concerning the extent to which mesquite should be controlled on grasslands. Davis (1979) did not notice an increase in grasses in mesquite infested areas when either 75 percent or 90 percent of the mesquite was removed by grubbing and also noted that grasses appear to recover from drought conditions faster in areas infested with mesquite. However, Fisher (1948) stated that in a moderate to dense stand of mesquite there is severe competition with grasses for moisture, light, and, to a lesser extent, plant nutrients.

Many studies state conclusively that decreased coverage by mesquite results in an increased production of forage. However, studies that note either the number of mesquite plants before and after treatment or total decrease in mesquite cover, do not compare herbage yields to those on similar areas without mesquite. Furthermore, the effects of grazing are often not taken into consideration. To determine whether total removal of mesquite is more conducive to herbage production than partial removal, a knowledge of mesquite-free area herbage production is necessary. Without this knowledge, herbage production in mesquite infested areas will generally be assumed to increase until all mesquite is removed.

Prescribed burning and mesquite removal are generally oriented towards improving range land for domestic livestock. Most studies offer information concerning forage quality, changes in plant species composition (mostly in terms of the removal of undesirable species, including mesquite), increasing productivity of forage plants, vegetation height (in one form or another), biomass, and litter depth (Dix 1960, Owensby and Anderson 1967, Graves and McMurphy 1969, Anderson et al. 1970, Owensby et al. 1973, Bragg and Hulbert 1976). While these variables provide useful information, they do not provi any indication of vegetative structure (stem density at varying heights) or what degree of mesquite removal provides for the highest biomass production in the absence of grazing.

The objectives of this study were to determine if there are any statistically significant differences in vegetative structure in an ungrazed area between areas of different burn ages and/or mesquite densities, to determine the effects of fire and mesquite density on plant species composition and biomass, and to determine the effects of these latter two factors on stem density.

CHAPTER II

STUDY AREA

General

Fort Sill Military Reservation (FSMR) is located in Comanche County, southwestern Oklahoma (Figure 1). The 38,164 ha reservation, established in 1869, is a United States Army Artillery and Missile Center.

FSMR is located within the Central Rolling Red Prairie Resources area (U.S.D.A. Land Resources Regions and Major Land Resources Areas of the United States). Habitat types vary greatly, ranging from relatively flat prairie in the east to jagged, steep granite hills in the west. Fifty-one percent of the land is level to a slope of less than three percent, 20 percent is rolling with a 3 to 5% slope, and 29 percent has a slope of greater than five percent. Approximately 52 percent of FSMR is within the East Cache Creek watershed, 40 percent in the West Cache Creek watershed, and eight percent in the Big Beaver Creek watershed (Comanche Co. SCS 1970).

FSMR has a temperate, continental dry, subhumid climate. The area is influenced by weather patterns that are sustained by alternating movements of warm, moist air from the Gulf of Mexico and either contrasting cooler, modified marine air from the west coast or cooler, dry air from the arctic. Rapid weather changes are common and result in distinct fluctuations of temperature, cloudiness, wind, and

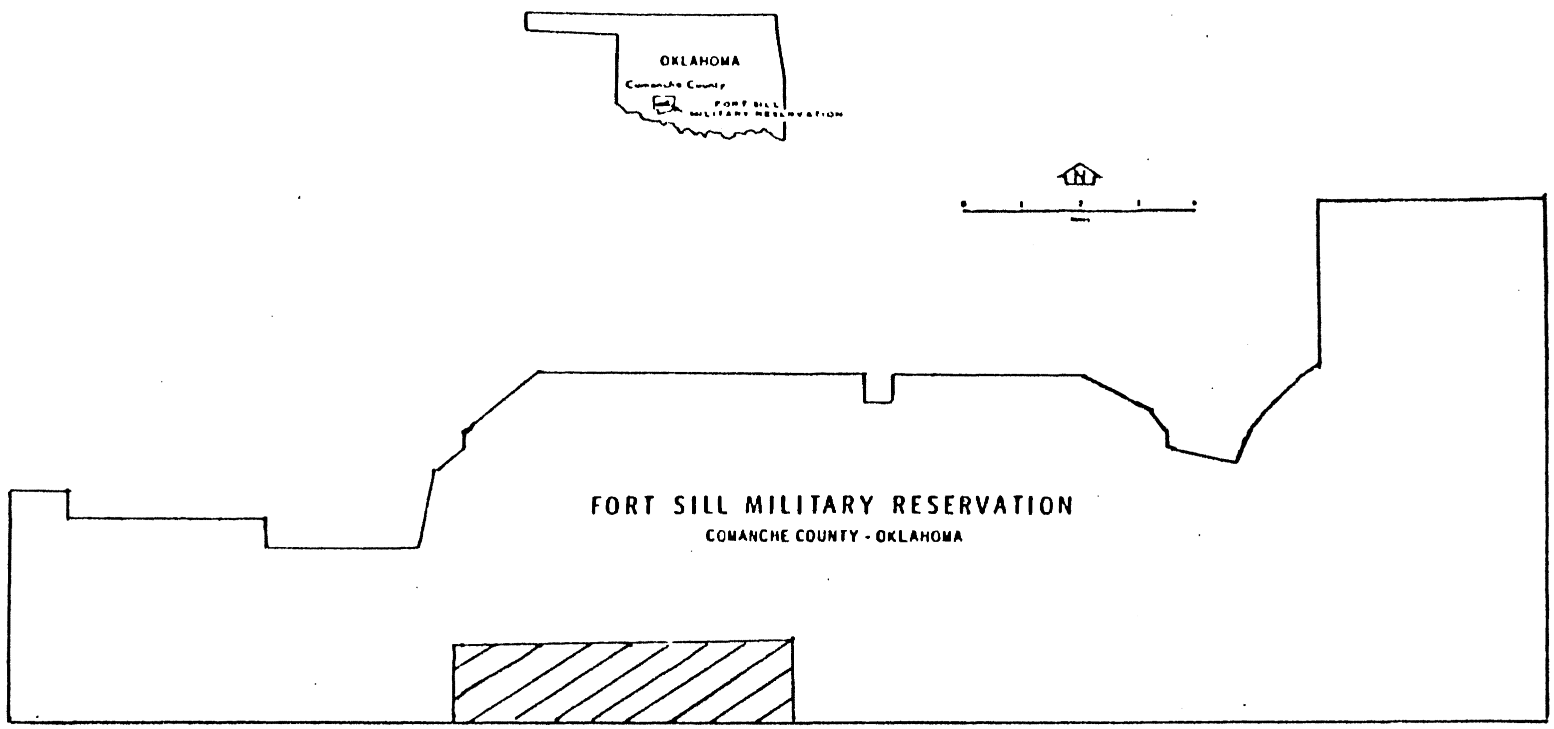

Figure 1. The Study Area at Ft. Sill Military Reservation, Comanche County, Oklahoma.

precipitation (Comanche Co. SCS 1970).

Mean annual temperature at FSMR is 17.1 C and mean annual monthly temperatures range from 4.8 C in January to 28.7 C in August. Freezing temperatures occur on an average of 74 days each year, between October and April. An average of five days per year have a high temperature below freezing. Minimum readings of -17.8 C or below occur in one out of every six years (Comanche Co. SCS 1970).

Mean annual precipitation ranges from 68 cm in the west to 83 cm in the northeast corner of the county. FSMR has recorded a mean annual precipitation of 77 cm with most rainfall occurs in spring (34%). The winter months are the driest, accounting for only about 15 percent of the total annual precipitation. Mean annual evaporation is high (1.61 m), and peaks between May and October (Comanche Co. SCS 1970).

Prevailing winds at FSMR are northerly in January and February and southerly during the remainder of the year. Mean wind speed is over 19 kph and winds of 50 to 80 kph are common (Comanche Co. SCS 1970).

The vegetation on FSMR closely resembles the climax communities associated with each soil type; soils being the major cause of variation within the plant community. Other variation is primarily due to past and present human influence. Areas once in crop production often vary from typical climax communities depending on the time since last in production (Comanche Co. SCS 1970). FSMR is presently not being grazed and most areas have not been grazed for over 30 years. Presently, major disturbances are primarily limited to fire (prescribed burning is used yearly in select areas and wildfires as a result of military training, i.e. vehicles and explosives, are common.

FSMR has three major grassland types. Tall grasses, such as big bluestem (Andropogon gerardi), little bluestem (Andropogon scoparius), sand bluestem (Andropogon hallii), switchgrass (Panicum virgatum), and Indiangrass (Sorghastrum nutans) occupy moister areas. Mid and short grasses, such as blue grama (Bouteloua gracilis) and sideoats grama (Bouteloua curtipendula), occupy the more drought natured areas (Comanche Co. SCS 1970).

Wooded areas are primarily restricted to riparian zones and rocky uplands. The most common bottomland species are American elm (Ulmus americana), pecan (Carya illinoensis), western hackberry (Celtis occidentalis), red oaks, blackjack oak (Quercus marylandica), and white oaks (post, bur, and chinquapin). Upland woods are dominated by blackjack and post oaks (Quercus stellata) with an understory of native grasses, numerous legumes and other forbs (Comanche Co. SCS 1970).

Mesquite is found on many Hardland and Slickspot range areas (Appendix A). The understory generally consists of native grasses with some forbs, which are especially abundant in disturbed areas (Comanche Co. SCS 1970).

Study Area Proper

The study area is located on a 2160 ha (Figure 1) tract along the southern boundary of the west range of FSMR. It extends north to a line parallel to and 0.6 km north of McKenzie Hill Road, south to South Boundary Road, east to Tank X Road and west to a line from False

Quanah Mt. to just west of Three-Crows Pond. This study area was selected because mesquite densities are diverse, prescribed burn ages are known (from 1982 to 1985), few wildfires occur in the area, and the area is accessible from all sides.

The soils on the study area (Appendix B) are diverse (20 types) but are dominated by the Foard series (62% of the study area), particularly the Foard-Slickspot complex (Table 1). The soils of the remaining area are primarily of the Port series (15.8%) and Granite Cobbly Land (9.2%) (Figure 2).

Ten range classes (Appendix A) are present on the study area (Figure 3). The majority of the area is Hardland Range (70.83%) and Loamy Bottomland (13.03%)(Table 2).

TABLE 1. SOIL TYPES PRESENT ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA.

		DISTRIBUTION	
SYMBOL	MAPPING UNIT	HECTARES	% COVERAGE
FsB	Foard-Slickspots complex, 1-3% slopes	1144.7	53.00
Po	Port loam	246.2	11.40
Gc	Granite cobbly land	199.0	9.21
FtB	Foard and Tillman soils, 1-3% slopes	149.5	6.92
Ro	Rock land	58.1	2.69
Ps	Port-Slickspots complex	50.8	2.35
Pc	Port clay loam	45.1	2.09
LaC	Lawton loam, 3-5% slopes	40.4	1.87
Bk	Breaks-Alluvial complex	34.9	1.62
Lm	Limestone cobbly land	32.0	1.48
St	Stony rock land	30.8	1.43
LaB	Lawton loam, 1-3% slopes	28.9	1.34
VeD	Vernon soils, 5-12% slopes	26.9	1.25
FsA	Foard-Slickspots complex, 0-1% slopes	26.2	1.21
FaA	Foard silt loam, 0-1% slopes	18.3	0.85
LzD	Lucien-Zaneis-Vernon complex, 5-12% slopes	8.2	0.38
VeC	Vernon soils, 3-5% slopes	5.8	0.27
Br	Broken Alluvial land	5.5	0.25
Es	Eroded clayey land	4.6	0.21
TmC	Tillman clay loam, 3-5% slopes	4.1	0.19

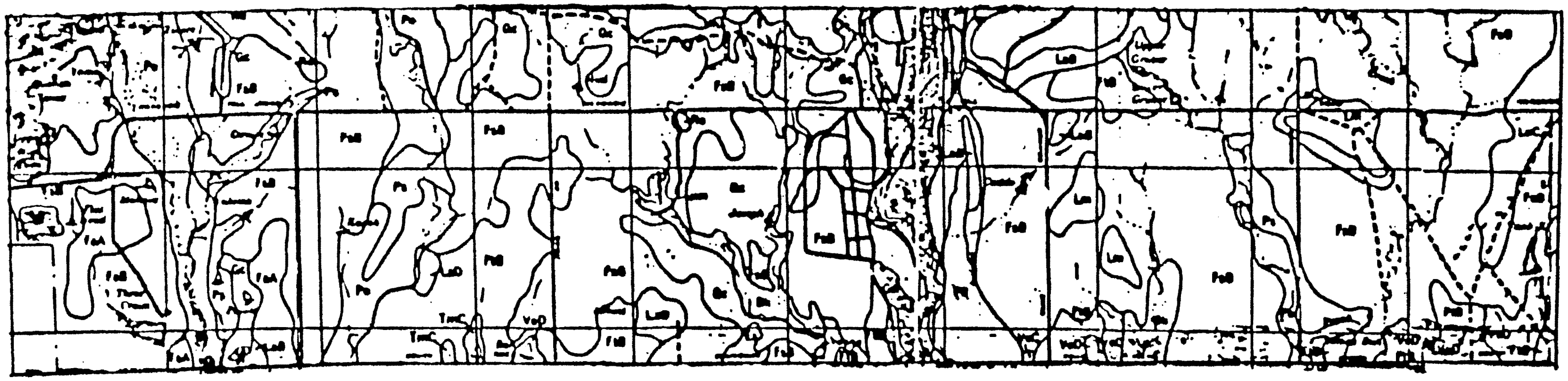

Figure 2. Soil Types on the Study Area at Ft. Sill Military Reservation, Comanche County, Oklahoma.

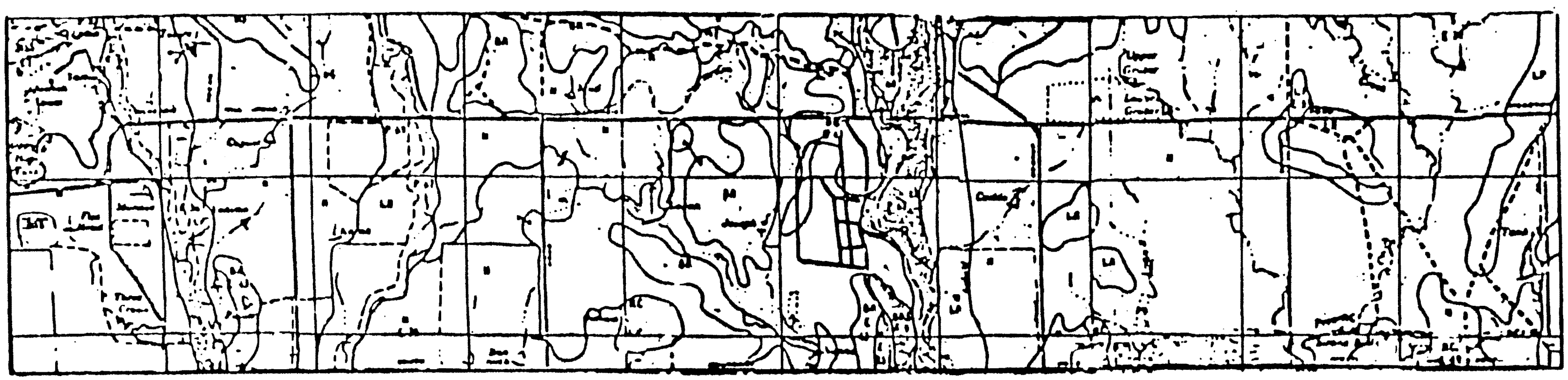

Figure 3. Range Classes on the Study Area at Ft. Sill Military Reservation, Comanche County, Oklahoma.

TABLE 2. RANGE CLASSES PRESENT ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA.

Range Class	Hectares	% Coverage
Hardland	1530.1	70.83
Loamy Bottomland	281.4	13.03
Boulder Ridge	135.4	6.27
Hilly Stony	58.1	2.69
Loamy Prairie	44.0	2.04
Limestone Ridge	34.0	1.57
Red Clay	29.5	1.37
Hilly Stony Savannah	26.6	1.23
Red Clay-Loamy Prairie	12.6	0.58
Boulder Ridge Savannah	8.4	0.39

CHAPTER III

METHODS

Habitat Designation

During 1985, three factors were used to delineate habitat types for comparing grassland communities. First, the range classes described by the National Handbook for Range and Related Grazing Lands (U.S.D.A.-SCS 1967) mapped in the Ft. Sill Conservation Plan (1970) were superimposed onto aerial photographs of the study area. Range classes are more broadly defined than soil types, incorporating soil type plus actual plant cover. Second, a map showing the different ages of prescribed burns (all early spring burns) was placed over the range classes and lastly, a map of mesquite densities was constructed with the aid of aerial photographs and ground truthing and was superimposed over the aforementioned maps. These maps made it possible to determine the range class, mesquite density, and burn age at any point in the study area. Mesquite densities were arbitrarily broken down into three classes, i.e., open grasslands (mesquite free), incomplete canopy (low mesquite density), and complete canopy (high mesquite density).

Effort was concentrated in Hardland range because it represented over 70 percent of the study area (Table 2) and other range classes had low variability in mesquite densities and prescribed burn ages. Concentrating on Hardland range consequently restricted the soil types examined to the Foard-Slickspots complex (Appendix A) and thus lessened vegetational differences due to soil type. Loamy Bottomland and Hilly Stony Savannah range classes were not considered because they are primarily forested.

Data were collected along 100 m fixed transects positioned about the longest axis of each habitat type. Markers were placed every 10 meters and transect lines began at least 20 meters from any road or trail.

Vegetation Analysis

Biomass, stem density, and species composition of plants were measured at each of the 10 sampling points along fixed transects. Biomass and stem density data were taken at monthly intervals from April through August, 1985. Species composition was determined in August.

Biomass was estimated using a "Robel pole". Robel et al. (1970) found that a visual obstruction measurement taken from a height of one meter and a distance of four meters provides a reliable index (R^2=0.96) of the amount of herbaceous vegetation on site. Four readings (to the nearest 1/4 dm) were taken at each of the ten points along each transect from the four cardinal compass bearings with the pole remaining in place. Pairwise t-test (LSD) were applied to mean robel pole readings to compare biomass estimates for each month and to determine monthly changes in the biomass of each habitat. Two points on the mesquite free burned area were not used in computations because both sites were altered midway through the study.

