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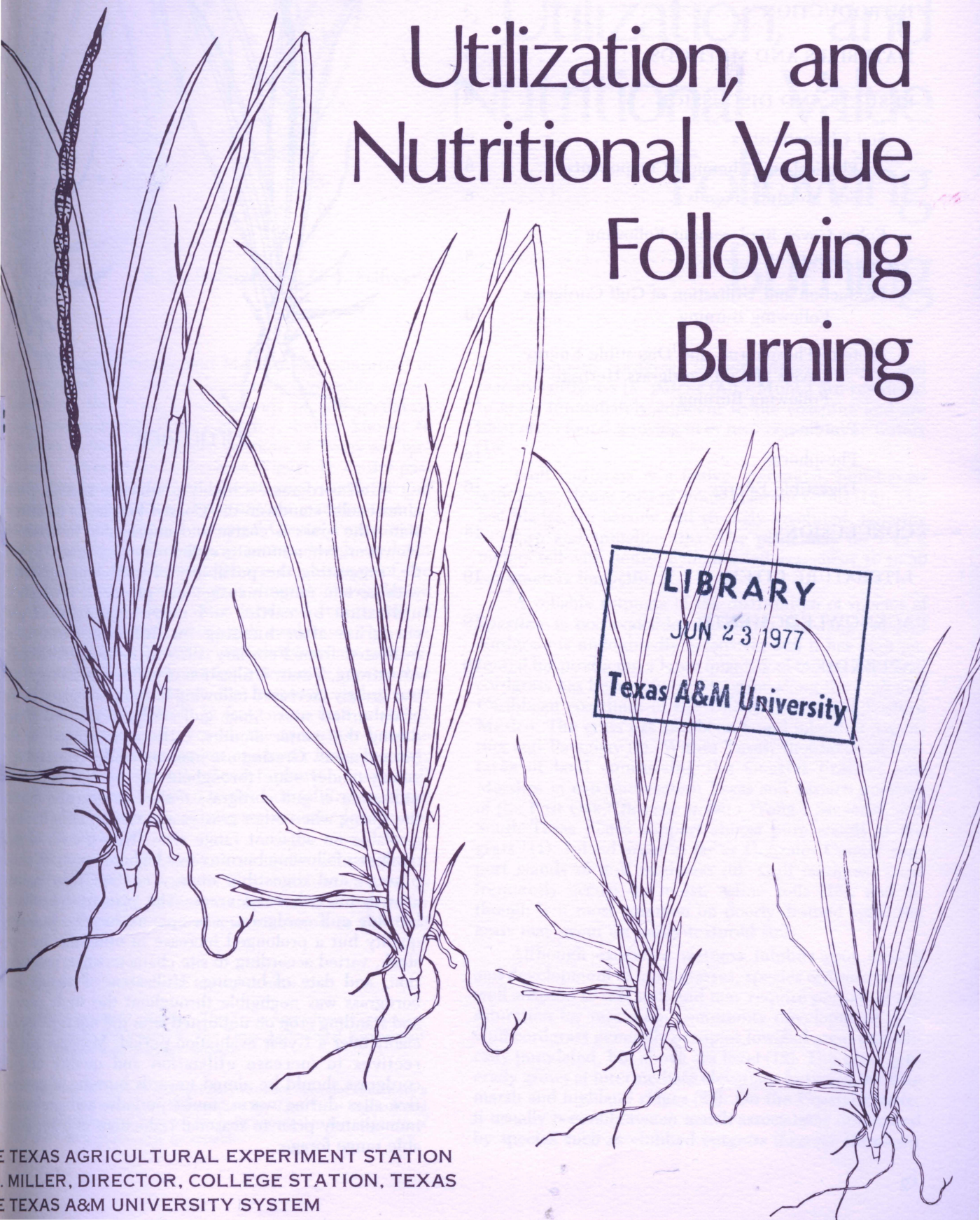
Gulf Cordgrass Production, Utilization, and Nutritional Value Following Burning



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Contents

Summary

Gulf cordgrass, a highly productive species, forms almost solid stands on the Coastal Prairie. In its mature state, the grass is coarse and unpalatable to livestock. However, when immature, the plants are grazed by cattle, suggesting the possibility of improving utilization with certain range management practices. Production, utilization by cattle, and nutritional value of gulf cordgrass after burning on different dates were evaluated from February 1975 to February 1976 near Armstrong, Texas. Utilization of gulf cordgrass regrowth was greatly increased following burning compared to use of unburned sites. Since gulf cordgrass afforded forage during the winter months, cattle concentrated on the burned areas. Grazing use maintained the regrowth in a young tender state throughout the winter. However, utilization of gulf cordgrass tended to decrease during the spring when other grasses and various forbs became available on adjacent range sites. New growth of gulf cordgrass following burning was higher in protein, phosphorus, and digestible energy content than mature growth on unburned areas. The primary benefits of burning gulf cordgrass, a temporary increase in forage quality but a prolonged increase in utilization by livestock, varied according to site characteristics, precipitation, and date of burning. Utilization of mature gulf cordgrass was negligible throughout the study period and standing crop on unburned sites did not vary appreciably over a 1-year evaluation period. Management directives to increase utilization and quality of gulf cordgrass should be aimed towards burning of productive sites during warm, moist periods, and preferably immediately prior to seasonal reductions of other available range forage.

