THE EFFECTS OF PRESCRIBED BURNING ON BROWSE, FORBS AND MAST IN A TEXAS LIVE OAK SAVANNAH

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Abstract: An isolated area of approximately 2,025 ha of live oak (*Quercus virginiana*) savannah was experimentally burned during a 2 year study on the Texas Coastal Plain. Two fall burns (October 1974 and 1975) and a spring burn (March 1975) were conducted, one on each of 3 separate areas of approximately equal size. Increased vegetative production on fall-burned areas was primarily due to a positive response of forbs. Grass production was increased only on the spring-burned area druing the second year postburn. Live oak rootcrown resprouts, following topkill, on all burned areas resulted in significant ($P < 0.05$) increases in the density of stems. However, live oak topgrowth production was significantly ($P < 0.05$) increased only on the spring-burned area. Mast production was lower on live oak regrowth in the fall-burned areas than on small, unburned live oak brush. Mast production on live oak regrowth in the spring-burned area was virtually non-existent during the first year postburn. Nutritive quality of browse generally was improved for both years following burning. Crude protein levels were significantly ($P < 0.1$) higher on the burned area throughout the first year postburn, but not the second year. Calcium:phosphorus ratios in browse were improved by burning in the first year postburn generally because of significantly ($P < 0.1$) higher phosphorus level. Calcium levels generally were not significantly ($P > 0.1$) different. There were no significant ($P > 0.1$) differences in crude protein, calcium, and phosphorus levels in forbs from the burned and unburned areas.

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Grasslands, forests, and fire share an intimate association through time as far back as man can determine (Leopold 1924, Humphrey 1953, Phillips 1962, Stewart 1976). Both natural and man-made fires have been important ecologically and man's part in burning is probably one of the oldest intentional wildlife management practices known.

Burning is not a panacea for all land management problems (Bonninghausen 1962, Isaac 1963, Wright 1974, Heady 1975) and if done at the wrong time of year or under extremely dry conditions, the results are usually detrimental to the ecosystem. Management of range and brushlands for the purpose of a highly productive state has been the primary goal of ranchers and range managers since the introduction of domestic stock (Odum et al. 1973, Komarek 1974, Heady 1975). Manipulation of plant succession to maintain appropriate seral stages is also the primary technique of wildlife management (Odum et al. 1973, Nelson 1974).

Prescribed burning, when followed by a growing season of adequate moisture, usually increases species diversity and net production, and improves the palatability of vegetation (Duvall 192, Kucera and Ehrenreich 1962, Gibbens and Schultz 1963, Launchbaugh 194, Leege 1969). Higher nutrient content and overall improved nutritional quality of forage often are attributed to burning (Lay 1957, Vlamis and Gowan 1961, Vallentine 1974, Hallisey and Wood 1976).

The overall objective for this study was to investigate the effects of prescribed burning on production and nutritional quality of deer foods in a live oak savannah.

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STUDY AREA

The area selected for this study was the Aransas National Wildlife Refuge, (Aransas County) situated in the Coastal prairies and Marches region of Texas (Thomas 1962). The area is a brush-infested live oak savannah as described by Dyksterhuis (1957) with scattered mottes of large trees dominated by live oak (Halloran 1943, White 1967, Springer 1975). The major portion of the refuge is a 21,862 ha peninsula, surrounded by St.

Charles and San Antonio Bays. The study area consisted of 2 areas: 2,000 ha which remained unburned and approximately 2,025 ha on which 3 prescribed burns were conducted. The burned area was arbitrarily divided into 3 approximately equal areas. The The fall-75-burned area was burned on 17 October 1974, the spring-75-burned area on 18 March 1975 and the fall-75-burned area on 14 October 1975.

METHODS

Pretreatment analysis of the vegetation on the burned and unburned areas was conducted in 1974 to determine the similarities in plant composition. Fire breaks, approximately 10 m wide, were cleared of vegetation and disked prior to burning. All burning activities were implemented and coordinated by refuge personnel. Burns were conducted during periods with moderate winds and high soil moisture to allow top kill of standing vegetation without excessive heating of the soil, observing precautions outlined by Bonninghausen (1962), Cooper (1963) and Wright (1974). All headfires were allowed to progress without interference, and no attempt was made to burn areas which did not ignite along the fire front. Approximately 20 percent of both fall-burned areas and 35-40 percent of the spring-75-burned area did not burn, primarily because of extensive stands of large trees and very dense brush with little herbaceous understory as fuel.