Species composition was determined by the point transect basal intercept method (Levy and Madden 1933). Species composition data were recorded at each of the ten points along each transect. The Shannon formula as modified by Pielou (1975) was used to calculate a diversity index (Odum 1959) for each habitat from the sum of the species identified on each transect. Schoener's (1968) index of similarity was used to determine the similarity of species composition among habitats. Principal components analysis (PCA) was applied to species composition data to identify those species that contributed the most variability to the system.

An apparatus was developed to determine stem density (number of stems per linear distance) at different heights (Figure 4). The apparatus consisted of two poles (2.54 cm x 142.86 cm) that were driven 23 cm deep into the ground. The portion above ground was marked off in five centimeter intervals from 0 to 120 cm. Holes large enough to allow insertion of a 9.5 mm diameter rod were drilled in the poles at each five centimeter mark. A 120 cm x 9.5 mm rod marked off in five centimeter intervals completed the apparatus. The apparatus was used as follows: the two large poles were placed in the ground at each of the ten points (110 cm apart) along transects. Vegetation in the area between the poles was undisturbed. The 9.5 mm rod was then run from one pole through the vegetation into the hole of the corresponding height on the other pole. The number of "stems" touching the rod for each five centimeter interval was then recorded. This procedure was repeated until the rod was above all the vegetation. Stem density profiles for each habitat were then quantified by regressing height on stem density. Only readings from 75 cm above ground level (AGL) and below were used in comparisons

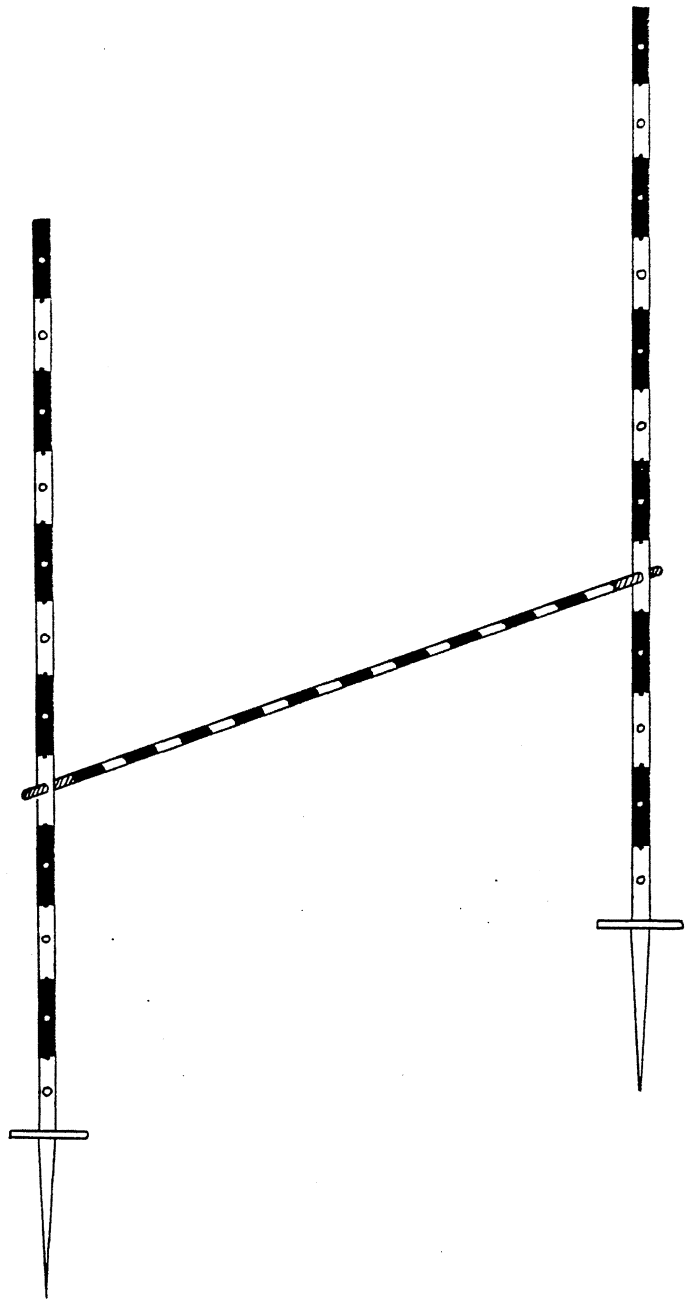

Figure 4. Design of Apparatus Used to
Measure Stem Density of
Vegetation at Various Heights.

because stem density readings above 75 cm deterred from the regression model and added little to comparisons. Additionally, two points in the unburned mesquite free area that were altered midway through the study were not used in regression calculations. Regression lines were compared using analysis of covariance to determine significant changes in a habitat over time and differences among habitats each month. Changes in stem density regressions were further elaborated on by noting changes in stem density at representative heights. By using the regression lines calculated for the stem density of each area (Appendix N), stem densities were calculated at heights of five centimeters and 50 cm above ground level to determine if some areas had higher stem densities closer to ground level or at higher levels than areas with similar total stem densities. Mean stem density was compared to biomass estimates and the correlation determined. This procedure also gave a profile of the vegetation that was compared relative to species composition and biomass estimates among habitats.

Pairwise T-test (LSD), regression analysis, analysis of covariance, and principal components analysis were all calculated using SAS statistics programs (Ray 1982).

CHAPTER IV

RESULTS

Species Composition

Thirty-two plant species were identified along transects (Table 3) in the study area (Appendix C). All areas were dominated by brome (Bromus sp.) and/or bare ground, one apparently at the expense of the other. There were no significant differences (P>0.05) between combined total percentages of brome and bare ground between different burn ages (Table 4) or mesquite densities (Table 5). There were no significant differences (P>0.05) between percentages of bare ground whether analyzed by burn age (Table 6) or mesquite density (Table 7), though areas without mesquite had approximately 50 percent more bare ground than areas with mesquite, and unburned areas had up to 50 percent less bare ground than burned areas (Figures 5, 6, 7). There was, however, a high negative correlation (R^2=0.95) between the quantity of bare ground and brome (Figure 8). Areas with mesquite, especially at high densities, had a higher percentage of brome than those areas without mesquite, though the only significant difference (P<0.05) was between high density mesquite areas and burned areas without mesquite (Table 8).

Principal components analysis (PCA) yielded results similar to those revealed by correlation. Only two factors, bare ground and brome, had loadings (99% of the total variance) and all areas loaded

TABLE 3. RELATIVE ABUNDANCE OF PLANT SPECIES (%) IN RELATION TO BURN AGE AND MESQUITE DENSITY ALONG STUDY AREA TRANSECTS AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age												
	Unburned			3-Years			2-Years		1-Year			Study-Year	
	Mesquite Density												
Species	N	L	H[1]	N	L	H	N	H	N	L	H	N	L
Bare ground	24	82	3	70	14	48	86	87	75	57	46	66	35
Japanese Brome	71		94		74	48		2		37	43	3	59
Little Bluestem	2			19			2		17			12	
Western Ragweed		1	2		2					1			2
Broomweed		2		1				1			3	2	
Hairy Grama				4			5	1		1		9	
Yarrow	1	1			1					1			
Vine Mequite		1	1			2							3
Blue Grama				3					6	2	5		
Sideoats Grama					3					1		1	
Panicum sp.					1						1	2	
Prairie Threeawn		9						4				1	
Gumweed		1				1							1
Silver Bluestem						1	3						
Sedge								1			1		
Star Violet				1			1						
Johnson Grass					3								

TABLE 3 (Continued)

Big Bluestem			1					
Plantago sp.			1					
Maximillian Sunflower	2							
Silverleaf Nightshade					2			
Canada Wild Rye					2			
Annual Dropseed		3						
Chaetopappa						1		
Buffalograss						1		
Mourning Lovegrass							1	
Rush								2
Silvery Golden Aster								1
Missouri Goldenrod								1
Yellow Neptunia				2				
Dotted Button Snakeroot				1				
Plains Coreopsis			1					
Switchgrass			1					

[1]N=No mesquite; L=Low mesquite density; H=High mesquite density

TABLE 4. COMPARISON (LSD), BY BURN AGE, OF COMBINED BROME AND BARE GROUND PERCENTAGES ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Burn age	N	Mean	Grouping
Unburned	3	91.33	A
2-Year old	2	87.50	A
1-Year old	3	86.00	A
3-Year old	3	84.67	A
Study-Year	2	81.50	A

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=8, LSD=23.041.

TABLE 5. COMPARISON (LSD), BY MESQUITE DENSITY, OF COMBINED BROME AND BARE GROUND PERCENTAGES ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Mesquite Density	N	Mean	Grouping
No Mesquite	5	79.00	A
Low Density	4	88.25	A
High Density	4	92.75	A

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=8, LSD=23.041.

TABLE 6. COMPARISON (LSD), BY BURN AGE, OF BARE GROUND PERCENTAGES FOR THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Burn age	N	Mean	Grouping
2-Year old	2	86.50	A
1-Year old	3	59.33	A
Study-Year	2	50.50	A
3-Year old	3	44.00	A
Unburned	3	36.33	A

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=8, LSD=55.776.

TABLE 7. COMPARISON (LSD), BY MESQUITE DENSITY, OF BARE GROUND PERCENTAGES ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Mesquite Density	N	Mean	Grouping
No Mesquite	5	64.20	A
Low Density	4	47.00	A
High Density	4	46.00	A

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=10, LSD=43.949.

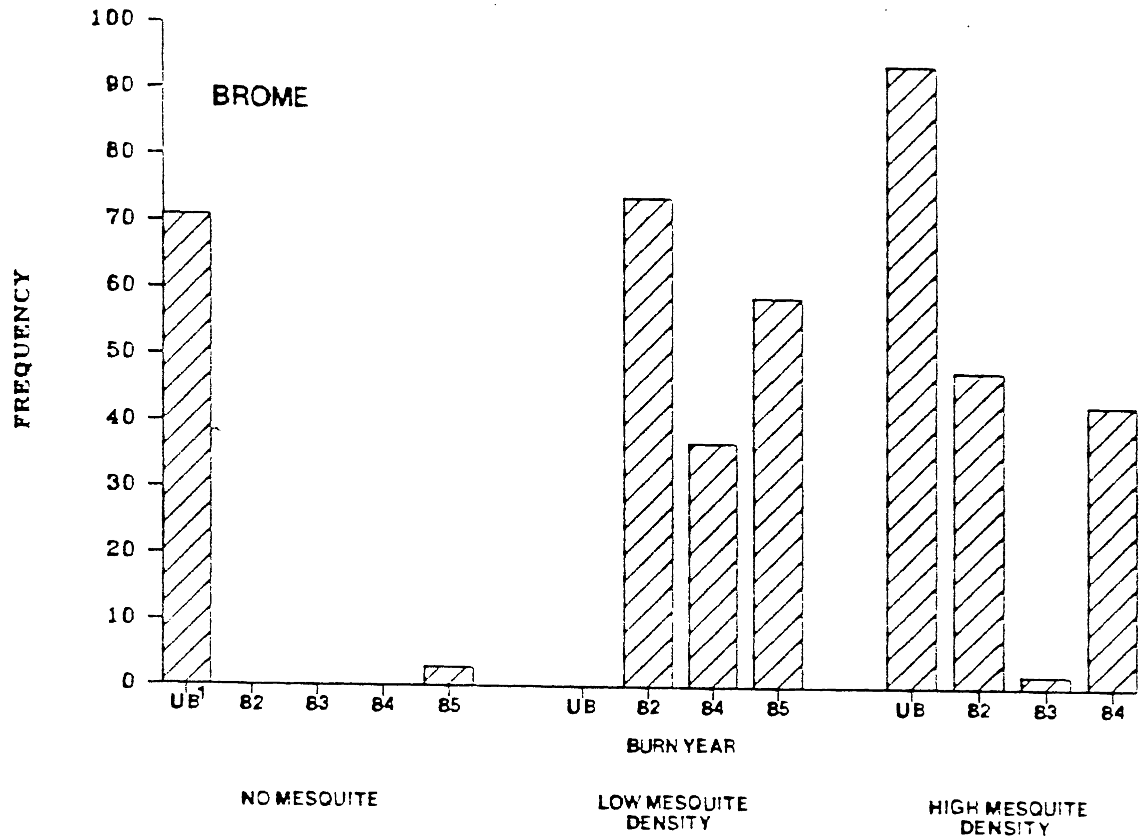

Figure 5. Frequency of Brome Occurrence in Relation to Burn Age and Mesquite Density on the Study Area at Ft. Sill Military Reservation, Comanche County, Oklahoma, 1985.

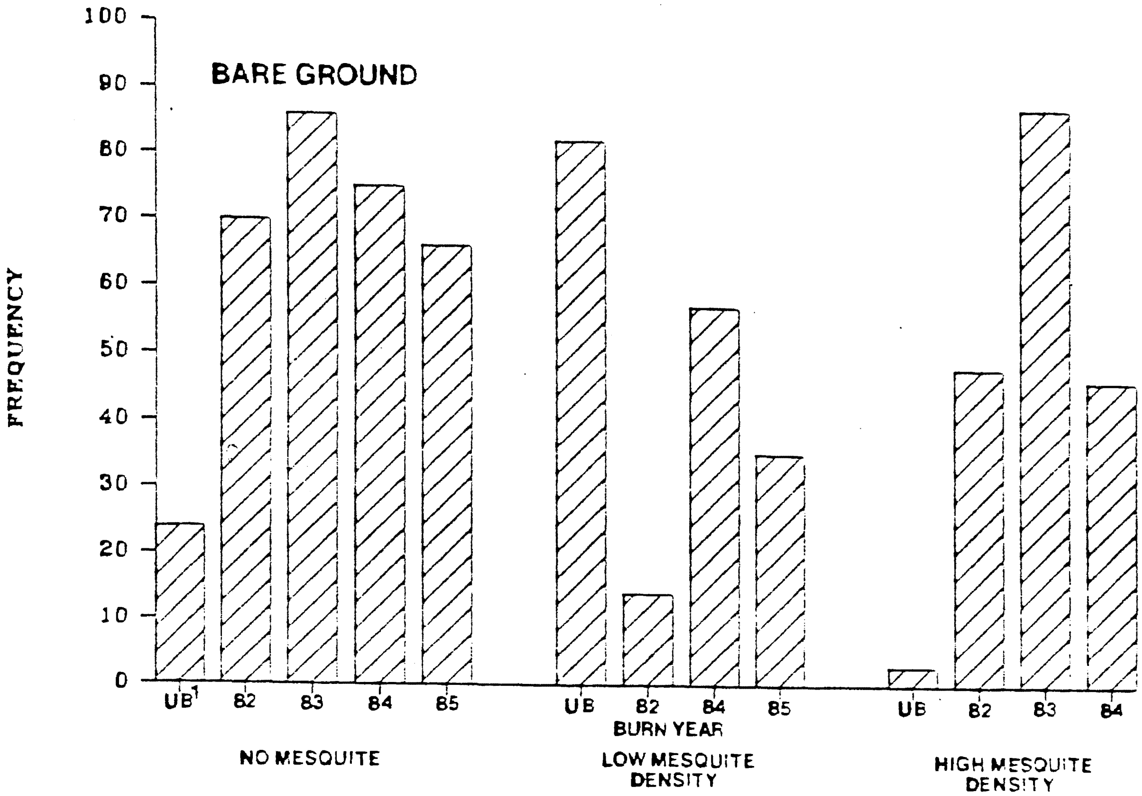

Figure 6. Frequency of Bare Ground Occurrence in Relation to Burn Age and Mesquite Density on the Study Area at Ft. Sill Military Reservation, Comanche County, Oklahoma, 1985.

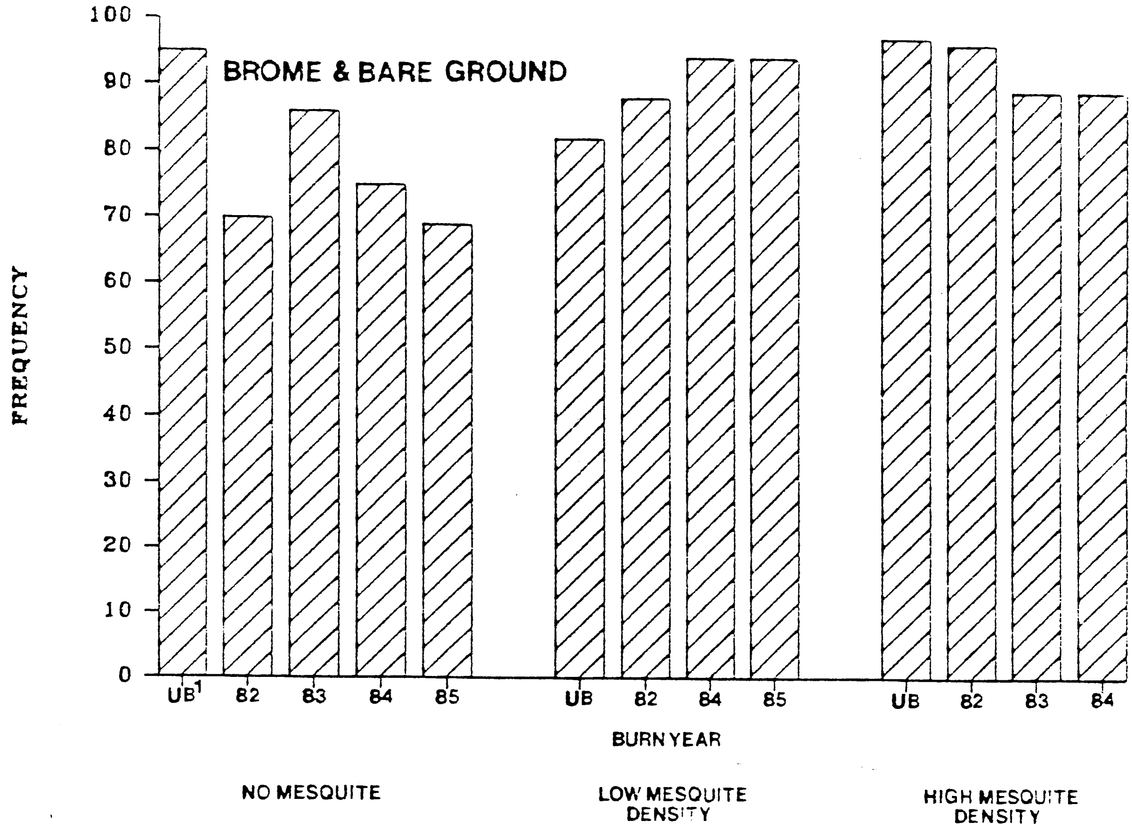

Figure 7. Frequency of Brome and Bare Ground in Combination in Relation to Burn Age and Mesquite Density on the Study Area at Ft. Sill Military Reservation, Comanche County, Oklahoma, 1985.