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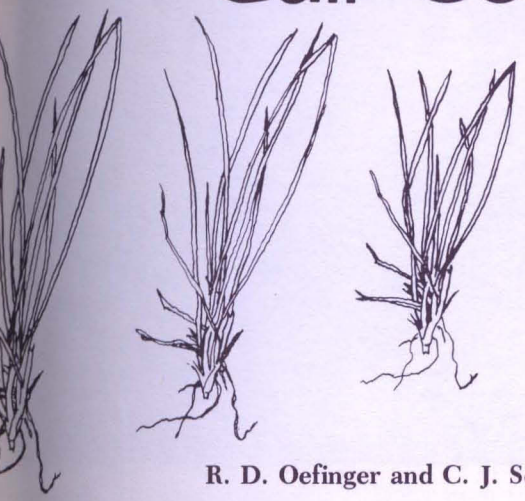

R. D. Oefinger and C. J. Scifres*

The Coastal Prairie and Marshes are comprised of approximately 3.8 million hectares[1] of valuable rangeland along the Texas Coast. Stands of gulf cordgrass [*Spartina spartinae* (Trin.) Hitch.], better known to ranchers in the southeastern portions of Texas as "sacahuista," are common in this area (Figure 1). Entire pastures may be occupied by almost pure stands of gulf cordgrass. Such pastures have unique management requirements as contrasted to typical Coastal Prairie since mature gulf cordgrass forage is coarse, tough, and not readily grazed by livestock. However, because of the plant's dominance of certain sites almost to the exclusion of other species, there is often localized overgrazing of adjacent sites not supporting gulf cordgrass. The sites most commonly occupied by gulf cordgrass are periodically inundated and support few alternative species that produce acceptable forage for livestock under such environmental conditions. In fact, when mature stands of gulf cordgrass are destroyed, the areas may become revegetated with other species of a lesser forage quality, particularly certain salt-tolerant plants. Since gulf cordgrass is so well adapted to the Coastal Prairie, more effective management techniques are needed to optimize its utilization.

Three species of *Spartina* commonly occur in Texas, but only gulf cordgrass occurs in such extensive areas as to be of substantial economic importance as forage for livestock. The other two species common to the Gulf Coast, smooth cordgrass (*S. alterniflora* Loisel.) and marshy cordgrass [*S. patens* (Ait.) Muhl.] are restricted to areas immediately adjacent to the coastline and are most often found growing in or near coastal saline waters (16).

Gulf cordgrass is a native, perennial, bunchgrass with large, dense tufts of stout, glabrous culms (12). The leaf blades are narrow and strongly involuted, tapering to sharp and spinelike tips. The plant may be 1 to 2 meters tall with dense, cylindric inflorescences 10 to 30 centimeters long (16).

A reliable estimate of the distribution of species of *Spartina* is not available. However, the range of gulf cordgrass is undoubtedly extensive, and it has high potential for producing a large quantity of forage (28). Gulf cordgrass has been reported to grow along the Gulf and Caribbean coastlines of the United States and Eastern Mexico. The grass has also been found inland in Argentina and Paraguay (6). Within Texas, thousands of hectares of land comprising the Coastal Prairies and Marshes in extreme eastern Texas and eastern portions of the Post Oak (*Quercus stellata* Wang.) Savannah and South Texas Plains support almost pure stands of the grass (11). Inland areas as far as Gonzales County support stands of gulf cordgrass (6). Gulf cordgrass most frequently occurs on moist, saline soils (13), and although is it most common on poorly-drained soils, the grass may occur on sandy-textured soils.

Although excessive wetness inhibits root growth and development of most grasses, species of *Spartina* are well adapted to wet soils and may require periods of soil saturation for maximum community development (10). Gulf cordgrass generally occupies lowland areas periodically inundated, but above sea level (12). The grass generally grows at intermediate elevations between the true marsh and highland ridges (25). On the Coastal Prairie, it usually occurs between marsh associations dominated by species such as clubbed cutgrass (*Leersia Hexandra*

[1]See appendix to convert metric to English units.

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Figure 1. Gulf cordgrass, coarse and unpalatable in the mature state, dominates large areas of the Coastal Prairie to the exclusion of other range forage species.

Swartz.), cattail (*Typha* sp.) and upland "chaparral" or mixed brush.[2] With continued disturbance of gulf cordgrass communities, seashore saltgrass (*Distichlis spicata* Greene) and other salt-tolerant species may invade the drier sites (1). These invaders are less productive than gulf cordgrass and are not desirable livestock forages.

Salinity is one of the major limiting factors in agriculture (32). Species of *Spartina* are evidently adapted to high salt spray concentrations. Daily spray applications of salt water to foliage of cordgrass had no apparent adverse effects on plant growth (21). Evidently, herbage of species of *Spartina* possess thick cuticular layers allowing the plant to tolerate salt spray. Gulf cordgrass grows abundantly where soil salinities range from about 0.6 to 2.1 percent and the water table is from 10 to 20 centimeters below the ground surface. Where soil salinity is slightly less than 1 percent, gulf cordgrass may grow in water 2 to 3 centimeters deep (1). The apparent adaptability of gulf cordgrass to saline environments characterizes the grass as a halophyte.

Gulf cordgrass is one of the most important grasses of salt marsh succession and is almost always used as a forage for livestock (1). Although the grass rates only fair as range forage, apparently due to the coarse, tough nature of the mature herbage, cattle may be forced to consume the mature plants when other rangeland vegetation has been severely overgrazed.

As a result of his many activities, which include periodic burning of wetland areas, man, of all biotic factors, has the greatest influence on the marshland ecosystem (23). Growth characteristics of gulf cordgrass give rise to its apparent adaptability to fire. Regrowth following burning progresses rapidly, thus quickly rendering succulent regrowth acceptable as forage to domestic grazing animals (6). Young regrowth is typically lower in lignin and fiber content than mature grass shoots and, therefore, is more tender and succulent (19). In addition, gulf cordgrass only rarely produces a heavy seed crop if left undisturbed. However, the grass may readily flower, sometimes in abnormal numbers, the first or second season after burning (9). Prescribed burning, therefore, has apparent potential for improvement of gulf cordgrass range.