A minimum of 50 randomly located 0.125 m^2 plots were clipped seasonally in the unburned area and in each of the burned areas beginning approximately 30 days after burning. All current year's growth of vegetation was clipped 2 cm above ground level, separated by species, oven dried, and weighed to the nearest gram. Current year's production of grasses, forbs, and woody regrowth was determined on the burned areas and compared to current year's growth on the unburned area. Mast production was determined on live oak regrowth on the burned areas, and compared to mast production on live oak brush ($<$ 1 m in height) of the unburned area. Acorns were counted on all live oak stems in randomsly-selected m^2 plots.

The 10 most common deer foods identified from rumen analysis of previous seasonal deer collections were sampled from the unburned, fall-74-burned, and fall-75-burned areas during 1976. Plant foods were collected by taking the terminal 4 to 8 cm of the growing tip of browse foods and large forbs and the entire plant of small, low growing forbs and grasses. A 10 g sample of each food species was collected from several plants. Plant samples were oven dried at 75-80 C for 48 hours, ground in a Wiley mill using a 40-mesh screen and stored in paper envelopes for chemical analysis of crude protein, calcium, and phosphorus content. Each sample was again oven dried for 24 hrs immediately prior to taking subsamples for determinations. Protein content was estimated using a modified micro-kjeldahl determination (Horwitz 1975). Calcium and phosphorus determinations were made with a Spectronic 70 spectrophotometer following the technique outlined by Hall and Hacskaylo (1963).

RESULTS

Pre-burn Vegetation

Burned and unburned areas were similar in plant community composition prior to burning. Ninety percent of the most common species (density $>$ 1 stem/m^2) on the unburned area were also present in comparable numbers on the burned area. Thirty-two species of plants were recorded on the unburned area, 19 of which had a density $>$ 1 stem/m^2. Twenty-nine species of plants were recorded on the burned area, 17 of which had a density $>$ 1 stem/m^2.

Post-burn Vegetation

During the spring and summer of 1975, forb production on the fall-74-burned area was over 700 kg/ha, which was 11 times higher than forb production on the unburned area (Table 1), however, sample size was insufficient for statistical evaluation. Forb production on the fall-74-burned area remained significantly ($P < 0.05$) higher than on the unburned area during the fall and winter of 1975. An average of over 90 kg/ha was produced compared to an average of 4 kg/ha on the unburned area. There was no significant ($P > 0.05$) difference in forb production between the fall-74-burned area and the unburned area during the spring of 1976. The fall-74-burned area produced 371 kg/ha, as compared to 118 kg/ha on the unburned area during the summer of 1976.

A much higher species diversity was maintained on the fall-74-burned area during 1975 and 1976. An average of 12 species was recorded on sampled plots as compared to an average of 4 on the unburned area. Forb production in the spring-75-burned area was not significantly ($P > 0.05$) different from that of the unburned area although a trend towards higher production was evident in all seasons except spring (Table 1). On this burn, forb production was never as high as it was on the fall-74-burned area. Species diversity of forbs on the spring-75-burned area was not as great as that found on the fall-74-burned area, but generally more species occurred there than on the unburned area.

While the sampling period for the fall-75-burned area was much shorter than for the fall-74-burned area, the trend for a significantly ($P < 0.05$) higher forb production during the first post-burn year was evident during the spring and summer sampling periods of 1976 (Table 1). Forb production on both the fall-74-burned area and the fall-75-burned area were significantly ($P < 0.05$) higher than the unburned area in the summer of 1976. Only the fall-75-burned area was significantly ($P < 0.05$) higher in forb production during the spring, producing 6 times as much as the unburned area.

Table 1. Index of production (oven-dried weight) based on standing live biomass, and diversity of forbs and grasses of the thicketized live oak savannah on the burned and unburned areas, Aransas National Wildlife Refuge, 1975 and 1976. Means at each sample date followed by same letter are not siginficantly ($P > 0.05$) different based on Duncans multiple range tests.