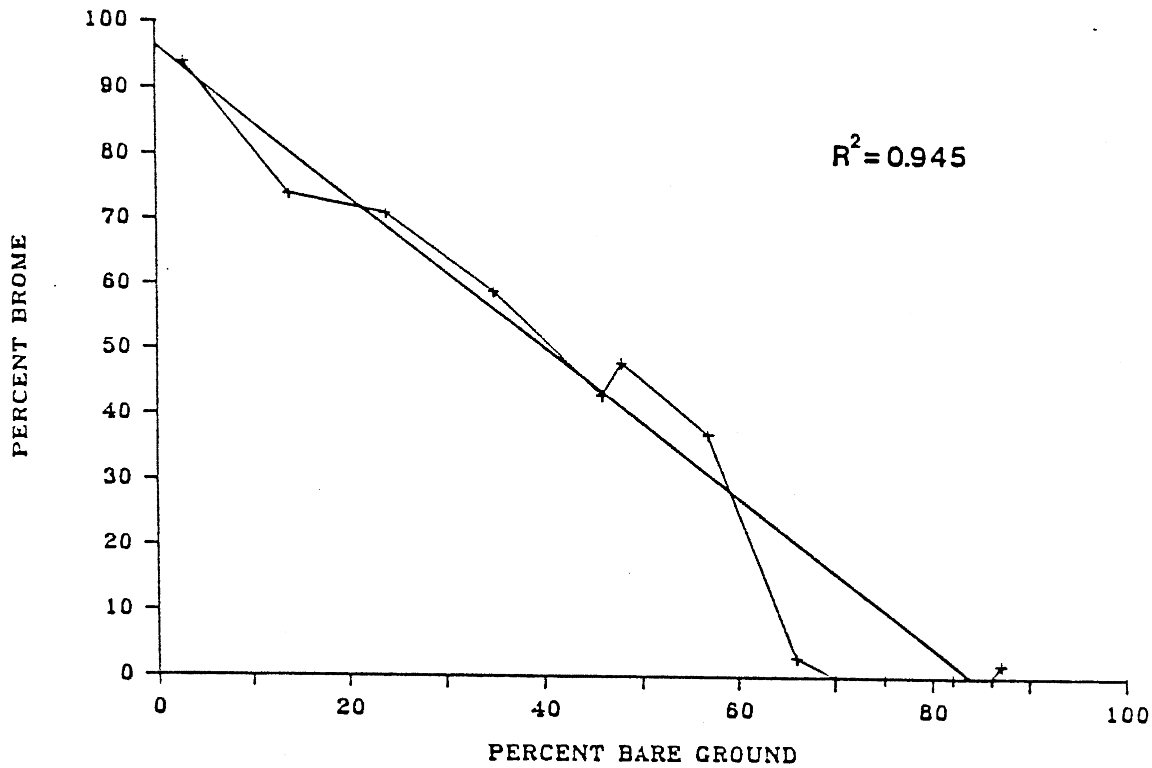

Figure 8. Regression of Percent Bare Ground On Percent Brome Cover for Study Area Transects at Ft. Sill Military Reservation, Comanche County, Oklahoma, 1985.

TABLE 8. COMPARISON (LSD), BY MESQUITE DENSITY, OF BROME PERCENTAGES ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Habitat	N	Mean	Grouping
High Mesquite Density	5	46.75	A
Low Mesquite Density	4	42.50	AB
Burned-No Mesquite	4	0.75	B

Means with the same grouping letter are not significantly different (P<0.05), D.F.=9, LSD=45.738.

positively (>0.7) on one or both of these factors (Table 9). Burned areas without mesquite, the unburned area with a low mesquite density, and the 2-year old burn with a high mesquite density all loaded positively only on bare ground. All other areas loaded positively on brome, but the 1-year old and study-year burns with low mesquite densities and the 3-year old and study-year burns with high mesquite densities also had positive loadings on bare ground.

By eliminating bare ground from PCA and restricting analysis to plant species, several more factors (plant species) became important (Table 10). Brome contributed most of the variability to the community (55%) and still had the same areas loading positively (>0.9). The 2-year old burn with a high mesquite density also loaded positively on brome but loaded higher on other factors. Little bluestem became the second most important factor, accounting for 23 percent of the total variance. Three of the four burned areas without mesquite loaded positively on this factor. The study-year burn area without mesquite and the 3-year old burn without mesquite loaded positively on hairy grama (Bouteloua hirsuta)(12% of the total variance). The unburned area with a low mesquite density and the 2-year old burn with a high mesquite density loaded positively on the remaining two factors - prairie threeawn (Aristida olignatha) (7% of the total variance) and broomweed (Gutierrezia dracunculoides)(2% of the total variance). High factor loadings are supported by the high relative frequencies of each species (Appendix D).

By noting habitat grouping patterns within each factor (plant species) and their similarity to habitat groupings inclusive and exclusive of brome it was possible to see how plant species

TABLE 9. PRINCIPAL COMPONENTS ANALYSIS FACTOR LOADINGS OF PLANT SPECIES COMPOSITION DATA (INCLUDING BARE GROUND) IN RELATION TO BURN AGE AND MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

		Factor 1	Factor 2
Burn Age	Mesquite Density	Bare Ground	Brome
2-years	none	0.983	0.000
1-year	none	0.983	0.000
3-years	none	0.981	0.000
Study-year	none	0.979	0.000
2-years	high	0.977	0.000
Unburned	low	0.977	0.000
1-year	low	0.739	0.667
3-years	low	0.000	0.999
Unburned	high	0.000	0.989
Unburned	none	0.000	0.987
Study-year	low	0.354	0.933
3-years	high	0.580	0.811
1-year	high	0.606	0.787

TABLE 10. PRINCIPAL COMPONENTS ANALYSIS FACTOR LOADINGS OF PLANT SPECIES (EXCLUDING BARE GROUND) IN RELATION TO BURN AGE AND MESQUITE DENSITY AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Burn Age	Mesquite Density	Brome	Little Bluestem	Hairy Grama	Prairie Threeawn	Broomweed
Unburned	HIGH	0.997	0.000	0.000	0.000	0.000
3-Years	HIGH	0.997	0.000	0.000	0.000	0.000
Study-Year	LOW	0.997	0.000	0.000	0.000	0.000
1-Year	LOW	0.996	0.000	0.000	0.000	0.000
Unburned	NONE	0.996	0.000	0.000	0.000	0.000
3-Years	LOW	0.996	0.000	0.000	0.000	0.000
1-Year	HIGH	0.990	0.000	0.000	0.000	0.000
1-Year	NONE	0.000	0.983	0.000	0.000	0.000
3-Years	NONE	0.000	0.980	0.000	0.000	0.000
Study-Year	NONE	0.000	0.780	0.437	0.000	0.000
2-Years	NONE	0.000	0.000	0.986	0.000	0.000
Unburned	LOW	0.000	0.000	0.000	0.960	0.255
2-Years	HIGH	0.260	0.000	0.000	0.469	0.843

composition was affected by the presence of brome (Table 10). PCA groupings, when brome is not considered (Table 11), showed all areas without mesquite loading positively on little bluestem (26% of the total variance). Other areas loaded on vine mesquite (Panicum obtusum)(18% of the total variance), prairie threeawn (14% of the total variance), blue grama (12% of the total variance), and western ragweed (Ambrosia psilostachya) (9% of the total variance).

Blue grama increased after burning and was found in 1-year old burns in areas with and without mesquite. However, increases in blue grama appeared to be only temporary. There were no other apparent correlations with burn age or mesquite density. Hairy grama and broomweed accounted for little of the overall variance when brome was not considered. Again, loadings correlated well to the high relative frequency of each species (Appendix D). Relative frequency data also indicated a correlation between the 1-year old burn and high blue grama density and the low mesquite density areas and western ragweed.

Schoener's similarity index (=0.7), when applied to plant composition data, including bare ground, produced results similar to those found in PCA (Table 9); the similarity of areas was because of the presence of bare ground or brome (Table 12).

There were no significant differences (P>0.05) in mean plant diversity indices in relation to burn age (Table 13) or mesquite density (Table 14) but, burned areas without mesquite were significantly different than those with mesquite (P<0.05) (Table 15). The higher diversity indices in areas without brome or only a low percentage of brome, suggest that in areas with high brome percentages, brome had an inhibitory affect on other plant species.

TABLE 11. PRINCIPAL COMPONENTS ANALYSIS FACTOR LOADINGS OF VARIOUS PLANT SPECIES (LESS BROME) IN RELATION TO BURN AGE AND MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Burn Age	Mesquite Density	Little Bluestem	Vine Mesquite	Prairie Threeawn	Blue Grama	Western Ragweed
3-years	NONE	0.964	0.000	0.000	0.000	0.000
Study-year	NONE	0.894	0.000	0.000	0.000	0.000
1-year	NONE	0.890	0.000	0.000	0.000	0.000
Unburned	NONE	0.721	0.000	0.000	0.000	0.000
Study-year	LOW	0.000	0.981	0.000	0.000	0.000
Unburned	HIGH	0.000	0.815	0.000	0.000	0.385
3-years	HIGH	0.000	0.793	0.000	0.000	-0.389
Unburned	LOW	0.000	0.000	0.923	0.000	0.000
2-years	HIGH	0.000	0.000	0.910	0.000	0.000
1-year	HIGH	0.000	0.000	0.000	0.898	0.000
1-year	LOW	0.000	0.000	0.000	0.826	0.285
3-years	LOW	0.000	0.000	0.000	0.000	0.856
2-years	NONE	0.467	0.000	0.000	0.000	-0.430

TABLE 12. SCHOENER SIMILARITY INDEX COMPARISON OF PLANT SPECIES COMPOSITION DATA (INCLUDING BARE GROUND) IN RELATION TO BURN AGE AND MESQUITE DENSITY FOR THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

		No Mesquite					Low Mesquite				High Mesquite		
			Burn Age				Burn Age				Burn Age		
		UB[1]	3	2	1	SY[2]	UB	3	1	SY	UB	3	2
	3-Years	.26	--	--	--	--	--	--	--	--	--	--	--
No	2-Years	.26	.78	--	--	--	--	--	--	--	--	--	--
Mesquite	1-Year	.26	.90	.77	--	--	--	--	--	--	--	--	--
	Study-year	.29	.83	.73	.79	--	--	--	--	--	--	--	--
	Unburned	.25	.71	.82	.75	.68	--	--	--	--	--	--	--
Low	3-Years	.86	.16	.15	.14	.19	.16	--	--	--	--	--	--
Mesquite	1-Year	.62	.60	.58	.59	.62	.59	.54	--	--	--	--	--
Density	Study-Year	.83	.35	.35	.35	.38	.38	.75	.73	--	--	--	--
	Unburned	.74	.03	.03	.03	.06	.05	.79	.41	.65	--	--	--
High	3-Years	.72	.49	.49	.48	.51	.50	.62	.85	.86	.52	--	--
Mesquite	2-Years	.26	.72	.87	.75	.72	.87	.16	.61	.37	.05	.50	--
Density	1-Year	.67	.50	.46	.51	.52	.48	.58	.85	.78	.46	.89	.51

[1]UB = Unburned [2]SY = Study year

TABLE 13. COMPARISON (LSD), BY BURN AGE, OF MEAN PLANT DIVERSITY INDICES ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Burn Age	N	Mean Diversity Index	Grouping
2-Years	2	1.3281	A
Study-Year	2	1.1231	A
3-Years	3	0.7501	A
1-Year	3	0.7117	A
Unburned	3	0.6663	A

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=8, LSD=1.2168.

TABLE 14. COMPARISON (LSD), BY MESQUITE DENSITY, OF MEAN PLANT DIVERSITY INDICES ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Habitat	N	Mean Diversity Index	Grouping
No mesquite	5	1.1526	A
Low Mesquite Density	4	0.8020	A
High Mesquite Density	4	0.5789	A

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=10, LSD=0.80806.

TABLE 15. COMPARISON (LSD), BY MESQUITE DENSITY, OF MEAN PLANT DIVERSITY INDICES (LESS THE UNBURNED OPEN AREA) ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Habitat	N	Mean Diversity Index	Grouping
Burned-No Mesquite	4	1.3627	A
Low Mesquite Density	4	0.8020	A B
High Mesquite Density	4	0.5789	B

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=8, LSD=0.74172.

If brome does inhibit other species, then plant diversity, with brome excluded from calculations, should show burned areas without mesquite as having significantly higher diversity indices (Table 16). However, when brome was removed from calculations there were no significant differences ($P>0.05$) between mean diversity indices in relation to burn age (Table 17) or mesquite density (Table 18).

Standing Crop Biomass

Biomass estimated with the Robel pole correlated well with stem density estimates. This suggest that biomass estimates were a consistent, if not accurate, estimate of standing crop biomass.

Mean standing crop biomass estimates (excluding woody vegetation) were higher in areas with mesquite throughout the course of the study (Table 19). In areas without mesquite (Figure 9), the unburned area consistently had a significantly higher ($P<0.05$) biomass estimate than the burned areas. The unburned area without mesquite also peaked in biomass in May while burned areas without mesquite peaked later in the growing season. Burn age seemed to have little affect in mesquite free areas, though the oldest burn (3-years old) most closely resembled the unburned area (Appendix E).

In areas with mesquite, the higher the mesquite density, the more herbage biomass was increased by burning (Figures 10, 11). High mesquite density areas (Figure 11) generally peaked in biomass in May, decreased in June, and increased again in July and August. Only the 2-year old burn had a higher standing crop biomass in July and August than in May. After the May peak, standing crop biomass decreased more rapidly in high mesquite density older burns; the unburned area had

TABLE 16. PLANT SPECIES DIVERSITY INDICES IN RELATION TO BURN AGE AND MESQUITE DENSITY FOR STUDY AREA TRANSECTS AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Burn Age	Mesquite Density	Diversity Index With Brome	Diversity Index Without Brome
2-Years	none	1.6309	1.6309
1-Year	none	0.7336	0.8623
3-Years	none	1.2412	1.2412
Study-Year	none	1.8453	1.6995
2-Years	high	1.0254	1.8181
Unburned	low	1.5313	1.5313
1-Year	low	0.6179	1.5610
3-Years	low	0.6578	1.8202
Unburned	high	0.3120	1.0001
Unburned	none	0.1555	1.0549
Study-Year	low	0.4009	1.0115
3-Years	high	0.3512	1.0397
1-Year	high	0.7836	1.3667

TABLE 17. COMPARISON (LSD), BY BURN AGE, OF MEAN PLANT DIVERSITY INDICES (LESS BROME), FOR THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Burn age	N	Mean	Grouping
2-Years old	2	1.7245	A
3-Years old	3	1.3670	A
Study-Year	2	1.3555	A
1-Year old	3	1.2633	A
Unburned	3	1.1954	A

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=8, LSD=0.73408.

TABLE 18. COMPARISON (LSD), BY MESQUITE DENSITY, OF MEAN PLANT DIVERSITY INDICES (LESS BROME), FOR THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Habitat	N	Mean	Grouping
Low Mesquite Density	4	1.4810	A
High Mesquite Density	4	1.3061	A
No Mesquite	5	1.2978	A

Means with the same grouping letter are not significantly different (P<0.05),D.F.=10, LSD=0.5486.

TABLE 19. MONTHLY MEAN BIOMASS ESTIMATES (Kg/Ha) FOR EACH MESQUITE DENSITY USED ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Mesquite Density		
Month	None	Low	High
April	734.96	1256.50	1988.95
May	1906.96	2561.21	4391.60
June	1977.44	3366.10	2457.80
July	2258.56	3454.00	3073.05
August	2258.56	3805.60	3366.10

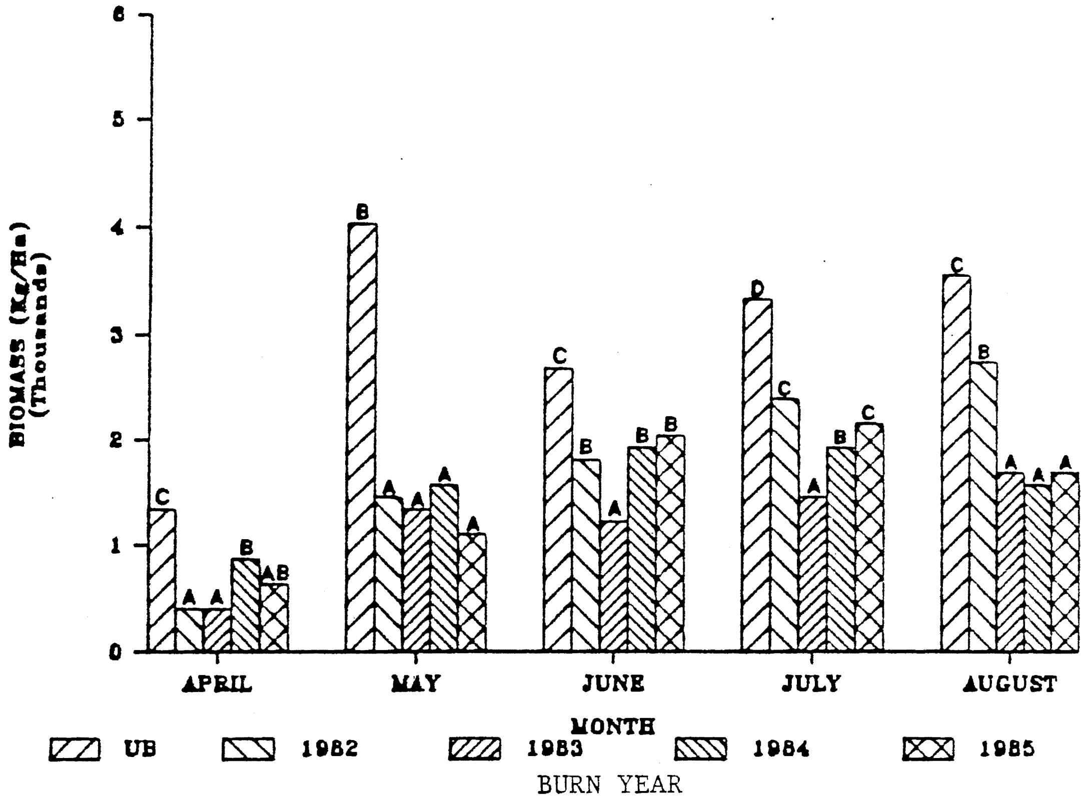

Figure 9. Monthly Biomass Estimates for Mesquite Free Areas on the Study Area at Ft. Sill Military Reservation, Comanche County, Oklahoma, 1985. Areas with the Same Letter Are Not Significantly Different.