The increased attraction of grazing animals for vegetative regrowth following a fire and the high nutritive quality of young grass shoots usually improve livestock gains (9). Vallentine (30) cites the benefits of burning as increasing the nutrient content of forage, particularly protein and phosphorus, in early growth stages. Improvement of palatability and nutrient content of grasses by burning, if only small areas are burned, may result in overgrazing of preferred species. Therefore, entire pastures should be burned and stocking rate adjusted accordingly (27).

Young shoots of cordgrasses have nutritive levels comparable to those reported for coastal bermudagrass [*Cynodon dactylon* (L.) Pers.] (4). For instance, protein content of the young grass shoots may exceed 13 percent. Herbage of mature grass is always lower in protein and phosphorus than immature, actively growing shoots. Even when the soil is not deficient in phosphorus, mature forage may not supply enough of the nutrient to meet animal requirements (19). Soils and forages in much of the Coastal Prairie are deficient in phosphorus which is usually supplemented in the water.

Confidence in predicting results of burning rangeland vegetation has been established through experience. However, the effects of fire in any given area may be highly dependent upon certain soil characteristics (15). Fire was once thought to be damaging to the soil by reducing organic matter and nitrogen content due to the high temperatures during burning (27). However, there are no experimental data available to justify such losses. The soil profile (other than organic debris and humus) of most burned areas is not degraded, and if erosion does not take place in significant proportions, fertility is im-

[2]McAtee, J. W. 1976. Unpublished data. The Texas Agricultural Experiment Station (Department of Range Science).

proved, at least temporarily (9). Soil horizons below surface organic layers are usually only slightly affected by fire, and no more than the upper portion of the humus is oxidized by burning (8). In addition, vegetative regrowth may be initiated 1 to 3 weeks earlier in the spring on burned than on unburned areas. Shoot initiation is evidently stimulated by the brief but sharp increase in soil surface temperatures during burning. Also, following burning, blackened and unshaded soil is considerably warmer than unburned areas during the day, providing an environmental stimulus for early growth (30).

Palatability, the plant characteristic derived from relative animal preference among two or more available forages, is an important factor in considering management of gulf cordgrass range. Forages, no matter how nutritious or abundant, have no value unless grazing animals consume them. If an economical method of harvesting could be developed and palatability improved, *Spartina* might become a valuable source of protein (28), especially for range livestock. Benefits from improved nutritive quality and palatability are most likely to be realized with forage species which are aggressive, highly productive, and persistent (31). Gulf cordgrass appears to meet these criteria, and prescribed burning has potential of becoming an integral part of the range management plan for gulf cordgrass range.

Despite the relative importance of gulf cordgrass in the Coastal Prairie, little research data have been accumulated concerning its ecology and management. Management of gulf cordgrass has traditionally focused on burning of mature stands to enhance palatable regrowth. There usually has been no management plan associated with the burning efforts. Landowners burn gulf cordgrass at their convenience or when supplemental grazing is critically needed rather than on a systematic, planned basis.

The purpose of the research was to study the growth, consumption, and nutritional value of gulf cordgrass herbage after burning as related to selected site characteristics.

Specific objectives of the research were to

1) evaluate gulf cordgrass herbage production and utilization by cattle as influenced by date of burning;
2) correlate edaphic characteristics (pH, salinity, moisture, and texture) with gulf cordgrass development following the burns; and
3) evaluate the nutritional value based on protein content, phosphorus content, and digestible energy of gulf cordgrass herbage at various time intervals following burning.

MATERIALS AND METHODS

The study area was located on the Armstrong Ranch in central Kenedy County, approximately 68 kilometers south of Kingsville, Texas. Five sites supporting almost solid stands of gulf cordgrass were selected for study. The sites, covering at least 3 hectares, were burned on different dates by ranch personnel. An adjacent, unburned area on each site was used as a control for comparisons. The sites were subjected to periodic flooding but usually not to prolonged inundation.

Vegetative responses were evaluated relative to changes in foliar cover, herbage production, and utilization[3] by cattle, and herbage quality at time-lapse intervals following burning; these were compared to the same criteria on the unburned areas. Soils on each site were characterized relative to selected chemical and physical characteristics. The study areas were evaluated, based on the selected variables, approximately at monthly intervals for a year beginning on February 20, 1975.

Soil samples from each site were recovered from 0- to 8-, 8- to 15-, and 15- to 30-centimeter depths at each sampling date. Soil moisture content, determined gravimetrically, was compared with rainfall received during each grazing period and related to extent of gulf cordgrass topgrowth development. In addition to monthly moisture content estimates, soils were characterized relative to pH based on a 1:2 to 1:5 slurry (22); salinity on aqueous extracts (3); textural components by the hydrometer method and/or by size class separation by weight (18); and organic matter content by acid digestion and titration (20).

Foliar cover, the amount of ground surface area covered by gulf cordgrass foliage, was estimated within burned plots with permanent line transects as described by Canfield (5). Three lines, approximately 30 meters long, were established within the burned plots at each site at the initiation of the study. Foliar cover was recorded at monthly intervals on burned areas for the first 4 months of study, then on a bimonthly basis thereafter to 1 year after burning. Estimation of foliar cover on adjacent, unburned plots was derived from gulf cordgrass density and average plant foliar area on each site. Foliar cover of unburned plots was estimated at the beginning and end of the 1-year evaluation period.