		Standing live biomass			
		Forbs		*Grasses*	
Sample date	*Area*	*No. Spp.*	*kg/ha*	*No. Spp.*	*kg/ha*
Spring 1975[a] (April)	Unburned	8	63	—	1416 a
	Fall-74 burn	14	745	—	601 b
	Spring-75 burn	9	45	—	276 b
Summer 1975[a] (July)	Unburned	2	58	7	1496 a
	Fall-74 burn	12	679	12	2077 a
	Spring-75 burn	11	223	13	1802 a
Fall 1975 (November)	Unburned	3	5 a	—	2062 a
	Fall-74 burn	12	118 b	—	1650 a
	Spring-75 burn	11	58 ab	—	1231 a
Winter 1975-76 (February)	Unburned	2	3 a	6	22 a
	Fall-74 burn	11	70 b	4	315 ab
	Spring-75 burn	6	28 a	6	544 b
	Fall-75 burn	10	44 ab	5	126 a
Spring 1976 (April)	Unburned	5	103 a	4	1137 a
	Fall-74 burn	12	126 a	5	979 a
	Spring-75 burn	8	70 a	8	893 a
	Fall-75 burn	15	420 b	14	388 a
Summer 1976 (July)	Unburned	2	118 a	8	1588 a
	Fall-74 burn	17	371 b	9	2061 ab
	Spring-75 burn	11	227 ab	8	2422 b
	Fall-75 burn	15	658 c	7	1070 a

[a]Insufficient sample size for statistical analysis of forb production.

Grass production on the burned areas was generally less than that on the unburned area in the spring of both years (Table 1). This decrease in grass production was significant ($P < 0.05$) in the spring of 1975, and while not significant ($P > 0.05$) in 1976, the trend was evident. Grass production on the fall-74-burned and fall-75-burned areas was not significantly ($P > 0.05$) different from the unburned area in all other seasons. Compared with the unburned area, the spring-75-burned area did have a significantly ($P < 0.05$) higher grass production in the winter of 1975-76 and in the summer of 1976. There was a general trend for greater diversity in grasses on the burned than on unburned areas.

Current-year live oak topgrowth production was not significantly ($P > 0.05$) different on the fall-74-burned and fall-75-burned areas when compared to the unburned area (Table 2). The spring-75-burned area, however, produced a significantly ($P < 0.05$)

Table 2. Density, height, and production (current year's growth) of live oak on thicketized live oak savannah of the burned and unburned areas on the Aransas National Wildlife Refuge, 1975 and 1976. Means at each evaluation date followed by same letter are not significantly ($P > 0.05$) different based on Duncans multiple range tests.

	Evaluation Date					
	Pre-burn	*Spring 75*	*Winter 75-76*	*Spring 76*	*Summer 76*	*Winter 76-77*
			Height (cm)			
Unburned	—	47 a	45 a	42 a	41 a	39 a
Fall-74 burn	—	17 b	16 c	18 c	23 b	—
Spring-75 burn	—	8 c	23 b	28 b	30 ab	24
Fall-75 burn	—	—	4 d	12 c	16 c	17 b
			Density (stems/ha X 1000)			
Unburned	100 a	—	128 a	80 a	100 a	84 a
Fall-74 burn	68 a	—	170 ab	209 b	154 ab	—
Spring-75 burn	112 a	—	337 c	377 bc	292 b	309 ba
Fall-75 burn	276 b	—	257 bc	440 c	267 b	646 c
			Current year herbage production[a] (kg/ha)			
Unburned	—	—	—	61 a	215 a	286 a
Fall-74 burn	—	—	—	49 a	263 a	—
Spring-75 burn	—	—	—	216 b	566 b	1953 b
Fall-75 burn	—	—	—	108 a	118 a	.516 ab
			Current year acorn production (acorns/m^2)			
Unburned	—	—	5.24	—	3.08	—
Fall-74 burn	—	—	0.76	—	1.04	—
Spring-75 burn	—	—	0.00	—	1.32	—
Fall-75 burn	—	—	—	—	0.32	—

[a]Based on oven-dry weight

greater amount of live oak topgrowth than either the fall burns or the unburned area. There was a significant ($P < 0.05$) decrease in stem height for all burned area which lasted for the entire study period. Compared to pre-burn levels, there was an average 245 percent increase in live oak stem densities on all burned areas by the end of the study period. No increase in stem densities was detected on the unburned areas.