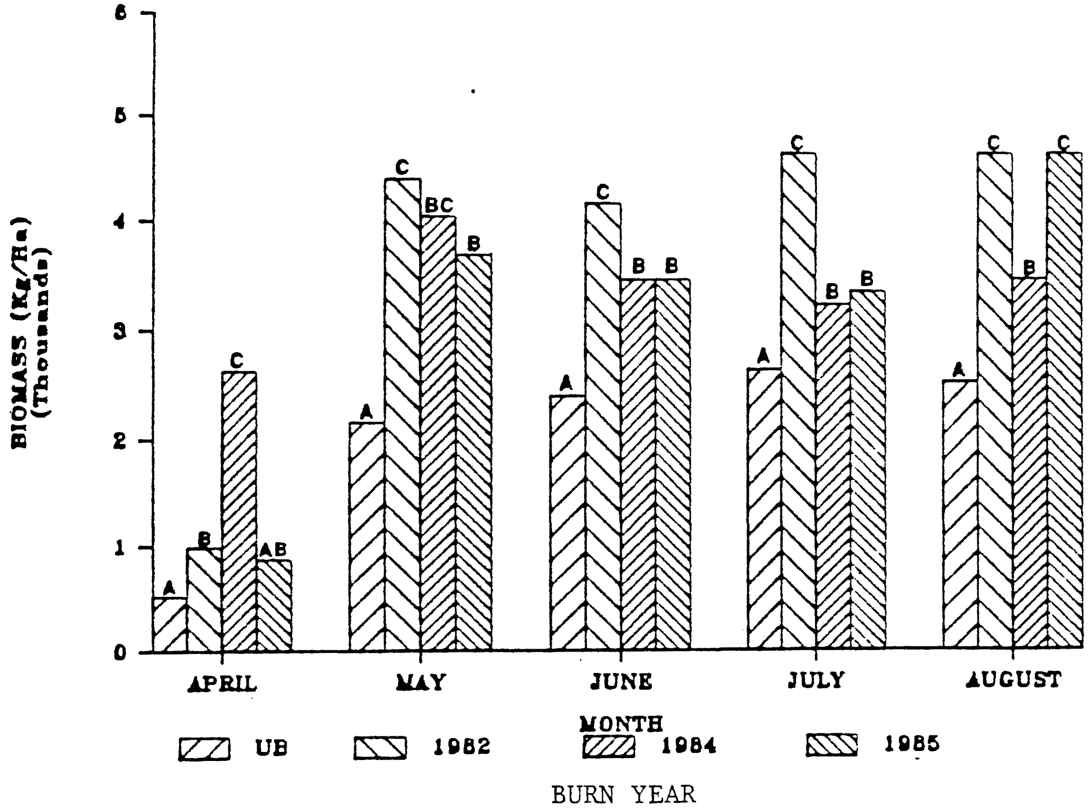

Figure 10. Monthly Biomass Estimates for Low Mesquite Density Areas on the Study Area at Ft. Sill Military Reservation, Comanche County, Oklahoma, 1985. Areas with the Same Letter Are Not Significantly Different.

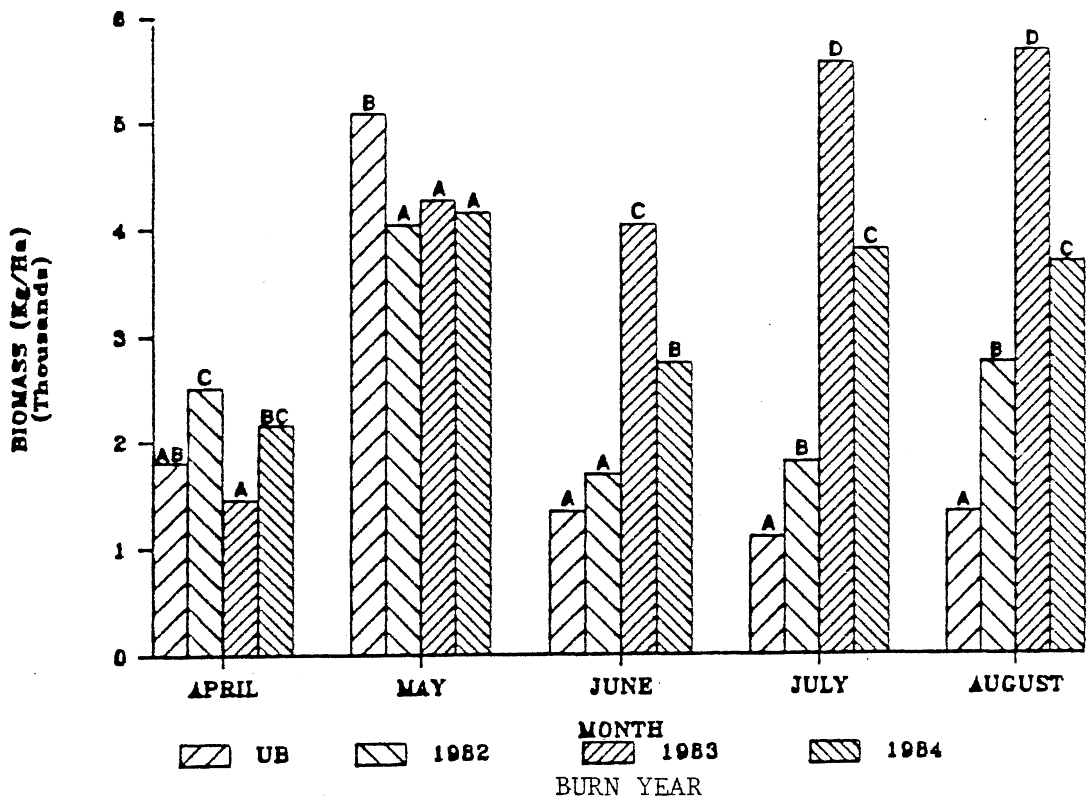

Figure 11. Monthly Biomass Estimates for High Mesquite Density Areas on the Study Area at Ft. Sill Military Reservation, Comanche County, Oklahoma, 1985. Areas with the Same Letter Are Not Significantly Different.

the greatest decrease (Appendix F).

Results in burned low mesquite density areas were similar to those in areas with high mesquite densities, though mean standing crop biomass increased throughout the study (Table 19). The unburned low mesquite density area had a significantly ($P<0.05$) lower biomass than burned low-mesquite density areas throughout the study (Figure 10). The 3-year old burn produced the highest standing crop biomass. All burned low mesquite density areas had a peak in biomass in May but only the 3-year old burn maintained a high standing crop biomass throughout the study. The 1-year old and study-year burns decreased in biomass in June and July but the study-year burn peaked again in August. The unburned low mesquite density area peaked in biomass later (July) in the growing season than the burned area (Appendix G).

Stem Profile Results

Stem Density. Mean stem density results were correlated (R^2=0.65) to Robel-biomass estimates (Figure 12). In areas without mesquite, the unburned area maintained the highest mean stem density (Table 20). In low mesquite density areas, the unburned area had the lowest mean stem density (Table 21). The 1-year old burn had the highest mean stem density of the high mesquite density areas (Table 22). Changes in stem density mirrored changes in standing crop biomass in areas without mesquite and low density mesquite areas (Figures 9, 10, Tables 20, 21). Stem density in high density mesquite areas did not always follow biomass estimates but trends were similar (Figure 11, Table 22).

Low mesquite density areas had stem densities higher than in

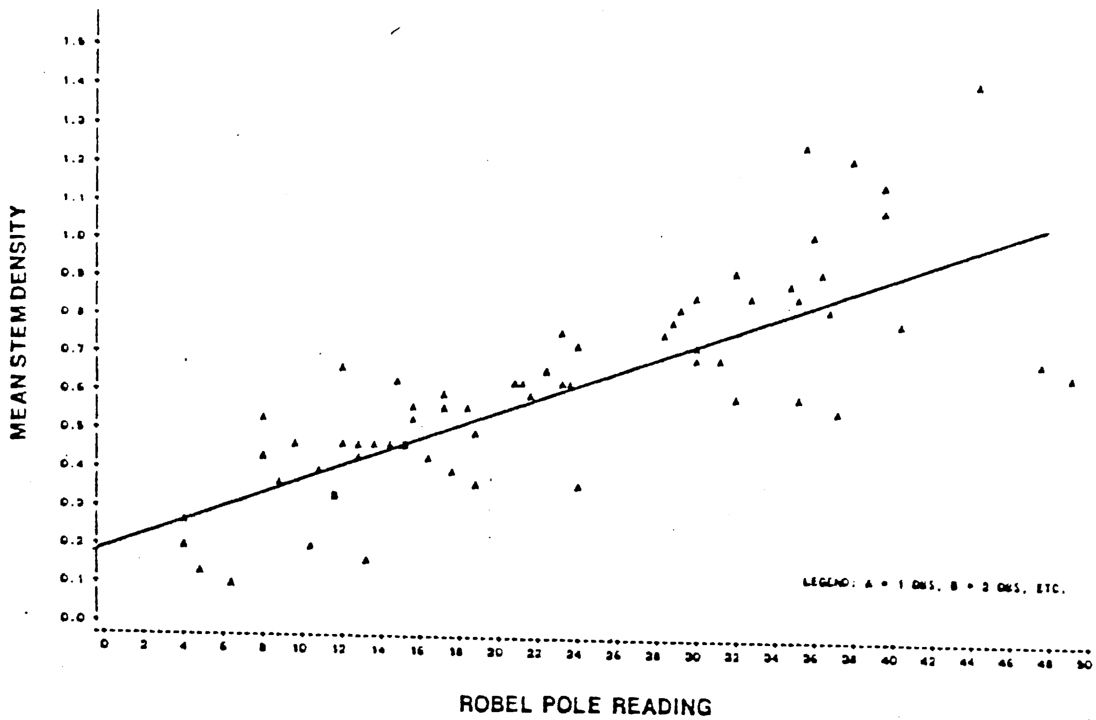

Figure 12. Regression of Robel Pole Readings on Mean Stem Density Estimates on the Study Area at Ft. Sill Military Reservation, Comanche County, Oklahoma, 1985. Areas with the Same Letter are Not Significantly Different.

TABLE 20. MEAN STEM DENSITY ESTIMATES (NUMBER OF STEMS PER 5 CM) FOR 5 cm TO 75 cm ABOVE GROUND LEVEL FOR AREAS WITHOUT MESQUITE ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age				
Month	UB	3-Years	2-Years	1-Year	Study-Year
April	0.460	0.280	0.201	0.520	0.105
May	1.044	0.453	0.343	0.463	0.188
June	0.864	0.560	0.406	0.559	0.392
July	0.807	0.639	0.427	0.603	0.580
August	0.731	0.633	0.450	0.458	0.479

TABLE 21. MEAN STEM DENSITY ESTIMATES (NUMBER OF STEMS PER 5 CM) FOR 5 CM TO 75 CM ABOVE GROUND LEVEL FOR LOW MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age			
Month	UB	3-Years	1-Year	Study Year
April	0.137	0.350	0.773	0.433
May	0.351	1.240	0.881	0.932
June	0.624	1.267	0.711	0.861
July	0.649	1.150	0.777	0.824
August	0.670	1.097	0.731	0.787

TABLE 22. MEAN STEM DENSITY ESTIMATES (NUMBER OF STEMS PER 5 CM) FOR 5 CM TO 75 CM ABOVE GROUND LEVEL FOR HIGH MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY OKLAHOMA, 1985.

	Burn Age			
Month	UB	3-Years	2-Years	Study-Year
April	0.534	0.590	0.160	0.493
May	1.439	0.888	0.582	0.923
June	0.650	0.623	0.598	0.741
July	0.464	0.428	0.715	0.851
August	0.341	0.372	0.676	0.610

mesquite free areas (except in unburned areas) and also generally had stem densities higher than high mesquite density areas late in the growing season (June-August).

In more recent burns (1-2 years old), high mesquite density areas had higher stem densities than mesquite free areas from May to August. However, the 3-year old burn and the unburned area with high mesquite densities had higher stem densities than low mesquite density areas in earlier months (April to June and April to May, respectively).

Areas with low brome percentages had peak stem densities later in the growing season (July-August) than areas with high brome percentages (May-June). Again these results correspond to peaks noted in standing crop biomass estimates.

Stem Distribution. Stem density-height regressions showed results similar to standing crop biomass estimates and mean stem density results; the same areas were generally significantly different each month.

Results from burned-open areas are unclear (Appendix H). In areas without mesquite, the unburned area was significantly ($P<0.05$) different from all other open areas throughout the study, except in August when it did not differ from the 3-year old burn. In April, only the 3-year old and study-year burns differed significantly ($P<0.05$). In May, the 3-year old and study-year burns were still significantly different and so were the 1-year old and study-year burns. In June, the same areas were also significantly different from each other and the 2-year old burn was significantly different from the three and 1-year old burns. By July, the 2-year old burn differed from the 3-year old, 1-year old, and study-year burns. None of the other burned-open areas was significantly different. In August, the 3-year old burn was significantly different from all other mesquite-free area burns. All other open areas were similar.

During April, in low mesquite density areas (Appendix I), only the 3-year old and study-year burns were similar ($P>0.05$). In May, only the 1-year old and study year-burns were similar. During June, all areas were significantly different except the unburned area and the 1-year old burn. In July and August, the 1-year old burn was the same as the study-year burn and the unburned area. All other areas were significantly different.

In high mesquite density areas (Appendix J), the 2-year old burn was significantly different ($P<0.05$) from all other burns in April. Other areas were not significantly different. By May, only the 3-year old and 1-year old burns were similar. During June, only the 2-year old and 1-year old burns were significantly different. In July, the unburned and the 3-year old burn were not significantly different. The same two areas were not similar in August, as were the 2-year old and 1-year old burns.

In mesquite-free areas (Appendix K), April regressions were significantly different ($P<0.05$) from those in all other months in all areas (except for that in the study-year burn) without mesquite. Between May and June, the three, two, and 1-year old burns had significant changes in stem density regressions. From June to July, only the study-year burn had a significant change in stem density distribution. By August, only the 1-year old and study-year burns had changed significantly since July.

In low mesquite density areas (Appendix L), all stem density regressions (except for that in the 1-year old burn) changed significantly between April and May. Only in the 3-year old burn did the stem density not change significantly between May and June. From June to July and from July to August, no changes were significant.

In high mesquite density areas (Appendix M), all areas had significant changes in stem density regressions between April and May. From May to June, only the 2-year old burn remained the same and from June to July, only the 1-year old burn remained the same. From July to August, all high mesquite density areas, except the 1-year old burn, changed significantly.

Because many areas peaked in stem density before August, changes in stem density regressions often caused late season regression to be similar to regressions from earlier months; the regressions for the months in between were generally different.

In the mesquite free area of the study-year burn, the differences in stem density between June and August regressions were not significant (Appendix K, Table 58). In the 1-year old burn, the May and August regressions were not different (Appendix K, Table 57). Peak stem density and standing crop biomass occurred in July in both cases.

In low mesquite density areas, results varied widely. In the 3-year old burn, June and August stem densities were significantly different, although there were no significant differences in the stem density regressions calculated between June and July or July and August (Appendix L), Table 60). The April regression was not significantly different from those in July or August in the 1-year old burn with a low mesquite density (Appendix L, Table 61). In the study-year burn, stem densities in May and July, and June and August were not significantly different (Appendix L, Table 62).

Stem densities in the high mesquite density area were also quite variable between burns. In the unburned area, the April regression was only significantly different from that from May (Appendix M, Table 63). In the 3-year old burn, April and June regressions were not significantly different (Appendix M, Table 64). In the 1-year old burn, April and August, May and July, and June and August regressions were not significantly different (Appendix M, Table 66).

Stem densities at five centimeters AGL in open areas, increased through June then decreased in July and August (Table 23). Low and high mesquite density areas showed similar responses, increasing only from April to May (Table 23). In addition, low mesquite density areas had the highest mean stem density at five centimeters AGL throughout the study. Open areas had the lowest stem density near ground level from April to June and the high mesquite density areas had the lowest from July to August.

Of the mesquite free areas, the unburned area had the highest stem density at five centimeter AGL (Table 24) and the study-year burn had the lowest. Of the low mesquite density areas, the 3-year old burn had the highest stem density, whereas, the unburned area had the lowest (Table 24). Of the high mesquite density areas, the unburned area had the highest stem density near ground level and the 2-year old burn had the lowest (Table 24). The 3-year old burn had the highest mean stem density at 5 cm AGL and the 2-year old burn had the lowest (Table 24).