Utilization of gulf cordgrass by livestock was estimated through the use of grazing exclosures. The exclosures, constructed from 10-gauge wire having 10- by 10-centimeter openings, were approximately 2 meters tall and were held securely in place by steel stakes. Eighteen such exclosures were placed in each plot, 12 per burned area and six per adjacent unburned area. The gulf cordgrass herbage within burned areas was harvested to a 2.5-centimeter stubble height at monthly intervals for the first 5 months of study, then on a bimonthly basis thereafter to 1 year after burning. Harvests were made from 0.25-square meter plots within the center of each protected area (ungrazed) and at least 2 meters away from the exclosure in the grazed areas. Immediately following each harvest, the exclosures were moved approximately 3.5 meters to begin the next sample grazing period. A paired-plot method as described

[3]The term "utilization" is used throughout to encompass forage removal, whatever the cause. It should be understood that although ingestion by cattle is probably the major cause of removal, substantial losses also occur due to trampling, weathering, use by wildlife and insects, and to other natural factors.

by Scifres et al. (24) was used to estimate utilization of gulf cordgrass for each grazing period. Differences in weight of air-dry (65 degrees centigrade) gulf cordgrass herbage within protected plots and corresponding grazed areas were used to estimate utilization of gulf cordgrass for each grazing period.

Production estimates of gulf cordgrass regrowth following burning were derived from harvests of plots, 0.25 square meter, within protected areas. Estimates of production were adjusted at each sampling date by subtracting the previous month's utilization estimate, thus allowing determination of actual production from one sampling date to the next.

Utilization estimates of unburned gulf cordgrass stands were made from a protected plant and comparably sized unprotected plant and were collected from one site each month for a 5-month period beginning with the initiation of study. Production estimates of unburned gulf cordgrass plants were obtained from a double-sampling method (volume versus weight) at the termination of the study (17).

Due to the aggregation of gulf cordgrass plants occurring over the study areas, it was necessary to adjust utilization and production estimates of burned areas to average basal area and plant numbers on each site. These adjustments were made after it was determined that there were no differences in numbers of regrowth shoots per unit area of gulf cordgrass bases surviving the fire, and that, within an evaluation date, there were no differences in shoot heights. Each production and utilization value was then adjusted to the average basal diameter of gulf cordgrass plants within burned areas on that site to convert all estimates to a common base.

At each sampling, green gulf cordgrass herbage was harvested in both burned and unburned plots for estimates of protein, phosphorus, and digestible energy levels. Crude protein content was determined using the Kjeldahl procedure for nitrogen determination (2); phosphorus was determined spectrophotometrically (14); and digestible energy was determined as outlined by Tilly and Terry (29). Monthly nutritional values were then interpreted in light of soil moisture levels, rainfall, and production of gulf cordgrass for that grazing period.

Density (number of plants/unit area), plant height, and canopy diameter of gulf cordgrass regrowth in unburned areas were periodically evaluated using the point-center-quarter method as outlined by Cottam and Curtis (7).

Variation in gulf cordgrass production, utilization, and protein content was sorted among sites and dates of sampling with appropriate statistical techniques. Regression equations were derived from production and utilization estimates to allow prediction of rate of change as influenced by time after burning (26).

The pastures were stocked with approximately one animal per 8 hectares as a cow-calf operation during this study. Burned areas were estimated to constitute less than 10 percent of the total area of each pasture, and gulf cordgrass constituted approximately 80 percent of the area available to grazing animals.

RESULTS AND DISCUSSION

The study areas were of similar topography and physical features. All areas were lowlands susceptible to periodic inundation. Gulf cordgrass dominated the vegetation on all sites, but other grasses and forbs were interspersed within the stand during early to mid-spring "green up." Honey mesquite (*Prosopis glandulosa* Torr. var *glandulosa*) savannahs typical of sandy, inland areas of the Coastal Prairie bordered the lowlands. This vegetation type grades into "chaparral" (mixed brush dominated by honey mesquite and species of *Acacia*) on the uplands to the west.

Soil Characteristics

Physical and Chemical Components

The loamy sand sites, burned in fall 1974 were characterized by a near neutral soil surface, becoming more basic to 30 centimeters deep (Table 1). Soluble salts averaged 0.28 percent or less in these soils regardless of depth. Organic matter was consistently greater on the loamy sand site, regardless of sample depth, than on other sites. Surface soil of the loamy sand site burned October 23, 1974, was acid and contained the greatest amount of organic matter, 2.1 percent, of the study areas.

Soil salinity on the alkali sandy loam site burned in spring 1974 was higher than for other study areas, particularly at the 8- to 30-centimeter depth (Table 1). Crusting and salt accumulation on the soil surface was apparent throughout the study, especially during drier periods. With increased precipitation, soluble salts were probably leached into underlying soil, thus accounting for increased salinity levels at lower depths at those times of sampling. Salt accumulations virtually eliminated forbs and grasses which occurred seasonally on the more mesic sites and favored salt-tolerant species such as shoregrass (saltgrass) (*Monanthochloe littoralis* Engelm.). Soil pH was basic regardless of depth, and organic matter accumulation never exceeded 0.44 percent. Soil texture was sandy loam to 8 centimeters deep and sandy clay loam at 8 to 30 centimeters deep.

Soil salinity of the alkali loamy sand, burned in winter 1975, ranged from 0.043 percent in the 0- to 8-centimeter layer, increasing to 0.68 percent at 15 to 30 centimeters deep (Table 1). Soil reaction was basic regardless of depth, and organic matter accumulation did not exceed 0.41 percent. Soil texture was loamy sand to 8 centimeters deep, increasing in clay content and becoming sandy loam and sandy clay loam at 8 to 15 centimeters and 15 to 30 centimeters deep, respectively.