The spring-75-burned area produced no acorns on live oak regrowth during 1975. This area, however, produced a crop of acorns in 1976 that compared well with the 1976 crop on the fall-74-burned area. Insufficient samples were taken to estimate total acorn production, but a comparative reduction was evident on all burned areas during the first post-burn year, with an increase in production occurring the subseqeuent year.

While the large motte vegetation type generally did not burn, the composition of this type was sampled in order to estimate the density and composition of woody species. American beautyberry (*Callicarpa americana*), yaupon (*Ilex vomitoria*), greenbrier (*Smilax* spp.) and live oak were the predominant woody species found in this type.

NUTRITIONAL QUALITY

Mean crude protein levels determined from the same 4 browse species (live oak, greenbrier, yaupon, and American beautyberry) and the same 4 forb species (verbena (*Verbena halei*), spadeleaf (*Centella asiatica*), western ragweed (*Ambrosia psilostachya*), and plantain (*Plantago hookeriana*) collected on the fall-75-burned area and unburned area showed a marked difference in their response to burning during February through May 1976 (Fig. 1). The mean crude protein levels of browse on the burned area were significantly ($P < 0.1$) higher than those from the unburned areas on every sample date except March. Forbs showed a trend for higher protein on the unburned area (Fig. 1), but due to high variability, there was no significant ($P > 0.1$) difference.

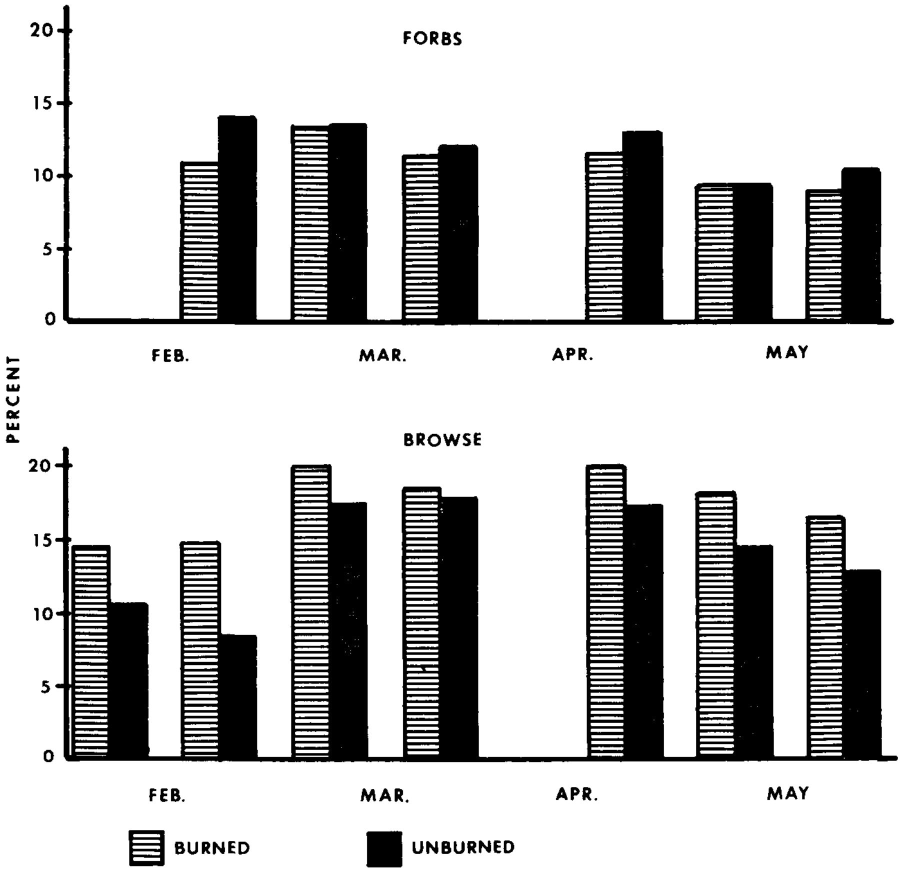

Fig. 1. Mean crude protein levels (percent dry weight) in 4 species each, of browse and forbs, collected from February through May on the fall-75-burned and unburned areas on the Aransas National Wildlife Refuge.