TABLE 23. MONTHLY NUMBER OF STEMS/5 cm (FROM REGRESSSION EQUATIONS) AT 5 cm ABOVE GROUND LEVEL, BY MESQUITE DENSITY, FOR THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Mesquite	Month					
Density	April	May	June	July	August	Mean
Open	1.888	2.008	3.255	3.251	2.952	2.671
Low	2.938	4.183	3.899	3.643	3.735	3.680
High	2.880	3.427	3.320	2.954	2.286	2.973
Mean	2.569	3.206	3.491	3.283	2.991	3.108

TABLE 24. NUMBER OF STEMS/5cm AT 5cm AGL (FROM REGRESSSION EQUATIONS), BY BURN AGE, FROM STUDY AREA TRANSECTS AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Mesquite	Burn Age					
Density	Unburned	3-Years	2-Years	1-Year	Study-Year	Mean
Open	3.631	2.980	2.498	2.758	2.200	2.813
Low	2.409	4.488	--	3.625	3.796	3.580
High	3.404	3.175	1.975	3.339	--	2.973
Mean	3.148	3.548	2.237	3.241	2.998	3.034

At 50 cm AGL, stems were only present during May in open areas, May and July in low mesquite density areas, and May, June and August in high mesquite density areas (Table 26). Low mesquite density areas had the highest mean stem density at 50 cm AGL and open areas had the lowest (Table 25).

Mesquite free areas had similar patterns of stem density at both 50 cm AGL and five centimeters AGL; the unburned areas had the highest em density and the study-year burn had the lowest (Table 26). In low mesquite density areas, the study-year burn had the highest stem density at 50 cm AGL and the 3-year old burn had the lowest (Table 26). In the high mesquite density areas, the 2-year old burn had the highest mean stem density at 50 cm AGL and the 3-year old burn had the lowest (Table 26). The 2-year old burns maintained the highest overall mean stem density at 50 cm AGL and the 3-year old burns had the lowest (Table 26).

TABLE 25. MONTHLY NUMBER OF STEMS/5cm (FROM REGRESSSION EQUATIONS) AT 50cm AGL, BY MESQUITE DENSITY, FOR THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Mesquite Density	Month					
	April	May	June	July	August	Mean
Open	-0.145*	0.214	-0.775*	-0.509*	-0.903*	-0.424*
Low	-0.099*	0.438	-0.289*	0.837	-0.253*	0.127
High	-0.970	0.156	0.208	-0.033*	0.648	0.002
Mean	-0.405*	0.269	-0.285*	0.098	-0.169*	-0.098*

* Zero stems

TABLE 26. MONTHLY NUMBER OF STEMS/5cm (FROM REGRESSSION EQUATIONS) AT 50cm AGL, BY BURN AGE, FOR THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Mesquite	Burn Age					
Density	Unburned	3-Years	2-Years	1-Year	Study-Year	Mean
Open	0.409	-0.450*	-0.302*	-0.342*	-0.874*	-0.312*
Low	0.189	-0.652*	--	0.235	0.451	0.056
High	-0.276*	-0.532*	0.915	-0.101*	--	0.002
Mean	0.107	-0.545	0.307	-0.208*	-0.212*	-0.110*

*Zero Stems

CHAPTER V

DISCUSSION

Species Composition

Mesquite apparently creates conditions, or is at least found where conditions prevail, that are very conducive to brome. The preponderance of brome in mesquite infested areas makes it difficult to determine the direct effects of mesquite on the remaining plant community. The negative relationship between brome and bare ground suggest the possibility that brome is simply "filling in" areas between other plants. However, species composition is so altered in high brome density areas that this explanation is unlikely. Principal Components Analysis (PCA) of species composition data, calculated with and without bare ground as a factor, were essentially identical. This analysis indicated that high percentages of brome determine species composition. Once the data was adjusted for brome, burning became an important factor. Three of the four burned mesquite free areas appeared unique because of high relative frequencies of little bluestem; a species not encountered in mesquite infested areas (whether burned or not) and occurred only in a low relative frequency in the unburned area without mesquite.

The affinity of little bluestem for areas outside the mesquite-brome complex was even more obvious when brome was not used in PCA. All burned areas without mesquite then loaded positively on little bluestem. The positive effects of early spring burning on little bluestem as noted by Aldous (1934) and Towne and Owensby (1984) was also apparent; all burned mesquite free areas had higher little bluestem percentages than did the unburned mesquite free area. Hulbert (1969) found that yields of big bluestem (Andropogon gerardi) were increased in response to removal of deep litter either by burning or clipping. Because both treatments responded similarly, Hulbert indicated that the major short term effect of fire was litter removal. However, when litter is sparse or absent, burning does not increase yields (Hulbert 1969). Hulbert (1969) suggested that this implies that when litter is abundant, burning will increase grass growth, but if litter is sparse or absent, grass production will decrease. In my study, burned mesquite free areas had virtually no litter. The removal of litter by burning apparently was a factor in increasing little bluestem. Schacht and Stubbendieck (1985) noted that early spring burning was detrimental to brome. This effect was also clearly seen in my data; the unburned mesquite free areas had a significantly higher percentage of brome than did the burned mesquite free areas.

In low mesquite density areas, the relative frequency of brome decreased as the time since burning increased (Appendix D, Table 28). This relationship appears to be the result of several factors. First, brome is generally found only beneath the mesquite canopy. In unburned areas, perennial grasses compete strongly with mesquite seedlings (Martin 1975) in the areas between mesquite trees and thus conditions are not conducive for expansion of brome. Secondly, early spring burning either lowers the relative percentage and/or slows development of perennial grasses (Kelting 1957) and allows initial infestation by brome and mesquite. However, native perennial grasses are later able to outcompete brome, and presumably mesquite seedlings, before they are able to colonize the area. Hulbert (1969) stated that fire results in a reduced water supply for tree seedlings.

In high mesquite density areas, burning appears to decrease brome numbers, though not to the extent that recolonization by other species enhanced. Unlike low mesquite density areas, perennial grasses are not in close proximity to these brome infested areas and thus recolonization of perennial grasses is slower (Martin 1975). Brome appears to recover from burning far faster than recolonization by perennial grasses (Appendix D, Table 29). In high mesquite density areas, other grasses may not only be responding to brome, but also to competition with mesquite for moisture, light, and plant nutrients (Fisher 1948, Darrow and McCully 1959). Therefore, high mesquite densities may severely limit colonization by other species even if brome is reduced by fire.

Species diversity is also affected by burning and the presence of the mesquite-brome complex. Mean diversity indices, compared by mesquite density, did not differ significantly unless burning was taken into account (Table 15). Burned areas without mesquite had a mean diversity index higher than both low and high mesquite density areas, though only significantly different from the latter. Unburned areas had the lowest mean diversity index (Table 13). Again, brome appeared to be the underlying factor because the lower diversity indices were from areas with high brome percentages. However, if brome was not considered in diversity calculations, there were no significant differences between diversity indices (Tables 17, 18).

The relationship between brome and bare ground may best explain these differences. If brome was replacing bare ground, as suggested by regression analysis (Figure 8), then areas with brome become less diverse due to the predominance of a single species (brome) and reduced equitability of the remaining species. However, the remainder of the plant community may be as diverse in areas with brome as in those areas without brome (Table 17).

Data from mesquite free areas tended to mimic the results found in other studies. In mesquite infested areas, brome dominated the community to such an extent that it obscured the effects of burning on plant species composition and diversity. Brome, a cool season grass, began to die back in June and July. As brome died, it fell over and formed a dense mat that was several centimeters thick that was not measured by the Robel pole. This "mat" apparently inhibited many other plants from growing and accounted for the decrease in biomass in June, and to some extent July. A few plants species, namely vine mesquite, nightshades (Solanum sp.), and broomweed were able to grow through the mat and these plants accounted for the majority of the late season increase in standing crop biomass.

Standing Crop Biomass

The plant assemblage in areas without mesquite showed responses to burning that were similar to those reported in other studies. Bieber and Anderson (1961), Anderson (1965), and Towne and Owensby (1984) found that early spring burning decreased herbage production and attributed the decrease to increased surface exposure and moisture loss. The reduction in biomass in burned areas on my study area may also be attributable to the effects of early spring burning on cool season grasses (brome). Because early spring burning can decrease brome yields, the decrease in brome could account for the decrease in biomass between burned and unburned mesquite free areas (Figure 9).

In burned high mesquite density areas, differences in the quantity of brome appeared to be negatively related to biomass. However, in low mesquite density areas the opposite was seen. In low mesquite density areas, however, competition was probably less severe, and one might expect higher biomass estimates in low density mesquite areas than high mesquite density areas. Many authors have noted similar responses when mesquite densities are reduced by methods other than prescribed burning (Cable and Tschirley 1961, Box 1968, Schuster 1968, Wright 1968).

Additionally, Kelting (1957) reported slower development of big bluestem in areas burned in February than in unburned areas. A similar response by vegetation on my study area could explain the relatively "short" stature of plant species observed in burned areas.

Stem Profile Data

Stem Density. Stem density appeared to be affected by mesquite density and to some degree, burn age. However, the fact that an area had been burned appeared to be of more importance than the time since it was last burned.

In unburned areas, the mesquite free area generally had a higher mean stem density than areas with mesquite. This difference was likely the result of the high brome percentages in mesquite areas (Figure 5). The high percentages of brome added considerably to the number of stems early in the growing season and amplified the difference between those areas with high brome percentages and those without. The high brome percentage, also was reflected by a low stem density late in the growing season. This effect was particularly evident in areas with high mesquite densities; when brome began to die back in June, there was very little vegetative material above 25cm AGL. There was very little difference in stem density between burn ages except that, in mesquite free areas and low mesquite density areas, stem density generally increased with burn age but decreased with burn age in high mesquite density areas. This trend was likely a result of differential brome density as well as the effects of fire on other species. Burned mesquite free areas, showed an increase in grass species that could account for the increase in total stems as these species colonized an area; the initial drop in density was a result of the loss of cool season grasses (brome) and lag time for the other species to recolonize and/or grow. The explanation given for open areas could also apply to areas of low mesquite density except that rather than an increase in grass species there was a change in grass species composition; prairie threeawn and annual dropseed were replaced by grama grasses - grama grasses had more stems per plant. Brome was present in the unburned low mesquite density area but it did not occur in the plant samples. Therefore, it is difficult to use brome to explain the effects of burning. It is unlikely, however, that brome increased after burning because it decreased in all other areas after burning.

High mesquite density areas initially reacted to burning by decreases in brome and increases in warm season grasses. However, brome quickly recolonized and thus the overall stem density was lowered because of the loss of standing plants late in the growing season. Because the 3-year old burn and unburned area were similar in species composition and stem density and the 2-year old burn was quite different (a higher species diversity and stem density), it appears that burning about every two years would be required to maintain a high species diversity.

Stem Distribution. Total stem density, may not be as good an index to the vegetative condition of an area as the distribution of stems. It is possible for two areas to have the same mean stem density but for one area to have 90% of its stems above a given level whereas the other has its stems 90% below the same level.

Low mesquite density areas had the highest total stem density at five centimeters AGL and mesquite free areas had the lowest (Tables 20, 21, 22, 23). Mesquite free areas had increasing stem density at five centimeters AGL only through June (total stem density increased through July) and low mesquite densities only increased through May (total stem density increased through June). In high mesquite density areas, stem densities at five centimeters AGL were similar to those for total stem density except that values for August had a higher stem density than May. Stem densities at five centimeters AGL were about five times higher than total stem density.

Apparently, stem densities increased in all areas between April and May, but those areas with high brome percentages had greater increases. Between May and June, areas with high brome percentages began to lose stems at five centimeters AGL; the higher the brome percentage the greater the decrease. However, in those areas with moderate percentages of brome (low mesquite density areas), stem density at five centimeters AGL did not precipitously decrease. It appears that in areas of lower brome percentages, other plant species were able to grow. The high mesquite density areas had such high brome percentages that relatively few other species were present and many of those present were not apparent until late in the growing season. The difference between burned (low brome percentage) and unburned (high brome percentage) areas without mesquite could also be related to differences in chronology.

May was the only month during which all mesquite densities had stems present at 50 cm AGL. Low densities of stem present at 50 cm AGL was again likely due to brome. In the mesquite free areas, only the unburned area had stems reach the 50cm AGL mark. All burned areas had relatively sparse, short vegetation and only rarely did stems grow to 50cm AGL. This difference in structure was obvious (except in August) when stem density-height regressions were compared (Appendix H) between unburned and mesquite free burned areas (Appendix H, Table 47).

In high mesquite density areas, there was a large increase in the number of stems at 50 cm AGL from April to June, probably all attributable to brome. Values then decreased in July as the brome died back. Brome tended to remain erect into early June and as it died back in late June and July, nightshades, broomweed, Canada wildrye, and other taller species expanded and/or began growing in the area. These species accounted for the late season increase in the number of stems at 50 cm AGL. One reason for the late season increase in the number of stems was that plants were no longer competing with brome for light and/or moisture and nutrients. Secondly, as the brome died it formed a layer of "mulch" over the area that may have served to reduce evaporation which allowed more and/or taller plants to grow in the area. Hulbert (1969) stated that soil moisture was distinctly higher in unburned plots than in denuded plots during the growing season, apparently because litter reduced evaporation more than it intercepted precipitation, and also because the lesser production in deep litter areas lowered water loss due to transpiration. Though the same mulch layer was present in the high and low mesquite density areas, the lack of sunlight in the high mesquite density areas limited the growth and diversity in those areas. Plants in the mesquite free areas were taller in the unburned area for probably the same reason. When the mulch layer was burned off, the evaporation rate increased ough to decrease the moisture available to plants with a resulting decrease in the size and diversity of plant (Kelting 1957).

In the low mesquite density areas, there was a notable increase in the number of stems between April and May at 50 cm AGL. Though the increase observed was not as great as that noted in the high mesquite density areas, the explanation for the increase is likely the same. Brome, and other species, were taller in low mesquite density areas probably because sunlight and nutrients were more abundant than in high mesquite density areas and moisture was more available than in mesquite free areas. Light penetration through the low mesquite density canopy allowed many species to grow that could not grow under the shade of the high mesquite density canopy.

Management Applications

Two factors are important to consider in the following recommendations: 1) the study area was not grazed and, 2) mesquite was in the "tree form" in all areas measured. Application of management recommendations without these points being taken into consideration could prove inappropriate.

All three types of areas (mesquite free, low mesquite density, high mesquite density) must apparently be managed in a somewhat different manner, depending on the management goal. The management goals to be considered include plant species diversity, plant species composition, early season standing crop biomass, late season standing crop biomass, total stem density, stem density near ground level and, stem density at 50 cm above ground level.

Mesquite Free Areas. Mesquite free areas responded to burning similar to what has been found in many other studies. Early spring burning increased plant diversity and the relative frequency of perennial grasses. Standing crop biomass and stem density at all levels, decreased. It is not possible to state for certain, from the results of my study, how often an area should be burned to maintain a high species diversity and good stand of perennial grasses. However, the 3-year old burn examined during this study still had a higher plant diversity and relative frequency of perennial grasses than did the unburned mesquite free area. Therefore, it is unlikely that similar areas need to be burned more frequently than once every three years. The standing crop biomass of the 3-year old burn also most closely resembled the unburned area. If standing crop biomass in mesquite free areas is a management goal, then burning should either not be considered or a recovery period of at least three years should be expected. Stem density, which is correlated with standing crop biomass, should be managed similar to standing crop biomass because the two factors responded in a like manner.

High Mesquite Density Areas. High mesquite density areas also had an increase in plant diversity and the relative number of perennial grasses following burning. However, because brome quickly recolonized the areas, burning every two years is apparently required to maintain diversity and perennial grasses. If increasing late and early season standing crop biomass is a goal, different management strategies will be required. To maintain a high early season standing crop biomass, an area should not be burned so that brome is maintained. To increase late season standing crop biomass, early spring burning (every two years) to reduce brome should be practiced. To increase total stem density or stem density at higher levels (50 cm above ground level), areas should be burned. To increase stem density at lower levels however, areas should not be burned. Again this is the result of brome: burning reduces low level numbers of stems (brome) but increases plant diversity and plant height (late in the growing season).

Low Mesquite Density Areas. Burning also increased diversity in low mesquite density areas. However, as in the mesquite free areas, the frequency of burning necessary to maintain a high species diversity can not be determined from the results of this study beyond stating that the 3-year old burn was more diverse than the unburned area. From the results of my study, it is difficult to determine whether or not burning increased perennial grasses in low mesquite density areas. Because areas under mesquite trees tended to respond similar to high mesquite density areas and the areas in between mesquite trees responded similar to mesquite free areas, it would seem that some type of intermediate management scheme would provide the best results. However, burning every two years, as in high mesquite density areas, would likely reduce grasses because of the resulting loss of moisture in the more open areas and burning less frequently would likely result in a dense stand of brome and possibly mesquite. Standing crop biomass was increased at all levels by burning in low mesquite density areas. The removal of brome (litter) promoted diversity and increased the number and/or height of species under the mesquite canopy. The partial shade of the mesquite tree apparently compensated to some extent for the loss of moisture due to the removal of the litter layer. Stem density was increased at all levels by burning for probably much the same reason.

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APPENDIX A

Study Area Range Site Descriptions and Correlations, Ft. Sill Military Reservation, Comanche County, Oklahoma. (From Ft. Sill Conservation Plan, 1970)

The following is a description of each range site, including an estimate of potential yield. Yields are given in air-dry weight and are based on plot clippings taken from sites in excellent condition.

Hardland Range Site (H). This site consists of nearly level and gently sloping clay loams and silt loams that have a heavy clayey compact subsoil. These soils absorb moisture very slowly and much of the moisture taken in is unavailable to plants. Moisture seldom penetrates to a depth of more than 0.61 m during the growing season.

The vegetation is primarily blue grama and buffalograss. The taller grasses, such as vine mesquite, sideoats grama, and little bluestem, grow in the drainageways and areas that receive extra moisture. Mesquite and pricklypear (*Opuntia* sp.) are common invaders.

The potential yield of air-dry herbage varies from 3257 kg/ha in wet years to 1685 kg/ha in drier years.

Red Clay Prairie Range Site (RC). This site consists of very gently sloping to strongly sloping, reddish, calcareous, clayey soils. The surface layer is somewhat granular but is underlain by dense clay. Water intake is fair to good if cover is maintained, but the soils become droughty if vegetation is sparse.

Little bluestem is the principal decreaser, and sideoats grama is the most productive increaser. Annual threeawn (*Aristida* sp.), Japanese brome (*Bromus japonicus*), little barley (*Hordeum pussilum*), red threeawn

(Aristida longiseta), and other weedy grasses and forbs are common invaders. Continued overuse often results in bare ground and invasion by pricklypear and mesquite.