Soil Moisture Trends

Upon initiation of the experiment in late February 1975, all study areas were inundated with 0.5 to 2 centimeters of standing water. However, the water did not

TABLE 1. EDAPHIC CHARACTERISTICS OF SITES WHERE GULF CORDGRASS RESPONSE TO BURNING WAS EVALUATED DURING 1975 NEAR ARMSTRONG, TEXAS

Site[1]	Burned	Soil depth (cm)	Salinity (%)	pH	Organic carbon (%)	Textural components (%)			Textural[5] class
						Sand	Silt	Clay	
Loamy sand[2]	Oct. 1, 1974	0-8	0.025	7.6	0.55	83	5	12	ls
		8-15	0.053	8.0	0.27	85	4	11	ls
		15-30	0.141	9.2	0.21	76	7	17	sl
	Oct. 23, 1974	0-8	0.523	6.6	2.10	72	9	19	sl
		8-15	0.461	7.2	0.69	69	8	23	scl
		15-30	0.685	8.8	0.39	65	6	29	scl
	Nov. 9, 1974	0-8	0.020	7.2	0.87	82	6	12	ls
		8-15	0.018	7.2	0.16	82	7	11	ls
		15-30	0.027	7.9	0.23	79	5	16	sl
	Avg	0-8	0.189	7.1	1.17	79	7	14	ls
		8-15	0.177	7.5	0.37	79	6	15	sl
		15-30	0.284	8.6	0.28	73	6	21	sl
Alkali sandy loam[3]	Spring, 1974	0-8	0.410	8.5	0.44	77	9	14	sl
		8-15	1.232	9.0	0.23	70	6	24	scl
		15-30	1.632	9.0	0.24	69	7	24	scl
Alkali loamy sand[4]	Winter, 1975	0-8	0.043	8.7	0.41	82	6	12	ls
		8-15	0.553	8.4	0.28	77	5	18	sl
		15-30	0.680	8.8	0.18	70	6	24	scl

[1]Data represent average of three loamy sand sites and from one alkali sandy loam and alkali loamy sand sites.

[2]Burning was completed from October 1 to November 9, 1974.

[3]Burning conducted during early May.

[4]Burning conducted on January 6.

[5]For textural classes, ls = loamy sand, sl = sandy loam, and scl = sandy clay loam.

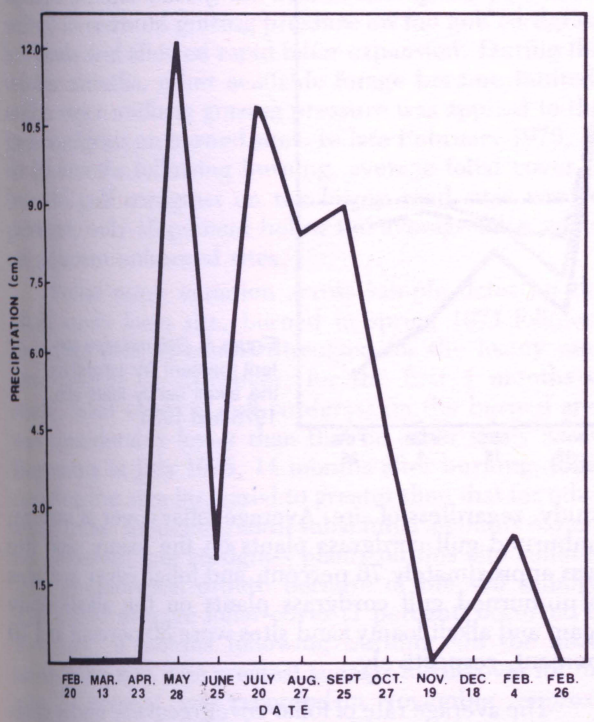

Figure 2. Precipitation (centimeters) during study of gulf cordgrass response to burning during 1975 and 1976.

cover the surface of most of the burned gulf cordgrass bunches. There was no rainfall from that time to the April 1975 sampling (Figure 2). The greatest single accumulation of rainfall for the study period, 12 centimeters, was recorded from April 23 to May 23. Rainfall declined from May to June but increased to 10.9 centimeters, the second highest amount received, during July. There was little variation in rainfall from July to September. After September, however, precipitation began to decrease steadily, with no rainfall recorded at the November sampling. Only 1 centimeter of rainfall was recorded in December, but precipitation increased to 2.8 centimeters in early February 1976. Precipitation for the study period averaged 4.68 centimeters per month.

Soil moisture content corresponded directly to available rainfall as would be expected, except at the October 27 sampling when soil moisture content of all sites increased to the highest levels for the study, while recorded precipitation decreased (Figures 3,4,5). Rainfall during the night preceding the morning of the sample collection date is responsible for this occurrence.

Average moisture content of soils on the loamy sand sites for the study period was 10 percent (Figure 3). The site burned October 23, 1974, maintained the highest average soil moisture content, 14 percent, of the three loamy sand sites. The lowest average soil moisture of the sites for the study period occurred on the area burned in November 1974. Soils on the alkali sandy loam site averaged the highest moisture content for the study, 14 percent (Figure 4). Soils on the alkali loamy sand site aver-