Protein levels in the same food samples on the fall-74-burned area were not significantly ($P > 0.1$) different from those on the unburned area, although a trend for the slightly higher protein levels in browse plants was noted on the burned area.

There was a high negative correlation ($r = -0.9$) between maturity (time) and protein levels in the browse plants sampled on the fall-75-burned and unburned areas (Fig. 2). Browse protein levels were highest at the onset of spring growth (March) ranging from means of 20 percent on the burned to 18 percent on the unburned area. By the end of the year (December), protein levels had decreased to approximately 6 to 7 percent, remaining slightly higher on the burned area. The low levels of December were maintained throughout January and February until spring growth was initiated. Based on homogenity of regression test, the decline in protein in the browse plants on the burned and unburned areas progressed at approximately the same rate.

Forbs responded to burning differently than browse (Fig. 3). Because of the relatively short growth period for most forbs, it generally was not possible to sample new growth of the same 4 species for more than a 3 month period. Consequently, new species were constantly replacing old ones on successive sample dates. The same species were sampled on the burned and unburned areas at each collection period. Protein levels in forbs generally were lower than those of browse species, with means ranging from a high of almost 14 percent in the early spring to a low of less than 8 percent at maturity. There was on significant ($P > 0.1$) difference in protein levels from the burned and unburned areas.

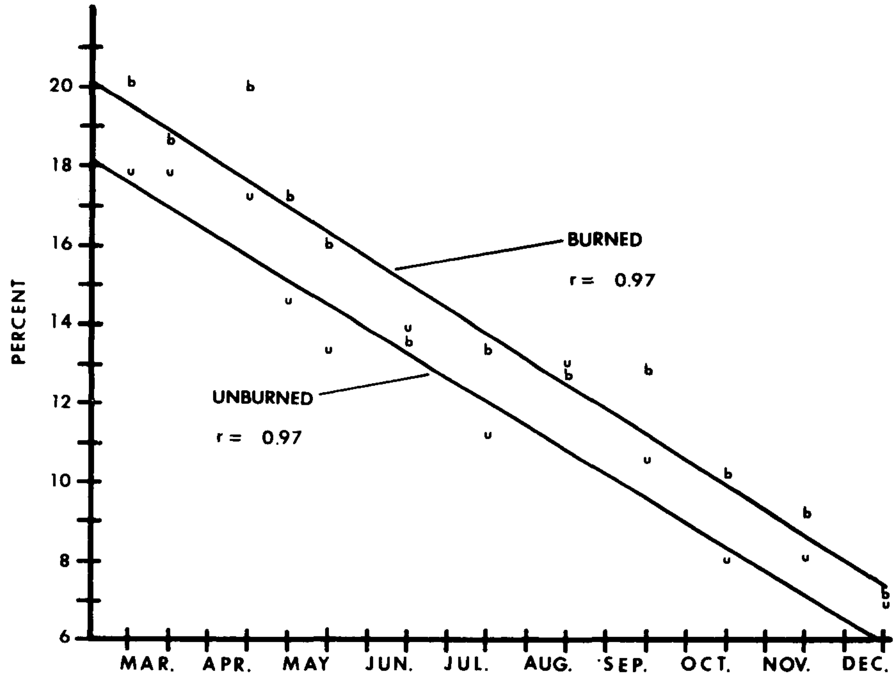

Fig. 2. Percent crude protein (dry weight) in browse from the fall-75-burned and unburned areas, based on mean levels of 4 species sampled from March to December 1976 on the Aransas National Wildlife Refuge. (b = burned data, u = unburned data).