The potential yield of air-dry herbage varies between 4267 kg/ha in moist years to 2000 lbs/acre in drier years.

Loamy Prairie Range Site (LP). This site consists of nearly level to moderately steep, productive, loamy soils. In excellent condition, cover is largely tall grasses, such as sand bluestem, big bluestem, Indiangrass, little bluestem, and switchgrass. If overgrazed, blue grama and buffalograss increase and tall and mid grasses decrease.

The potential yield of air-dry herbage varies from 5617 kg/ha in wet years to 3032 kg/ha in dry years.

Boulder Ridge Range Site (BR). This site consists of rolling to steep, dissected hills and ridges. The soils are deep and loamy and contain many cobblestones, a few scattered boulders, and an appreciable amount of gravel.

The principal decreasers are little bluestem, big bluestem, Indiangrass, switchgrass, and wild rye (Elymus sp.). The principal increasers are sideoats grama, blue grama, and hairy grama. The most common invaders are annual threeawn, Japanese brome, silver bluestem (Andropogon saccharoides), and buffalograss.

The potential yield of air-dry herbage varies between 4492 kg/ha in wet years to 2246 kg/ha in dry years.

Limestone Ridge Range Site (LR). This site consists of shallow to very shallow, dark colored soils over limestone. The vegetation consists dominantly of short grasses, such as hairy grama, tall grama (*Bouteloua hirsuta pectinata*), blue grama, and sideoats grama.

The potential yield of air-dry herbage varies from 2807 kg/ha in wet years to 1347 kg/ha in dry years.

Hilly Stony Range Site (HS). This site consists of gently sloping to very steep, very shallow to deep soils and granite outcrops over granite bedrock. Hairy grama is the major decreaser on south-facing slopes. Annual forbes make up a high percentage of the vegetation.

The potential yield of air-dry herbage varies from 2021 kg/ha in wet years to 1124 kg/ha in dry years.

Hilly Stony Savannah Range Site (HSS). This site consists of hilly to very steep, very shallow to deep, stony soils. Big bluestem, little bluestem, and sideoats grama are the principal decreasers. Blue grama and hairy grama are the principal increasers.

The potential yield of air-dry herbage varies from 2021 kg/ha in wet years to 1124 kg/ha in dry years.

Loamy Bottomland Range Site (LB). This site consists of deep loam to clay loam soils on bottomlands. These soils occasionally receive additional moisture from overflow.

The climax vegetation consists of tall to mid grasses, such as big bluestem, eastern gamagrass (*Tripsacum dactyloides*), Indiangrass, switchgrass, Canada wildrye (*Elymus canadensis*), Virginia wildrye (*Elymus virginicus*), and western wheatgrass (*Andropogon smithii*). Woody plants include pecan, elm, oak, hackberry, and cottonwood (*Populus deltoides*).

The potential yield of air-dry herbage varies from 7863 kg/ha in wet years to 3931 kg/ha in dry years.

Boulder Ridge Savannah Range Site (BRS). This site consists of rolling to steep, dissected hills and ridges. The soils are deep and loamy and contain many cobblestones, scattered boulders, and an appreciable amount of gravel.

The principal decreasers are little bluestem, big bluestem, Indiangrass, switchgrass, and wildrye. The principal increasers are sideoats grama, blue grama, hairy grama, blackjack oak, and post oaks. The most common invaders are annual threeawn, Japanese brome, and silver bluestem.

The potential yield of air-dry herbage varies from 3000 kg/ha in wet years to 1685 kg/ha in dry years.

APPENDIX B

Description of Study Area Soils, Ft. Sill Military Reservation, Comanche County, Oklahoma.
(From Ft. Sill Conservation Plan, 1970)

Breaks-alluvial Land Complex (Bk). This complex consists of shallow to deep, loamey to clayey, upland soils on broken and moderately steep side slopes.

The areas are long and are between 30 and 152 m wide. The slope is 8 to 20 percent on breaks and 0 to 2 percent on the bottomlands.

This complex is too small for separate use and management and is better suited to range, wildlife habitat, and pasture than to crops. The vegetation on the side slopes consists of short and mid grasses. Tall grasses and deciduous trees dominate the bottomlands.

Important management problems consists of protecting the grass by controlling grazing, reseeding barren areas, and controlling erosion. This soil type is found in Loamy Prairie and Loamy Bottomland range.

Broken Alluvial Land (BR). This land consists of broken slopes and channeled areas in the alluvium flood plains. It is dissected by meandering channels and is frequently flooded. The dominant slope is 0 to 2 percent, but the broken side slopes have gradients of at least eight percent, and some are nearly vertical. The texture ranges from fine sandy loam to heavy clay loam.

This land is loamy and fertile but, because of the broken slopes and frequent flooding, is unsuitable to cultivation. It is suitable for use as pasture, range, and wildlife habitat. The vegetation consists mainly of deciduous trees and tall grasses. Management to protect the grass and control erosion is needed. This soil type is found in Loamy Bottomland range.

Eroded Clayey Land (Es). This land consists of severely eroded, fine-textured soils and some gullies. The slope range is 2 to 5 percent. Erosion has removed most or all the original surface layer. Where part of the surface layer remains, it is less than 5 cm thick. The plow layer consists predominantly of material from the subsoil and substratum.

This land type has been retired from cultivation. It is suitable only as range and wildlife habitat. Except in areas reseeded to native grasses, the vegetation is mainly weeds and low order grasses.

Reestablishing grass is difficult but necessary on severely eroded areas. Only limited amounts of vegetation can be expected. Little bluestem, buffalograss (*Buchloe dactyloides*), blue grama, and sideoats grama are suitable native species. This soil type is found in Red Clay Prairie range.

Foard Series. This series consists of deep, nearly level to gently sloping, dark brown, friable silt loam that is 13 to 25 cm thick and has weak granular structure. It is slightly acid or neutral in reaction. The boundary between the surface layer and the subsoil is abrupt. The subsoil is dark grayish brown to dark brown, very firm clay. It has weak blocky structure or is massive, and is extremely hard when dry. This layer is neutral or moderately alkaline in reaction. It is underlain by clayey red beds that are mottled in spots with redder and yellower colors.

Foard soils are associated with Tillman and Vernon soils. They are less red in the subsoil than Tillman soils and lack the transition zone between the surface layer and the subsoil.

Foard soils are moderately well drained and moderately fertile. They are somewhat droughty, have very slow permeability, and release moisture to plants rather slowly. The depth to free carbonates ranges from 30 to 61 cm.

Foard Silt Loam, 0 to 1 Percent Slopes (FaA). This soil occurs as nearly level flats. Included in mapping were small areas having slopes of 1 to 3 percent and a few scattered slickspots. Small grains, grain sorghums, and millet are suitable crops for this soil.

The vegetation consists of short and mid grasses. Surface crusting and droughtiness are the major limitations. This soil type is found in Hardland range.

Foard and Tillman Soils, 1 to 3 Percent Slopes (FtB). This mapping unit is 60 to 70 percent Foard silt loam and 30 to 40 percent llman clay loam. Included in mapping were soils similar to Tillman soils but calcareous to the surface, small areas of Vernon soils and Stamford clay, and a few scattered slickspots.

Controlling erosion is a problem in places but not a serious one. Adapted crops for these soils are small grains, grain sorghums, and millet. This soil type is found in Hardland range.

Foard-Slickspots Complex, 0 to 1 Percent Slopes (FsA). This complex is 65 to 90 percent Foard soils and 10 to 35 percent slickspots. The surface layer of the slickspots ranges from loam to clay loam in texture, is 5 to 25 cm thick, and has a crust that is .30 to 2.5 cm thick that is glazed and whitish when dry. The surface layer of the Foard soil ranges from silt loam to clay loam in texture. The boundary between the surface layer and a dense massive clay subsoil is abrupt. The color of these layers ranges from grayish brown to reddish brown. The reaction is mildly or moderately alkaline. The depth to calcareous material ranges from 25 to 76 cm.

This complex is difficult to till. Plant emergence is retarded because the surface tends to crust and moisture is not readily available. Applying agriculture gypsum to slickspots reduces surface crusting, increases water intake, and improves soil structure.

This complex is suited to small grains, cool season crops, and native grasses such as buffalograss, alkali sacaton (Sporobolus airoides), and blue grama. This soil type is found in Hardland and Slickspot ranges.

Foard-Slickspots Complex, 1 to 3 Percent Slopes (FsB). This upland complex is 10 to 45 percent slickspots. Except for spots of Tillman clay loam, which make up 10 to 15 percent of the area, this complex consists of Foard soils.

The surface layer of the slickspots ranges from loam to clay loam in texture, is 5 to 25 cm thick, and has a crust that is 0.30 to 2.5 cm thick that is glazed and whitish when dry. The surface layer of the Foard soil ranges from silt loam to clay loam in texture. The boundary between the surface layer and a dense, massive clay subsoil is abrupt. Color ranges from brown to reddish brown. The reaction is mildly or moderately alkaline. The depth to calcareous material ranges from 25 to

76 cm.

Soil conservation practices are needed to control erosion and reduce surface crusting. Applying agriculture gypsum to slickspots reduces surface crusting, increase water intake, and improves soil structure. This complex is suited to small grains. This soil type is found in Hardland and Slickspot range.

Granite Cobbly Land (Gc). This land consists of rolling to steep areas on dissected hills and ridges on uplands. The slope is 5 to 40 percent. Granite cobblestones make up 25 to 70 percent of the surface. The remaining portion consists of deep, brown to reddish brown loams to clay loams that contain an appreciable amount of gravel and a few scattered boulders. Included in mapping were alluvial soils, less than 61 m wide, and small areas where the depth to bedrock is 0.3 to 1.2 m.

This land is suitable for range and wildlife habitat. It is excessively drained and has excessive runoff. Permeability is moderate. The vegetation consists of mid and tall grasses. Scrub oak is common in some areas. Controlling grazing and protection from fire are needed. This soil type is found in Boulder Ridge range.

Lawton Series. This series consists of very gently sloping and gently sloping soils on uplands. These soils are deep, brown, and loamy. They developed in a subhumid climate, in noncalcareous granitic outwash from the Wichita Mountains. They occur along the courses of former drainageways that spread out from the mountains.

The surface layer is brown to reddish brown loam and is 15 to 36 cm thick. It has moderate, medium, granular structure and is friable when moist and hard when dry. It is slightly acid or neutral in reaction.

This layer grades to reddish brown clay loam that has weak, medium, granular structure and extends to a depth of 36 to 46 cm. The subsoil is dark reddish brown to yellowish red heavy clay loam. It has moderate, medium, blocky structure and is firm when moist and very hard when dry. It is neutral in reaction. Yellowish red sandy loam to clay loam is at a depth of 1.1 to 2.3 m.

In most places these soils have granitic sand and pebbles throughout the profile but not enough to impair the moisture holding capacity. Gravel beds occur at a depth of 1.5 to 2.3 m or, in areas near the Wichita Mountains, nearer to the surface.

Lawton soils are associated with Foard, Tillman, and Vernon soils. They are less clayey and less alkaline than either Foard or Tillman soils.

The vegetation consists of mid and tall grasses. Bermuda grass (Cynodon dactylon), King Ranch bluestem (Andropogon ischaemum var.), and Caucasian bluestems do well in tame pasture.

Lawton Loam, 1 to 3 Percent Slopes (LaB). Water erosion is a moderate hazard. Small grains and millet are suitable crops. This soil type is found in Loamy Prairie range.

Lawton Loam, 3 to 5 Percent Slopes (LaC). This soil is on uplands along former drainageways. It has a 15 to 30 cm surface layer and is suitable to cultivation. Small grains are the best suited crops. This soil type is found in Loamy Prairie range.

Limestone Cobbly Land (Lm). This land consists of limestone cobblestones and strongly sloping to steep, dark colored soils that are shallow to very shallow over limestone, limestone conglomerate, or, in some small areas, caliche.

The soil is 8 to 51 cm thick. The surface layer ranges from loam to clay loam in texture and is 15 to 75 percent limestone gravel and cobblestones. The substratum consists of limestone, limestone conglomerate, or caliche.

This land is excessively drained and has excess runoff. Permeability is moderate. The vegetation consists of short, mid and tall grasses; the taller grasses growing on the deeper soils. This land is suitable as wildlife habitat and range but has a low carrying capacity. Control of grazing and protection from fire are needed. This soil type is found in Limestone Ridge range.

Lucien Series. This series consists of shallow, sloping to strongly sloping soils on uplands. These are reddish brown, noncalcareous, loamy soils that developed from Permian sandstone.

The surface layer is reddish brown loam and is about 25 cm thick. It has weak, fine, granular structure and is very friable when moist and soft when dry. It is neutral in reaction. The underlying material is dark reddish brown, consolidated, fine grained sandstone.

These soils range in thickness from 13 cm near rock outcrops to as much as 51 cm. The surface layer texture is mainly loam but ranges from silt loam to fine sandy loam. Color ranges from dark reddish brown to reddish brown. The reaction is neutral to medium acid.

Lucien soils are associated with Zaneis and Vernon soils but are less clayey than the calcareous Vernon soils. They are shallower to bedrock than and lack the developed textural subsoil of Zaneis soils.

Lucien soils are in range. The vegetation consists of tall and mid grasses.

Lucien-Zaneis-Vernon Complex, 5 to 12 Percent Slopes (LzD). This complex consists of sloping to strongly sloping soils on dissected, erosional uplands. It is 30 to 60 percent Lucien soils, 10 to 30 percent Zaneis loam, 20 to 50 percent Vernon soils, and 5 to 15 percent rock outcrops. Included in mapping were alluvial soils on valley floors less than 30.5 m wide and small areas of Minco loam. This complex is suitable for use as range and wildlife habitat. The vegetation consists of tall and mid grasses. This soil type is found in Loamy Prairie and Red Clay Prairie range.

Port Series. This series consists of nearly level, brown to dark reddish brown soils on flood plains. They formed in loam and clay loam under deciduous trees and tall grasses.

The surface layer of these soils is either loam or clay loam. Where the texture is loam, the surface layer ranges from 25 to 64 cm thick and from brown to reddish brown in color. It has a granular structure and is friable when moist and slightly hard when dry. The reaction is slightly acid or neutral. The subsoil is reddish brown, granular loam. It is friable when moist and slightly hard when dry. The underlying material ranges from loam to light clay in texture and from dark brown to yellowish red in color.

Where the texture is clay loam, the surface layer is 30 to 76 cm thick. It is generally dark brown but ranges from reddish brown to dark grayish brown. It is friable or firm and has medium granular structure. The subsoil is reddish brown clay loam that is firm and is neutral to alkaline in reaction. It ranges from brown through reddish brown to yellowish red in color. Underlying material is calcareous, reddish brown, massive, firm clay loam. Darkened layers of buried soils at a depth of 0.91 to 1.5 m are common. The depth to free carbonates ranges from 0.38 to 1.3 m.

Port soils are moderately fertile and have good tilth and structure. Port loam is easier to work and is more permeable than Port clay loam, but its subsoil stores less moisture for plants.

These are among the most productive soils on FSMR. They are suited to small grain, alfalfa, forage sorghum, millet, lespedeza, pecan trees, and tame and native pasture.

Port Clay Loam (Pc). This is the most extensive bottomland soil on FSMR and one of the most productive. It is suited to all area crops. Maintaining plant nutrients is the main management requirement. This soil type is found in Loamy Bottomland range.

Port Loam (Po). This is the second most extensive bottomland soil on FSMR. It is very productive and is suited to all area crops. The areas in native or tame pasture are productive of forage. Maintaining plant nutrients is the main management requirement. This soil type is found in Loamy Bottomland range.

Port-Slickspots Complex (Ps). This complex consists of Port soils and slickspots. Included in mapping were small areas of Lela and Miller soils. Slickspots make up 10 to 25 percent of the mapping unit. They occur as clusters that may total more than two hectares. Slickspots are usually less than 9.1 m in diameter.

The surface layer of the slickspots ranges from loam to clay loam in texture, is 5 to 51 cm thick, and has a crust that is 0.3 to 2.5 cm thick and is glazed and whitish when dry. In many areas, erosion has removed most or all the surface layer. The boundary between this layer and the subsoil is abrupt. The subsoil consists of weak blocky to massive clay to clay loam. The color of the surface layer and subsoil ranges from grayish brown to reddish brown. The substratum may vary in color and range from sandy loam to clay in texture. The reaction in all horizons ranges from neutral to moderately alkaline. Calcareous material can occur from the surface down to a depth of 76 cm.

This complex is subject to flooding. Where floods are frequent, scour channels have formed. These channels are usually intermittent and have only sparse vegetation.

This complex is not suitable for cultivation. The vegetation on Port soils consists of tall grasses. Vegetation on the slickspots consists of mid and short grasses, such as alkali sacaton, white tridens (Tridens albescens), saltgrass (Distichlis spicata), and buffalograss, and in some areas saltcedar (Tamarix gallica) and mesquite. Some slickspots are barren or nearly so. This soil type is found in Loamy Bottomland range.

Rock Land (Ro). Rock land is 35 to 90 percent granite outcrop and 10 to 50 percent gently sloping to moderately steep soils that are very shallow over granite bedrock. Included in mapping were deeper soils, which make up 10 to 12 percent of this type land.

Rock land is associated with Granite outcrop and Stony rock land. It has a smaller percentage of rock outcrops than Granite outcrop and a smaller percentage of deep stony soils than Stony rock land. This soil type is found in Hilly Stony range.

Stony Rock Land (St). This land is hilly to very steep. It is 15 to 50 percent Granite outcrops, 10 to 30 percent very shallow soils over granite, and 15 to 70 percent deep stony soils. The slope ranges from 15 to 50 percent.

Stony rock land is associated with Granite outcrop and Rock land. It has a smaller percentage of outcrops than Granite outcrop land and a higher percentage of deep stony soils than Rock land.

This land is used as range and wildlife habitat. The vegetation is a sparse cover of short and mid grasses on the shallow soils and tall grasses and scrub oak on the deep stony soils. This soil is found in Hilly Stony and Hilly Stony Savannah range.

Tillman Series. This series consists of deep, very gently sloping and gently sloping, reddish brown soils on uplands. These soils are calcareous below a depth of 33 cm.