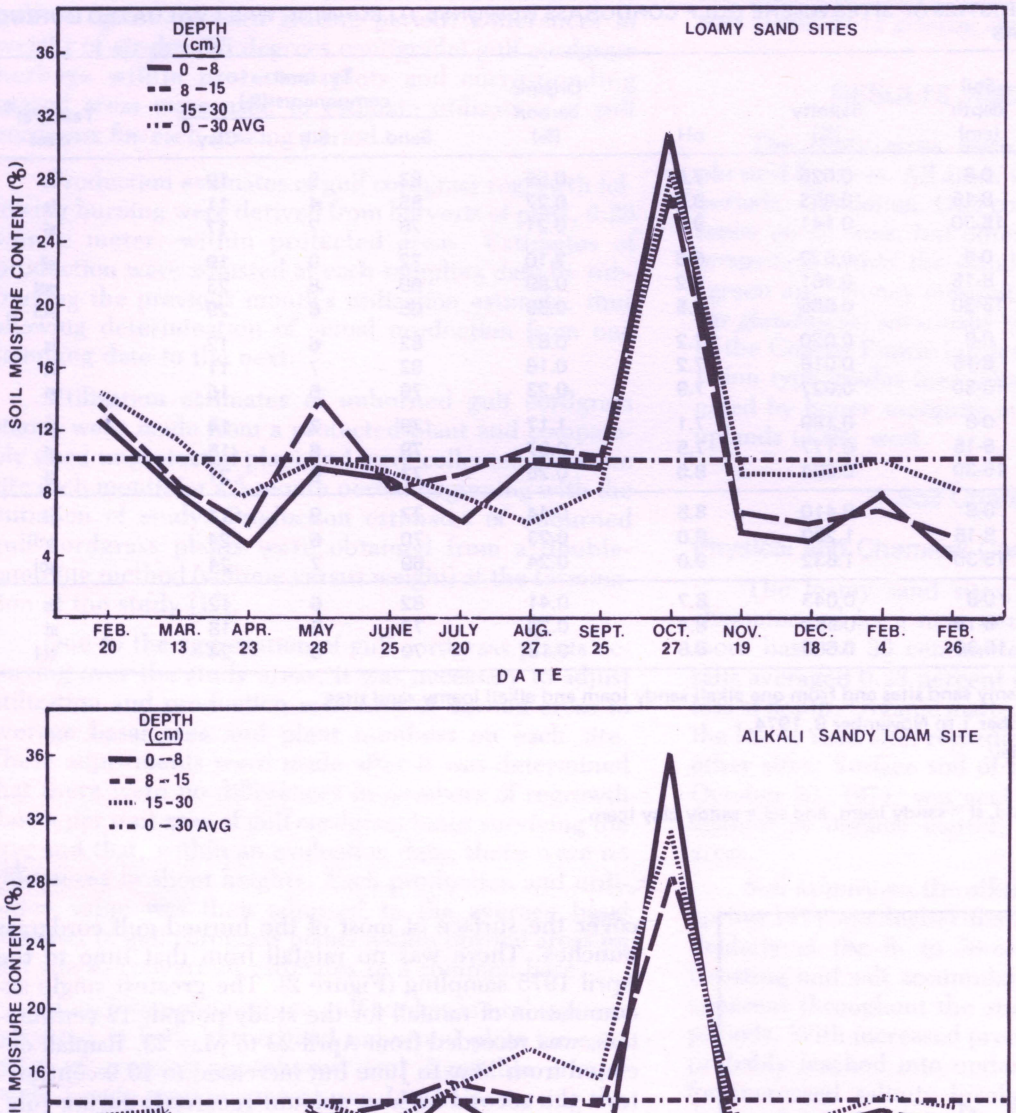

Figure 3. Soil moisture content (percent of dry weight) on the loamy sand sites, 1975 and 1976.

Figure 4. Soil moisture content (percent dry weight) on the alkali sandy loam site, 1975 and 1976.

aged 12.5 percent moisture content for the evaluation period (Figure 5).

Foliar Cover Replacement Following Burning

Foliar cover was monitored as an index of gulf cordgrass foliar growth, expansion, and regrowth rate in conjunction with herbage production following burning. Foliar cover trends on burned areas were fairly consistent for all sites. Expansion in foliar cover of regrowth of gulf cordgrass following burning was significantly different among sites and among sampling dates. Foliar cover estimates of unburned, mature gulf cordgrass plants did not vary appreciably from initiation to termination of study, regardless of site. Average foliar cover of matur unburned gulf cordgrass plants on the loamy sand si was approximately 76 percent, and foliar cover averag of unburned gulf cordgrass plants on the alkali san loam and alkali loamy sand sites were 80 percent and 7 percent, respectively.

The average rate of foliar cover recovery under gra ing for the period of evaluation on the loamy sand site burned in fall 1974 was 5 percent per month. Averag rate of foliar cover recovery for the evaluation period o the loamy sand site burned October 23, 1974, 5.5 pe cent per month, was significantly greater than on th other loamy sand sites. The greatest increase in foli