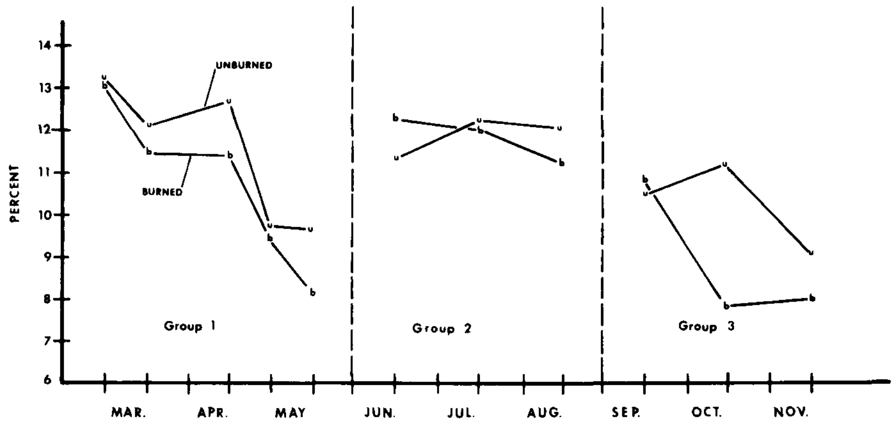

Fig. 3. Percent crude protein (dry weight) in 3 groups of forbs from the fall-75-burned and unburned areas, based on mean levels of 4 species (each group) sampled from March to November 1976 on the Aransas National Wildlife Refuge.

Group 1 = *Verbena halei, Centella asiatica, Ambrosia psilostachya, Plantago sp.*

Group 2 — *Centella asiatica, Ambrosia psilostachya, Cassia fasciculata, Commelina erecta.*

Group 3 = *Centella asiatica, Ambrosia psilostachya, Cassia fasciculata, Rhynchosia americana.*

There was no significant ($P > 0.1$) difference in calcium levels in browse or forbs from the fall -74-burned, fall-75-burned and unburned areas during 1975. Levels of calcium in browse species were highly variable throughout the year with a trend for increase during April through August (Fig. 4). Calcium levels varied from lows of 0.3 to 0.4 percent during April and May to highs of 0.7 to 0.9 percent in August and October. Winter levels remained within the range of 0.6 to 0.9 percent on both burned and unburned areas.

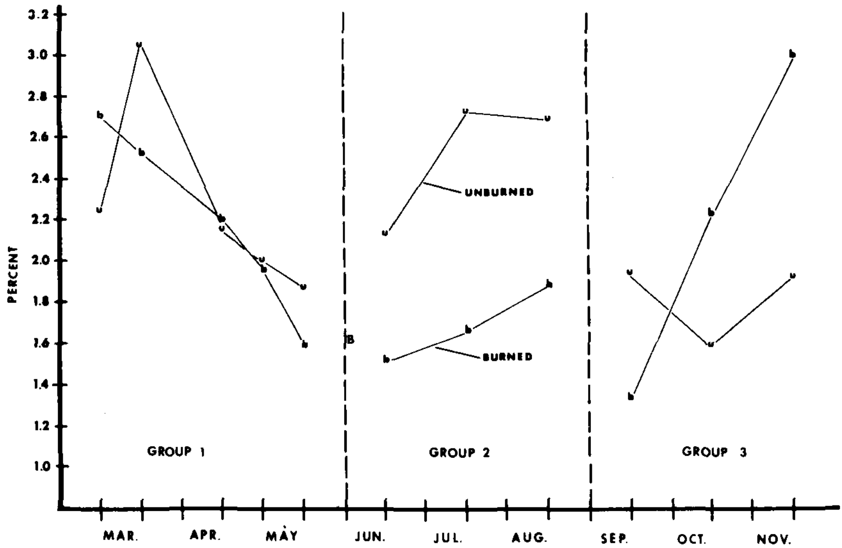

Fig. 4. Percent calcium (dry weight) in browse from the fall-75-burned and unburned areas, based on mean levels of 4 species sampled from March to November 1976 on the Aransas National Wildlife Refuge.

Levels of calcium were generally much higher in forbs than in browse species. Calcium levels in forbs generally varied from 1.3 to 3.0 percent during the year, with no significant (P > 0.1) difference between fall-74-burned, fall-75-burned, and unburned areas during 1976. Percentages of calcium in forbs of Group 1 from the fall-75-burned and unburned areas during March through May showed a tendency to decrease with maturity (Fig. 5) with the exception of the second sample date. Mean calcium level in