The surface layer is brown to dark reddish brown friable clay loam, 13 to 25 cm thick, and has fine granular structure. In most places, this layer is underlain by 5 to 20 cm of reddish brown clay loam that has moderate, fine, granular structure and grades to weak, fine blocky structure with increasing depth. The subsoil is compact and blocky. The texture is either light clay or silty clay. The color is ordinarily reddish brown but ranges to dark reddish brown. This layer is very firm when moist and extremely hard when dry. The underlying material is yellowish red, highly calcareous, massive clay.

Tillman soils are associated with Foard, Vernon, Stamford, Zaneis, and Lawton soils. They are more reddish than Foard soils and have a transition zone between the surface layer and the subsoil. They are deeper over the undeveloped clay red beds and have a well differentiated subsoil which Vernon soils lack. Their surface layer is less loamy than Zaneis and Lawton soils, and their subsoil is more clayey.

Tillman soils are somewhat excessively drained and have very slow permeability. The native grasses consists of short and mid grasses.

Tillman Clay Loam, 3 to 5 Percent Slopes (TmC). Included in mapping were Vernon soils, scattered slickspots, and small areas that are similar to Tillman soils but are calcareous above a depth of 30 cm.

Small grain and grain sorghums are best adapted to this soil. Droughtiness and erosion are major limitations. This soil type is found in Hardland range.

Vernon Series. This series consists of shallow, reddish, calcareous Permian clays that are compact and nearly impervious. The calcareous surface layer is red to dark reddish brown, friable clay to clay loam and is 5 to 20 cm thick. It has strong, fine, granular structure. The subsoil is red, very firm clay. It either has medium, fine, blocky structure or is massive. It is extremely hard when dry. This layer is calcareous and contain small lime concentrations. Red, calcareous, massive clay is at a depth of 13 to 76 cm. These soils are moderately alkaline. Free lime generally occurs in the surface layer and throughout the profile.

Vernon soils are associated with Foard, Tillman, Stamford, Zaneis, and Lucien soils. They are more clayey than Lucien soils and are more shallow over the nearly impervious substratum of raw clay than Stamford soils. Native cover consists of short and mid grasses.

<u>Vernon Soils, 3 to 5 Percent Slopes</u> (VeC). These soils are on erosional uplands. Their surface layer is calcareous, granular clay to clay loam 10 to 30 cm thick. The depth to the substratum is 23 to 51 cm. In areas near the Wichita Mountains, these soils have a loamy mantle, but in some areas most of this has been removed by erosion. Included in mapping were spots of Stamford clay.

Small grain can be grown on this soil. Water erosion is a serious hazard. This soil is found in Red Clay Prairie range.

<u>Vernon Soils, 5 to 12 Percent Slopes</u> (VeD). These soils are on erosional uplands. In places the gradient is as much as 15 percent. The surface layer is 5 to 20 cm thick and the depth to substratum is 13 to 51 cm. Included in mapping were small areas of Lucein soils, small areas that have a gravelly or rocky surface layer, and small eroded areas. These soils erode unless well managed. This soil type is found in Red Clay Prairie range.

APPENDIX C

Study Area Plant List, Ft. Sill Military Reservation, Oklahoma.

List includes plants listed in Ft. Sill Conservation plan for each range type found in the study area plus those noted during the course of the study.

Common Name	Scientific Name
Alfalfa	Medicago sativa
Alkali Sacaton	Sporobolus airoides
American Elm	Ulmus americana
Annual Brome	Bromus sp.
Annual Dropseed	Sporobolus neglectus
Annual Skullcap	Scutellaria drummondii
Annual Sunflower	Helianthus annuus
Annual Threeawn	Aristida sp.
Autumn Olive	Elaeagnus umbellata
Barrel Cactus	Echinocereus baileyi
Basketflower	Centauria americana
Bermudagrass	Cynodon dactylon
Big Bluestem	Andropogon gerardi
Big Bluets	Houstonia angustifolia
Bitter Sneezeweed	Helenium amarum
Blackeyesusan	Rudbeckia hirta
Blackjack Oak	Quercus marylandica
Black Medic	Medicago lupulina
Black Sampson	Echinacea angustifolia
Black Willow	Salix nigra
Blue Aster	Aster coerulescens
Blue-Eyed Grass	Sisyrinchium angustifolium
Blue Grama	Bouteloua gracilis
Blue Star	Amsonia ciliata
Blue Windigo	Baptisia australis
Bracted Plantain	Plantago aristida
Bristlegrass	Setaria sp.
Broom Snakeweed	Gutierrezia sarothrae
Buffalograss	Buchloe dactyloides
Canada Wild Rye	Elymus canadensis
Carolina Whitlow Grass	Draba reptans
Carpetweed	Mollugo verticillata
Catclaw sensitivebriar	Schrankia uncinata
Chaetopappa	Chaetopappa asteroides
Chickweed	Stellaria media
Common Broomweed	Gutierrezia dracunculoides
Common Mullein	Verbascum thapsus
Compassplant	Silphium laciniatum

Coralberry	Symphoricarpos orbiculatus
Corn Salad	Valerianella radiata
Cream Windigo	Baptisia bracteata
Croton	Croton sp.
Cut-leaf Evening Primrose	Oenothera laciniata
Cutleaf Ironplant	Haplopappus spinulosis
Daisy Fleabane	Erigeron ramosus
Dogwood	Cornus sp.
Dwarf Dandelion	Krigia oppositifolia
Eastern Cottonwood	Populus deltoides
Eastern Gamagrass	Tripsacum dactyloides
Eastern Red Cedar	Juniperus virginiana
Eriogonum	Eriogonum longifolium
Falsegarlic	Nothoscordum texanum
Fall Witchgrass	Leptoloma cognatum
Field-Pansy	Viola rafinesqii
Fine-Leaf Hymenoxys	Hymenoxys linearifolia
Flax	Linum sp.
Fringeleaf Paspalum	Paspalum ciliatifolium
Gamagrass	Tripsacum dactyloides
Gaura	Gaura sp.
Gayfeather	Liatris punctata
Goldaster	Chrysopsis pilosa
Goldenrod	Solidago sp.
Grape	Vitis sp.
Greenbriar	Smilax sp.
Greenflower Pepperweed	Lepidium densiflorum
Greenthread	Thelesperma sp.
Gumweed	Grindelia squarrosa
Halfshrub Sundrop	Oenothera serrulata
Hairy Grama	Bouteloua hirsuta
Hairy Dropseed	Sporobolus asper pilosus
Hairy Goldaster	Chrysopsis villosa
Heath Aster	Aster ericoides
Hemp Dogbane	Apocynum cannabinum
Illinois Bundleflower	Desmanthus illinoensis
Indian Blanket	Gaillardia pulchella
Indiangrass	Sorghastrum nutans
Indian Paint Brush	Castilleja indivisa
Inland Rush	Juncus interior
Jagged Chickweed	Holosteum umbellatum
Japanese Brome	Bromus japonicus
Johnsongrass	Sorghum halepense
King Ranch Bluestem	Andropogon ischaemum var.
Kuhnia	Kuhnia eupatoriodes
Large-Bracted Wild Indigo	Baptisia leucophaea
Large Flowered Tickseed	Coreopsis grandiflora
Least Bluet	Hedyotis crassifolia
Leavenworth's Eryngo	Eryngium leavenworthii
Lemon Monarda	Monarda citriodora
Lespedeza	Lespedeza sp.
Little Bluestem	Andropogon scoparius
Little Barley	Hordeum pussilum
Maximillian Sunflower	Helianthus maximilani

Meadow Garlic	Allium canadense
Mesquite	Prosopis juliflora
Missouri Evening Primrose	Oenothera missouriensis
Missouri Goldenrod	Solidago missouriensis
Mourning Lovegrass	Eragrostis lugens
Muhly	Muhlenbergia sp.
Nailwort	Paronychia sp.
Noseburn	Tragia ramosa
Nuttall's Astragalus	Astragalus nuttallianus
Oklahoma Penstemon	Penstemon oklahomensis
Osage Orange	Maclura pomifera
Panicled Aster	Aster simplex
Pecan	Carya illinoensis
Perennial Sunflower	Helianthus sp.
Plains coreopsis	Coreopsis tinctoria
Poccoon	Lithospermum sp.
Poison Ivy	Toxicodendron radicans
Poppymallow	Callirhoe sp.
Post Oak	Quercus stellata
Prairie Acacia	Acacia angustissima
Prairie-coneflower	Ratibida columnifera
Prairie Flax	Linum rigidum
Prairie Hymenoxys	Hymenoxys scaposa
Prairie Kuhnia	Kuhnia eupatorioides texana
Prairie Mimosa	Desmanthus leptolopus
Prairie Ragwort	Senecio plattensis
Prairie Spiderwort	Tradescantia occidentalis
Prairie Sunflower	Helianthus petioralis
Prairie Threeawn	Aristida olignatha
Prairie Verbena	Verbena bipinnatifida
Prairie Wind Flower	Anemone caroliniana
Prickly Lettuce	Lactuca scariola
Pricklypear	Opuntia compressa
Purple-Flower Ground Cherry	Physalis lobata
Purple Lovegrass	Eragrostis spectabilis
Purple Poppy Mallow	Callirhoe involuerata
Purpletop	Tridens flava
Rayless Gaillardia	Gaillardia suavis
Redbud	Cercis canadensis
Red Threeawn	Aristida longiseta
Rippleseed Plantain	Plantago major
Rough Buttonweed	Diodia teres
Rough False Pennyroyal	Hedeoma hispidum
Rough Tridens	Tridens muticus
Sagewort	Artemisia sp.
Salt Cedar	Tamarix gallica
Saltgrass	Distichlis spicata
Sand Bluestem	Andropogon hallii
Sand Dropseed	Sporobolus cryptandrus
Sand Plum	Prunus angustifolia
Scarlet Gaura	Gaura coccinea
Scribner Panicum	Panicum scribnerianum
Sedges	Carex spp.
Sensitive Briar	Shrankia nuttallii

Showy Evening Primrose	Oenothera speciosa
Sideoats Grama	Bouteloua curtipendula
Silver Bluestem	Andropogon saccharoides
Silverleaf Nightshade	Solanum elaeagnifolium
Silvery Golden Aster	Chrysopsis villosa
Sixweek Fescue	Festuca octiflora
Skunkbush Sumac	Rhus trilobata
Sleepy Catchfly	Silene antirrhina
Slender Day Flower	Commelia erecta
Small Skullcap	Scutellaria parvula
Small Soapweed	Yucca glauca
Smartweed	Polygonum sp.
Smooth-White Hymenopappus	Hymenopappus scabioseus
Southern Dewberry	Rubus trivialis
Spiderwort	Tradescantia sp.
Spreading Chervil	Chaerophyllum texanum
Spreading Pricklypear	Opuntia humifusa
Spring Beauty	Claytonia virginica
Star Violet	Hedyotis nigricans
Stickerweed	Solanum carolinense
Switchgrass	Panicum virgatum
Tall Dropseed	Sporobolus asper
Tall Grama	Bouteloua hirsuta pectinata
Texasplume	Gilia rubra
Thread-leaf Thelesperma	Thelesperma filifolium
Tickclover	Desmodium sp.
Tumble Windmillgrass	Chloris verticillata
Uniola	Uniola latifolia
Verbena	Verbena sp.
Vetch	Vicia sp.
Vine Mesquite	Panicum obtusum
Virginia Wheatgrass	Elymus virginicus
Wavyleaf Thistle	Cirsium undulatum
Western Hackberry	Celtis occidentalis
Western Ragweed	Ambrosia psilostachya
Western Wheatgrass	Andropogon smithii
Western Yarrow	Achillea lanulosa
White Astragalus	Astragalus crassicarpus
White Bladderpod	Lesquerella ovalifolia
White Heath Aster	Aster ericoides
White Top	Erigeron strigosus
White Tridens	Tridens albescens
Whitlow Grass	Draba brachycarpa
Wild Buckwheat	Erigonum racemosum
Wild Carrot	Daucus carota
Wild Oats	Avena sativa
Wildrye	Elymus sp.
Witchgrass	Panicum capillare
Woodsorrel	Oxalis sp.
Woolly Indianwheat	Plantago purshii
Wright's Plantain	Plantago wrightiana
Yellow Neptunia	Neptunia lutea
Yellow Paint Brush	Castilleja citrina
Yellow Woodsorrel	Oxalis stricta

APPENDIX D

TABLE 27. PLANT SPECIES RELATIVE FREQUENCIES IN RELATION TO BURN AGE FOR MESQUITE FREE AREAS AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age				
Species	Unburned	3-Years	2-Years	1-Year	Study Year
Little Bluestem	13.3	47.4	18.2	61.5	27.8
Hairy Grama		21.1	27.3		16.7
Star Violet		5.3	9.1		
Broomweed		5.3			11.1
Brome	66.7				5.6
Blue Grama		10.5		23.1	
Prairie Threeawn					5.6
Sideoats Grama					5.6
Buffalo Grass				7.7	
Chaetopappa				7.7	
Silver Bluestem			27.3		
Neptune			9.1		
Dotted Button Snakeroot			9.1		
Switchgrass		5.3			
Coreopsis		5.3			
Western Yarrow	6.7				
Maximillian Sunflower	13.3				
Panicum sp.					5.6
Juncus sp.					11.1
Silvery Golden Aster					5.6
Missouri Goldenrod					5.6

TABLE 28. PLANT SPECIES RELATIVE FREQUENCIES IN RELATION TO BURN AGE FOR LOW MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age			
Species	Unburned	3-Years	1-Year	Study-Year
Western Ragweed	7.7	10.0	7.7	7.1
Brome		50.0	61.5	71.4
Western Yarrow	7.7	5.0	7.7	
Gumweed	7.7			7.1
Vine Mesquite	7.7			14.3
Hairy Grama			7.7	
Prairie Threeawn	38.5			
Broomweed	15.4			
Blue Grama			7.7	
Sideoats Grama			7.7	
Dotted Button Snakeroot		10.0		
Annual Dropseed	15.4			
Johnson Grass		10.0		
Big Bluestem		5.0		
Plantago sp.		5.0		
Panicum sp.		5.0		

TABLE 29. PLANT SPECIES RELATIVE FREQUENCIES IN RELATION TO BURN AGE FOR HIGH MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age			
Species	Unburned	3-Years	2-Years	1-Year
Brome	83.3	71.4	18.2	52.9
Broomweed			9.1	11.8
Vine Mesquite	8.3	14.3		
Cyperus sp.			9.1	5.9
Prairie Threeawn			18.2	
Hairy Grama			9.1	
Blue Grama				17.6
Western Ragweed	8.3			
Silverleaf Nightshade			18.2	
Canada Wildrye			18.2	
Gumweed		7.1		
Silver Bluestem		7.1		
Panicum sp.				5.9
Mourning Lovegrass				5.9

APPENDIX E

TABLE 30. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE UNBURNED AREA WITHOUT MESQUITE ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
May	32	34.844	A
August	32	31.234	A B
July	32	28.984	B C
June	32	24.609	C
April	32	12.266	D

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=155, LSD=5.4623.

TABLE 31. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE 3-YEAR OLD BURN WITHOUT MESQUITE ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
August	40	23.688	A
July	40	21.125	B
June	40	15.688	C
May	40	12.813	D
April	40	4.188	E

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=195, LSD=2.4475.

TABLE 32. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE 2-YEAR OLD BURN WITHOUT MESQUITE ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
August	40	15.313	A
July	40	12.938	A B
May	40	11.625	B
June	40	10.625	B
April	40	4.125	C

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=195, LSD=3.4719.

TABLE 33. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE 1-YEAR OLD BURN WITHOUT MESQUITE ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
June	40	17.375	A
July	40	17.000	A
August	40	14.438	B
May	40	13.563	B
April	40	8.125	C

Means with the same grouping letter are not significantly different (P<0.05), D.F.=195, LSD=2.3481.

TABLE 34. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE STUDY-YEAR BURN WITHOUT MESQUITE ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
July	40	18.556	A
June	40	17.750	A
August	40	15.313	B
May	40	10.375	C
April	40	6.250	D

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=195, LSD=2.1978.

APPENDIX F

TABLE 35. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE UNBURNED AREA WITH A HIGH MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
May	40	44.438	A
April	40	15.750	B
June	40	12.188	C
August	40	11.813	C
July	40	9.500	C

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=195, LSD=3.0782.

TABLE 36. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE 3-YEAR OLD BURN WITH A HIGH MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
May	40	34.750	A
August	40	23.875	B
April	40	21.688	B
July	40	16.313	C
June	40	14.688	C

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=195, LSD=4.8992.

TABLE 37. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE 2-YEAR OLD BURN WITH A HIGH MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
August	40	49.250	A
July	40	47.563	A
May	40	37.125	B
June	40	35.087	B
April	40	13.125	C

Means with the same grouping letter are not significantly different (P<0.05), D.F.=195, LSD=7.6100.

TABLE 38. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE 1-YEAR OLD BURN WITH A HIGH MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
May	40	36.375	A
July	40	32.688	A
August	40	32.188	A
June	40	24.125	B
April	40	18.750	B

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=195, LSD=5.8627.

APPENDIX G

TABLE 39. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE UNBURNED AREA WITH A LOW MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
July	40	23.000	A
August	40	22.375	A
June	40	20.875	A B
May	40	18.750	B
April	40	4.875	C

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=195, LSD=2.7771.

TABLE 40. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE 3-YEAR OLD BURN WITH A LOW MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
August	40	39.750	A
July	40	39.625	A
May	40	37.875	A
June	40	35.500	A
April	40	8.938	B

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=195, LSD=4.4829.

TABLE 41. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE 1-YEAR OLD BURN WITH A LOW MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
May	40	35.063	A
June	40	30.063	B
August	40	29.875	B
July	40	28.438	B
April	40	23.125	C

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=195, LSD=4.5838.

TABLE 42. MONTHLY COMPARISON (LSD) OF ROBEL POLE READINGS FOR THE STUDY-YEAR BURN WITH A LOW MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

Month	N	Mean	Grouping
August	40	40.438	A
May	40	31.875	B
June	40	29.938	B
July	40	29.313	B
April	40	7.875	C

Means with the same grouping letter are not significantly different ($P<0.05$), D.F.=195, LSD=5.7831.