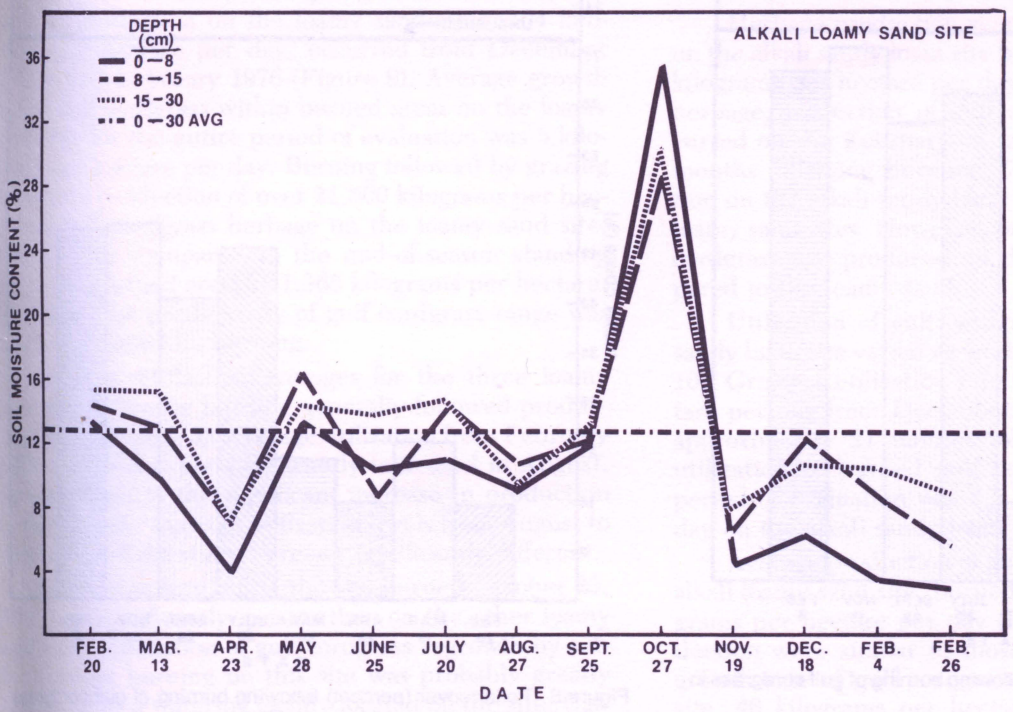

Figure 5. Soil moisture content (percent dry weight) on the alkali loamy sand site, 1975 and 1976.

cover among sampling dates on the loamy sand sites, 46 percent, occurred from May to July, 7 to 9 months following burning (Figure 6). Apparently, cattle grazing on upland forages during the mid to late spring period resulted in reduced grazing pressure on the gulf cordgrass lowlands and allowed rapid foliar expansion. During the winter months, other available forage became limited, and a more uniform grazing pressure was applied to the gulf cordgrass on burned sites. In late February 1976, 15 to 16 months following burning, average foliar cover of burned gulf cordgrass on the loamy sand sites was 60 percent, only 16 percent below the average foliar cover on adjacent unburned sites.

Foliar cover variation across sample dates on the alkali sandy loam site, burned in spring 1974 followed the same general trends discussed for the loamy sand sites (Figure 7). However, for the first 4 months of study, foliar cover of gulf cordgrass on the burned area was considerably lower than that on other study areas. Beginning in July 1975, 14 months after burning, foliar cover on the area increased to greater than that for other study areas. Evidently, until substantial amounts of rainfall occurred, gulf cordgrass plants on this site suffered from physiological drouth because of the soil salinity. The lowest average foliar cover (1 percent) occurred in February, 9 months following burning, on the alkali sandy loam site. The greatest average foliar cover for the site, 77 percent, was recorded in November, approximately 18 months after burning. The greatest change in foliar expansion on the alkali sandy loam site, 60 percent, occurred from May to July when other alternative forage was available to the cattle. Average foliar recovery rate of burned gulf cordgrass regrowth on the site was 6 percent per month. At the termination of the study, 21 months following burning, average foliar cover of burned gulf cordgrass regrowth on the alkali sandy loam site was 75 percent, only 5 percent less than the foliar cover of adjacent unburned gulf cordgrass.

Growth form of gulf cordgrass on the alkali sandy loam site differed considerably from that of plants on

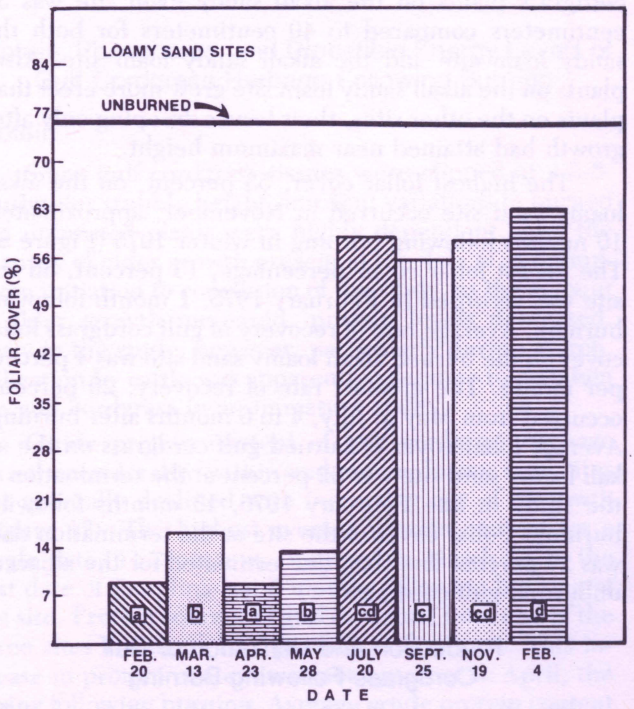

Figure 6. Foliar cover (percent) following burning of gulf cordgrass in fall 1974. (Means followed by the same letter are not significantly different at the 95-percent level of probability among dates according to Duncan's Multiple Range Test.)