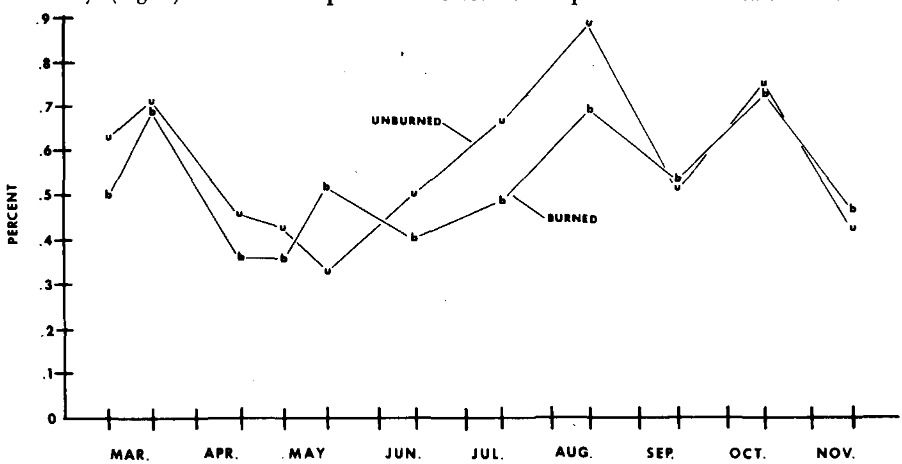

Fig. 5. Percent calcium (dry weight) in forbs from the fall-75-burned and unburned areas, based on mean levels of 4 species sampled from March to November 1976 on the Aransas National Wildlife Refuge. (See Fig. 3 for groups).

forbs from the unburned area was higher due to an extremely high level (4.2%) in ragweed. Group 2 forbs showed a much higher level of calcium on the unburned area. Group 2 and Group 3 forbs showed a general trend for increasing calcium levels with maturity on both areas. Winter levels remained high (2.5 to 3.0%) through January and February.

Mean phosphorus levels in the 4 species of browse plants sampled on the fall-75-burned and unburned areas were negatively correlated with maturity (time) (Fig. 6).

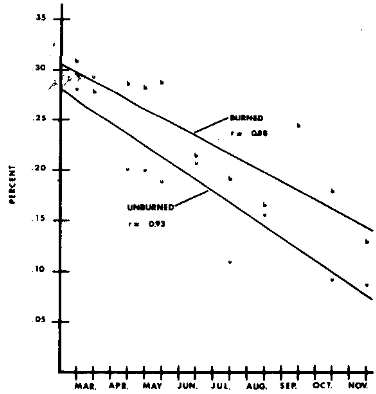

Fig. 6. Percent phosphorus (dry weight) in browse from the fall-75-burned and unburned areas, based on mean levels of 4 species sampled from March to December 1976 on the Aransas National Wildlife Refuge. (b = burned data, u = unburned data).

According to homogenity of regression tests, the rate of decrease in phosphorus content was approximately the same on both sides. A significantly ($P < 0.1$) higher mean phosphorus level was noted in browse plants from the fall-75-burned area. Levels varied from 0.06 to 0.29 percent in browse plants on the unburned area, and from 0.12 to 0.32 percent on the fall-75-burned area. Winter levels remained between 0.06 and 0.08 percent on the unburned area, and between 0.12 and 0.13 percent on the fall-75-burned area. There was no significant ($P > 0.1$) difference in phosphorus levels in browse or forbs from the fall-74-burned and the unburned area during 1976.

Mean phosphorus levels, in the same 3 groups of forbs tested for protein and calcium, decreased with maturity; however, levels from the unburned area were slightly higher (Fig. 7). Mean phosphorus levels in forbs were erratic and varied from 0.09 to 0.25 percent. Winter levels were generally low, ranging from 0.0 to 0.15 percent with no detectable difference between burned and unburned areas.

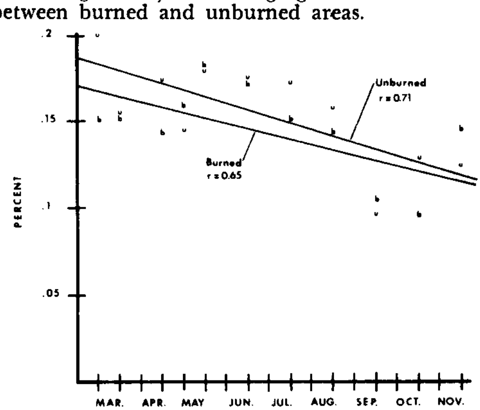

Fig. 7. Percent phosphorus (dry weight) in forbs from the fall-75-burned and unburned areas, based on mean levels of 4 species sampled from March to November 1976 on the Aransas National Wildlife Refuge. (b = burned data, u = unburned data).