APPENDIX H

TABLE 43. ANALYSIS OF COVARIANCE (P>|T|) FOR APRIL STEM DENSITY REGESSIONS FROM MESQUITE FREE AREAS, ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age			
	Unburned	3-Years	2-Years	1-Year
3-Years	0.0232	--	--	--
2-Years	0.0011	0.3219	--	--
1-Year	0.0012	0.3364	0.9766	--
Study-Year	0.0001	0.0273	0.2235	0.2125

TABLE 44. ANALYSIS OF COVARIANCE (P>|T|) FOR MAY STEM DENSITY REGESSIONS FROM MESQUITE FREE AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age			
	Unburned	3-Years	2-Years	1-Year
3-Years	0.0001	--	--	--
2-Years	0.0001	0.1901	--	--
1-Year	0.0001	0.9020	0.1517	--
Study-Year	0.0001	0.0016	0.0649	0.0011

TABLE 45. ANALYSIS OF COVARIANCE (P>|T|) FOR JUNE STEM DENSITY REGESSIONS FROM MESQUITE FREE AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age			
	Unburned	3-Years	2-Years	1-Year
3-Years	0.0001	--	--	--
2-Years	0.0001	0.0250	--	--
1-Year	0.0001	0.9884	0.0259	--
Study-Year	0.0001	0.0147	0.8422	0.0153

TABLE 46. ANALYSIS OF COVARIANCE (P>|T|) FOR JULY STEM DENSITY REGESSIONS FROM MESQUITE FREE AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age			
	Unburned	3-Years	2-Years	1-Year
3-Years	0.0122	--	--	--
2-Years	0.0001	0.0018	--	--
1-Year	0.0024	0.5989	0.0094	--
Study-Year	0.0007	0.3842	0.0241	0.7307

TABLE 47. ANALYSIS OF COVARIANCE (P>|T|) FOR AUGUST STEM DENSITY REGESSIONS FROM MESQUITE FREE AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESRERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age			
	Unburned	3-Years	2-Years	1-Year
3-Years	0.0993	—	—	—
2-Years	0.0001	0.0022	—	—
1-Year	0.0001	0.0034	0.8977	—
Study-Year	0.0001	0.0102	0.6229	0.7164

APPENDIX I

TABLE 48. ANALYSIS OF COVARIANCE (P>|T|) FOR APRIL STEM DENSITY REGESSIONS FROM LOW MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age		
	Unburned	3-Years	1-Year
3-Years	0.0243	--	--
1-Year	0.0001	0.0001	--
Study-Year	0.0002	0.1396	0.0001

TABLE 49. ANALYSIS OF COVARIANCE (P>|T|) FOR MAY STEM DENSITY REGESSIONS FROM LOW MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age		
	Unburned	3-Years	1-Year
3-Years	0.0001	--	--
1-Year	0.0001	0.0001	--
Study-Year	0.0001	0.0354	0.1652

TABLE 50. ANALYSIS OF COVARIANCE (P>|T|) FOR JUNE STEM DENSITY REGESSIONS FROM LOW MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age		
	Unburned	3-Years	1-Year
3-Years	0.0001	--	--
1-Year	0.2051	0.0001	--
Study-Year	0.0002	0.0001	0.0225

TABLE 51. ANALYSIS OF COVARIANCE (P>|T|) FOR JULY STEM DENSITY REGESSIONS FROM LOW MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age		
	Unburned	3-Years	1-Year
3-Years	0.0001	--	--
1-Year	0.0605	0.0001	--
Study-Year	0.0101	0.0001	0.4851

TABLE 52. ANALYSIS OF COVARIANCE (P>|T|) FOR AUGUST STEM DENSITY REGESSIONS FROM LOW MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age		
	Unburned	3-Years	1-Year
3-Years	0.0001	—	—
1-Year	0.3065	0.0001	—
Study-year	0.0493	0.0001	0.3450

APPENDIX J

TABLE 53. ANALYSIS OF COVARIANCE (P>|T|) FOR APRIL STEM DENSITY REGESSIONS FROM HIGH MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age		
	Unburned	3-Years	2-Years
3-Years	0.4754	--	--
2-Years	0.0001	0.0001	--
1-Year	0.6115	0.2219	0.0001

TABLE 54. ANALYSIS OF COVARIANCE (P>|T|) FOR MAY STEM DENSITY REGESSIONS FROM HIGH MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age		
	Unburned	3-Years	2-Years
3-Years	0.0001	--	--
2-Years	0.0001	0.0003	--
1-Year	0.0001	0.6737	0.0001

TABLE 55. ANALYSIS OF COVARIANCE (P>|T|) FOR JUNE STEM DENSITY REGESSIONS FROM HIGH MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age		
	Unburned	3-Years	2-Years
3-Years	0.6977	—	—
2-Years	0.4459	0.7085	—
1-Year	0.1851	0.0866	0.0369

TABLE 56. ANALYSIS OF COVARIANCE (P>|T|) FOR JULY STEM DENSITY REGESSIONS FROM HIGH MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age		
	Unburned	3-Years	2-Years
3-Years	0.5954	—	—
2-Years	0.0002	0.0001	—
1-Year	0.0001	0.0001	0.0455

TABLE 57. ANALYSIS OF COVARIANCE . (P<|T|) FOR AUGUST STEM DENSITY REGESSIONS FROM HIGH MESQUITE DENSITY AREAS ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	Burn Age		
	Unburned	3-Years	2-Years
3-Years	0.6072	--	--
2-Years	0.0001	0.0001	--
1-Year	0.0001	0.0001	0.2710

APPENDIX K

TABLE 58. ANALYSIS OF COVARIANCE (P>|T|) FOR MONTHLY STEM DENSITY REGESSIONS OF THE UNBURNED AREA WITHOUT MESQUITE ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.0001	--	--	--
June	0.0001	0.0115	--	--
July	0.0001	0.0010	0.4374	--
August	0.0002	0.0001	0.0622	0.2758

TABLE 59. ANALYSIS OF COVARIANCE (P>|T|) FOR MONTHLY STEM DENSITY REGESSIONS FOR THE 3-YEAR OLD BURN WITHOUT MESQUITE ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.0116	--	--	--
June	0.0001	0.1162	--	--
July	0.0001	0.0066	0.2492	--
August	0.0001	0.0085	0.2837	0.9300

TABLE 60. ANALYSIS OF COVARIANCE (P>|T|) OF MONTHLY STEM DENSITY REGESSIONS FOR THE 2-YEAR OLD BURN WITHOUT MESQUITE ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.0160	--	--	--
June	0.0005	0.2797	--	--
July	0.0001	0.1518	0.7242	--
August	0.0001	0.0672	0.4526	0.6903

TABLE 61. ANALYSIS OF COVARIANCE (P>|T|) OF MONTHLY STEM DENSITY REGESSIONS FOR THE 1-YEAR OLD BURN WITHOUT MESQUITE ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.0001	--	--	--
June	0.0001	0.0765	--	--
July	0.0001	0.0099	0.4165	--
August	0.0001	0.9215	0.0616	0.0074

TABLE 62. ANALYSIS OF COVARIANCE (P>|T|) OF MONTHLY STEM DENSITY REGESSIONS FOR THE STUDY-YEAR BURN WITHOUT MESQUITE ON THE SYUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.1197	--	--	--
June	0.0001	0.0001	--	--
July	0.0001	0.0001	0.0005	--
August	0.0001	0.0001	0.1029	0.0060

APPENDIX L

TABLE 63. ANALYSIS OF COVARIANCE (P>|T|) OF MONTHLY STEM DENSITY REGESSIONS FOR THE UNBURNED AREA WITH A LOW MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.0001	--	--	--
June	0.0001	0.0001	--	--
July	0.0001	0.0001	0.6261	--
August	0.0001	0.0001	0.3758	0.6902

TABLE 64. ANALYSIS OF COVARIANCE (P>|T|) OF MONTHLY STEM DENSITY REGESSIONS FOR THE 3-YEAR OLD BURN WITH A LOW-MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.0001	--	--	--
June	0.0001	0.7467	--	--
July	0.0001	0.2724	0.1556	--
August	0.0001	0.0829	0.0398	0.5236

TABLE 65. ANALYSIS OF COVARIANCE (P>|T|) OF MONTHLY STEM DENSITY REGESSIONS FOR THE 1-YEAR OLD BURN WITH A LOW MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.1792	--	--	--
June	0.4395	0.0345	--	--
July	0.9637	0.1944	0.4130	--
August	0.6053	0.0631	0.7977	0.5739

TABLE 66. ANALYSIS OF COVARIANCE (P>|T|) OF MONTHLY STEM DENSITY REGESSIONS FOR THE STUDY-YEAR BURN WITH A LOW MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.0001	--	--	--
June	0.0001	0.0300	--	--
July	0.0001	0.1135	0.5863	--
August	0.0001	0.0344	0.2808	0.5930

APPENDIX M

TABLE 67. ANALYSIS OF COVARIANCE (P>|T|) OF MONTHLY STEM DENSITY REGESSIONS FOR THE UNBURNED AREA WITH A HIGH MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.0001	--	--	--
June	0.1982	0.0001	--	--
July	0.4408	0.0001	0.0398	--
August	0.0336	0.0001	0.0007	0.1749

TABLE 68. ANALYSIS OF COVARIANCE (P>|T|) OF MONTHLY STEM DENSITY REGESSIONS FOR THE 3-YEAR OLD BURN WITH A HIGH MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.0001	—	--	--
June	0.6478	0.0003	--	--
July	0.0249	0.0001	0.0070	--
August	0.0026	0.0001	0.0005	0.4383

TABLE 69. ANALYSIS OF COVARIANCE (P>|T|) OF MONTHLY STEM DENSITY REGESSIONS FOR THE 2-YEAR OLD BURN WITH A HIGH MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.0001	--	--	--
June	0.0001	0.7664	--	--
July	0.0001	0.0166	0.0259	--
August	0.0001	0.0749	0.1376	0.4557

TABLE 70. ANALYSIS OF COVARIANCE (P>|T|) OF MONTHLY STEM DENSITY REGESSIONS FOR THE 1-YEAR OLD BURN WITH A HIGH MESQUITE DENSITY ON THE STUDY AREA AT FT. SILL MILITARY RESERVATION, COMANCHE COUNTY, OKLAHOMA, 1985.

	MONTH			
	April	May	June	July
May	0.0001	--	--	--
June	0.0047	0.0372	--	--
July	0.0001	0.4079	0.2083	--
August	0.1809	0.0004	0.1351	0.0060

APPENDIX N

STEM DENSITY EQUATIONS

S = Number of Stems   H = Height

Burn Year	Mesquite Density	Month	Equation	R^2
Unburned	Open	April	$S=3.229-0.140(H)+0.001(H^2)$	0.71
Unburned	Open	May	$S=3.567-0.095(H)+0.001(H^2)$	0.66
Unburned	Open	June	$S=4.377-0.164(H)+0.001(H^2)$	0.80
Unburned	Open	July	$S=3.622-0.132(H)+0.001(H^2)$	0.68
Unburned	Open	August	$S=3.359-0.123(H)+0.001(H^2)$	0.72
Unburned	Low	April	$S=0.966-0.042(H)+0.0004(H^2)$	0.51
Unburned	Low	May	$S=2.025-0.081(H)+0.001(H^2)$	0.68
Unburned	Low	June	$S=2.900-0.103(H)+0.001(H^2)$	0.71
Unburned	Low	July	$S=2.831-0.095(H)+0.001(H^2)$	0.80
Unburned	Low	August	$S=3.321-0.121(H)+0.001(H^2)$	0.83
Unburned	High	April	$S=3.532-0.149(H)+0.001(H^2)$	0.66
Unburned	High	May	$S=3.842-0.069(H)+0.0002(H^2)$	0.60
Unburned	High	June	$S=4.167-0.174(H)+0.002(H^2)$	0.77
Unburned	High	July	$S=3.289-0.144(H)+0.001(H^2)$	0.64
Unburned	High	August	$S=2.189-0.092(H)+0.001(H^2)$	0.57

3-Year Old Open	April	$S=2.208-0.100(H)+0.001(H^2)$	0.33
3-Year Old Open	May	$S=3.111-0.134(H)+0.001(H^2)$	0.62
3-Year Old Open	June	$S=3.284-0.131(H)+0.001(H^2)$	0.80
3-Year Old Open	July	$S=3.213-0.117(H)+0.001(H^2)$	0.81
3-Year Old Open	August	$S=3.084-0.111(H)+0.001(H^2)$	0.85
3-Year Old Low	April	$S=2.228-0.097(H)+0.001(H^2)$	0.61
3-Year Old Low	May	$S=5.173-0.167(H)+0.001(H^2)$	0.75
3-Year Old Low	June	$S=5.435-0.180(H)+0.001(H^2)$	0.84
3-Year Old Low	July	$S=4.845-0.160(H)+0.001(H^2)$	0.82
3-Year Old Low	August	$S=4.761-0.160(H)+0.001(H^2)$	0.86
3-Year Old High	April	$S=3.703-0.153(H)+0.001(H^2)$	0.71
3-Year Old High	May	$S=3.767-0.124(H)+0.001(H^2)$	0.69
3-Year Old High	June	$S=3.615-0.144(H)+0.001(H^2)$	0.70
3-Year Old High	July	$S=2.649-0.110(H)+0.001(H^2)$	0.67
3-Year Old High	August	$S=2.142-0.087(H)+0.001(H^2)$	0.61
2-Year Old Open	April	$S=1.584-0.072(H)+0.001(H^2)$	0.46
2-Year Old Open	May	$S=2.547-0.113(H)+0.001(H^2)$	0.63
2-Year Old Open	June	$S=2.856-0.124(H)+0.001(H^2)$	0.65
2-Year Old Open	July	$S=2.742-0.115(H)+0.001(H^2)$	0.72
2-Year Old Open	August	$S=2.760-0.113(H)+0.001(H^2)$	0.77

2-Year Old High	April	$S=1.112-0.048(H)+0.0005(H^2)$	0.55
2-Year Old High	May	$S=1.915-0.052(H)+0.0004(H^2)$	0.62
2-Year Old High	June	$S=2.142-0.063(H)+0.001(H^2)$	0.70
2-Year Old High	July	$S=2.397-0.070(H)+0.001(H^2)$	0.55
2-Year Old High	August	$S=2.311-0.068(H)+0.001(H^2)$	0.61
1-Year Old Open	April	$S=1.601-0.073(H)+0.001(H^2)$	0.52
1-Year Old Open	May	$S=2.922-0.121(H)+0.001(H^2)$	0.76
1-Year Old Open	June	$S=3.216-0.127(H)+0.001(H^2)$	0.74
1-Year Old Open	July	$S=3.348-0.130(H)+0.001(H^2)$	0.85
1-Year Old Open	August	$S=2.703-0.109(H)+0.001(H^2)$	0.77
1-Year Old Low	April	$S=5.184-0.221(H)+0.002(H^2)$	0.69
1-Year Old Low	May	$S=3.180-0.089(H)+0.001(H^2)$	0.65
1-Year Old Low	June	$S=3.173-0.107(H)+0.001(H^2)$	0.65
1-Year Old Low	July	$S=3.252-0.107(H)+0.001(H^2)$	0.78
1-Year Old Low	August	$S=3.334-0.115(H)+0.001(H^2)$	0.82
1-Year Old High	April	$S=3.174-0.133(H)+0.001(H^2)$	0.60
1-Year Old High	May	$S=4.183-0.144(H)+0.001(H^2)$	0.68
1-Year Old High	June	$S=3.356-0.118(H)+0.001(H^2)$	0.68
1-Year Old High	July	$S=3.482-0.115(H)+0.001(H^2)$	0.51
1-Year Old High	August	$S=2.501-0.084(H)+0.001(H^2)$	0.53

Study-Year	Open	April	$S=0.855-0.039(H)+0.0004(H^2)$	0.43
Study-Year	Open	May	$S=1.418-0.063(H)+0.001(H^2)$	0.52
Study-Year	Open	June	$S=2.543-0.107(H)+0.001(H^2)$	0.70
Study-Year	Open	July	$S=3.332-0.132(H)+0.001(H^2)$	0.81
Study-Year	Open	August	$S=2.853-0.115(H)+0.001(H^2)$	0.80
Study-Year	Low	April	$S=3.375-0.153(H)+0.002(H^2)$	0.59
Study-Year	Low	May	$S=4.349-0.151(H)+0.001(H^2)$	0.90
Study-Year	Low	June	$S=4.086-0.145(H)+0.001(H^2)$	0.86
Study-Year	Low	July	$S=3.645-0.125(H)+0.001(H^2)$	0.77
Study-Year	Low	August	$S=3.523-0.123(H)+0.001(H^2)$	0.70

VITA 2

John Allen Ratzlaff

Candidate for the Degree of

Master of Science

Thesis: THE EFFECTS OF EARLY SPRING BURNING AND MESQUITE DENSITY ON PLANT SPECIES COMPOSITION, BIOMASS, AND STEM DENSITY IN HARDLAND RANGE.

Major Field: Wildlife Ecology

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma, September 24, 1959, the son of Bennie Lee and Nancy Sue Ratzlaff.

Education: Graduated from John Marshall High School, Oklahoma City, Oklahoma, in May, 1977; received Bachelor of Science Degree in Wildlife Ecology and Zoology from Oklahoma State University, in May, 1981; completed the requirements for the Master of Science degree from Oklahoma State University, in December, 1987.

Professional Experience: Teaching Assistant, Department of Botany, Oklahoma State University, January, 1981, to May, 1981; Fisheries Extension Agent, U.S. Peace Corps, Tanzania, East Africa, August, 1981, to March, 1983; Teaching Assistant, Department of Zoology, Oklahoma State University, January, 1984, to December, 1985; Research Assistant, Oklahoma State University, January, 1985, to August, 1985; Teaching Assistant, Oklahoma State University, August, 1985, to May, 1986; Research Assistant, Oklahoma State University, June, 1986, to August, 1986, Teaching Assistant, Oklahoma State University, August, 1986, to December, 1986; Endangered Species Biologist, U.S. Fish and Wildlife Service, Albuquerque, New Mexico, February, 1987, to present.