The calcium to phosphorus ratio found in browse species from the burned area was generally lower (1.3:1-4.4:1) than on the unburned area (2.0:1-8.6:1) (Table 3). Calcium to phosphorus ratios in forbs generally were much higher and displayed a high degree of variability (Table 3). Ratios from the burned area ranged from 9:1 to 26:1, compared to a range of 11:1 to 21:1 on the unburned area.

Table 3. Calcium to phosphorus ratios based on mean levels of calcium and phosphorus in four species of browse and four species of forbs sampled on the burned (fall-75 burn) and unburned areas of the Aransas National Wildlife Refuge, 1976.

	Calcium: Phosphorus ratio			
	Browse		*Forbs*	
Sample date	*Burned*	*Unburned*	*Burned*	*Unburned*
February	2.8:1	4.9:1	21:1	11:1
March	2.1:1	2.4:1	17:1	15:1
April	1.3:1	2.3:1	16:1	13:1
May	1.6:1	2.0:1	12:1	12:1
June	1.8:1	2.3:1	9:1	12:1
July	2.6:1	5.9:1	11:1	16:1
August	4.3:1	5.6:1	12:1	17:1
September	2.1:1	4.6:1	13:1	21:1
October	4.4:1	8.6:1	26:1	12:1
November	3.6:1	5.2:1	22:1	16:1

DISCUSSION

A trend for increased production in live oak on burned areas was evident, at least during the first year postburn. An increase in forb production was unquestionable, and up to a 6-fold increase was statistically supported. The fall burns seemed better suited for deer food production. Both fall burns resulted in much more forb topgrowth than did the spring burn and did not reduce mast production as severely. Virtually no acorns or grapes were produced in the portions of the spring-75-burned area which was burned during the flowering period for oaks and grapes. It was apparent that production of other browse species such as yaupon and greenbrier was increased by fall and spring burns. Spring burns (late March and April) also were considered to have possible detrimental effects on nesting birds, small mammals, and deer fawns. Fawns have been reported as early as late March on the Refuge.

The increased palatability and digestibility of new growth in plants is well documented (Bissell et al. 1955, Blair and Halls 1968, Torgerson and Pfander 1971.) Blair and Halls (1968) also reported that the quality of forage in several southern browse species was directly related to their rate of growth. Findings in this study showed live oak resprouts on burned areas grew at an accelerated rate during the first year after burning. It is likely that digestibility and palatability also were improved by burning.

While the diversity and abundance of forbs was increased by burning, especially fall burns, it is questionable that any improvement in the nutritive quality of these plants was caused by burning. The lower protein and phosphorus levels common to forbs growing on the burned area is similar to phenomena reported for grasses growing in open aeas (Laycock and Price 1970). Plants such as grasses and annual forbs, normally shallow rooted plants, were subjected to varying levels of stress due to the relatively rapid changes of water and nutrient availability, and temperature in the surface soils of burned areas. A more stable condition existed on the unburned areas with adequate layers of litter and mulch, and less competition. Plants with deeper and more extensive root systems would be less likely to respond to short term changes in water and nutrient availability, but could benefit from the higher soil temperature and increased nutrient levels carried deeper into the soil by percolating water. This hypothesis could explain the differential response of browse and forb quality on the burned and unburned areas.

Other studies have reported the fertilizing effect of burning (Ahlgren 1963, Hallisey and Wood 1976). The beneficial effects of fertilizer application to palatability and digestibility of browse, forbs, and grasses was reported by Longhurst et al. (1968). Whether the improved palatability of foods on burned areas results from the fertilizing efftcs of burning or the accelerated growth rate remains an objective for other researchers. It is apparent, however, that burning on the Aransas Refuge increased the availability (and probably the palatability) of forbs and browse, and the nutritive content of browse.

In view of this, it stands to reason that burning on the Refuge should improve the carrying capacity of the area with better quality forage. The reduced mast production in live oak bush is not a severe problem in the temperate southern coastal plain, especially when sufficient numbers of large trees in the mottes are unburned.

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