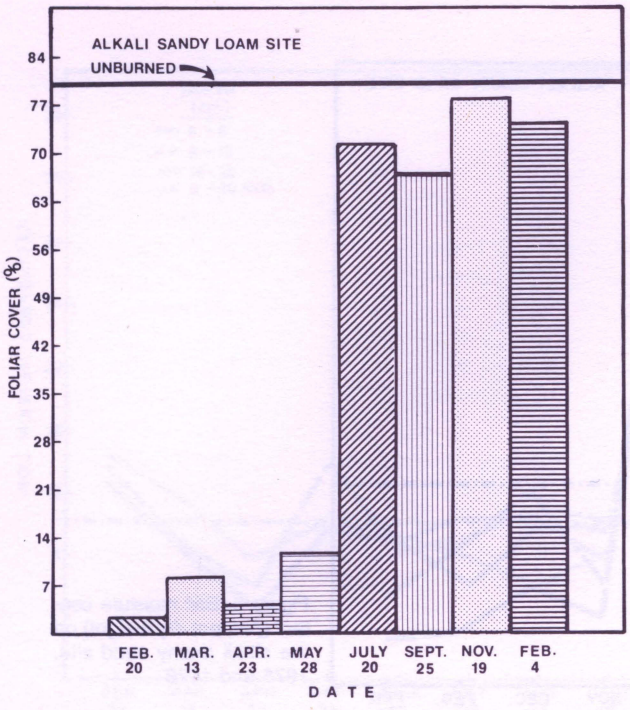

Figure 7. Foliar cover (percent) following burning of gulf cordgrass in spring 1974.

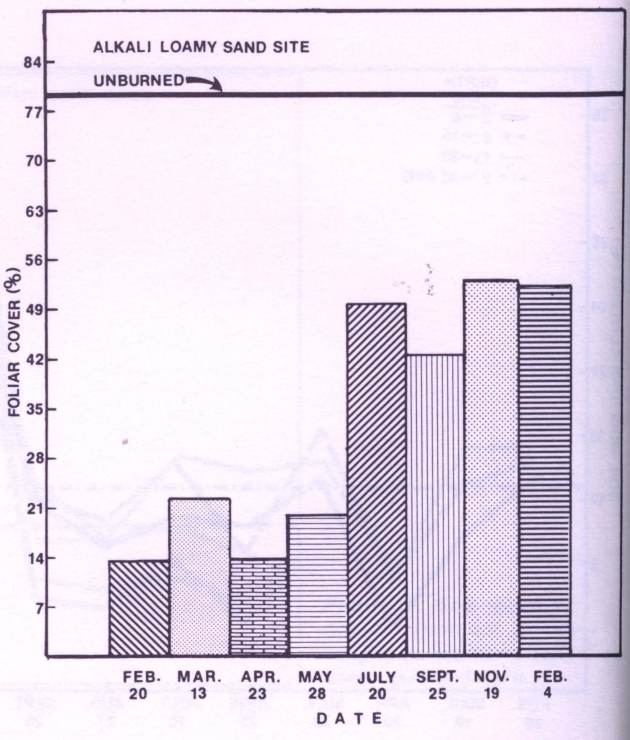

Figure 8. Foliar cover (percent) following burning of gulf cordgrass in winter 1975.

other sites. Mature plants were not as large, relative to basal diameter and height, as the mature gulf cordgrass plants on other sites. Average height of mature plants on the alkali sandy loam site was 25 centimeters compared to 108 centimeters and 78 centimeters for plants on the loamy sand site and the alkali loamy sand site, respectively. Average basal diameter of mature, unburned gulf cordgrass plants on the alkali sandy loam site was 32 centimeters compared to 40 centimeters for both the sandy loam site and the alkali sandy loam site. Also, plants on the alkali sandy loam site grew more erect than plants on the other sites, their leaves drooping only after growth had attained near maximum height.

The highest foliar cover, 53 percent, on the alkali loamy sand site occurred in November, approximately 10 months following burning in winter 1975 (Figure 8). The lowest foliar cover percentage, 13 percent, on the site was recorded in February 1975, 1 month following burning. Average rate of recovery of gulf cordgrass foliar cover on the burned alkali loamy sand site was 4 percent per month. The greatest rate of recovery, 29 percent, occurred from May to July, 4 to 6 months after burning. Average foliar cover of burned gulf cordgrass on the alkali loamy sand site was 52 percent at the termination of the study in late February 1976, 13 months following burning. Foliar cover of the site at the termination date was 27 percent less than that estimated for the adjacent unburned gulf cordgrass.

Production and Utilization of Gulf Cordgrass Following Burning

Standing crop of unburned gulf cordgrass on the loamy sand sites averaged 1,250 kilograms per hectare at initiation of the study and was 1,356 kilograms per hectare at termination of the study. The slight increase in standing gulf cordgrass crop was probably due to normal seasonal variation and measurement error. Standing crop of mature, unburned plants on the alkali sandy loam site averaged 1,050 kilograms per hectare at the beginning of the study and 980 kilograms per hectare at the end of the study. Standing crop of unburned stands on the alkali loamy sand site in March 1975 was 1,323 kilograms per hectare and 1,273 kilograms per hectare at the final sampling in February 1976.

Utilization of gulf cordgrass foliage from unburned sites was negligible regardless of evaluation date. Variation in utilization values was considered a product of sampling error since only occasionally were a few leaf tips of unburned plants grazed.

The numbers of gulf cordgrass plants per hectare on the loamy sand and alkali loamy sand sites were similar. Average gulf cordgrass densities were 2,450; 2,500; and 7,000 plants per hectare, on the loamy sand, alkali loamy sand, and alkali sandy loam sites, respectively. Though the alkali sandy loam site supported greater numbers of gulf cordgrass plants, the plants were shorter, explaining differences in weight of standing crop. Average basal area of burned regrowth was 59 square centimeters per plant on the loamy sand sites, 49 square centimeters per plant on the alkali loamy sand site, and 17 square centimeters on the alkali sandy loam site. In addition, average basal area for mature, unburned gulf cordgrass plants was 1,257 square centimeters per plant for the loamy sand and alkali loamy sand sites and 804 square centimeters per plant for the alkali sandy loam site.

The first significant increase in growth rate based on herbage production of gulf cordgrass following burning on the loamy sand sites occurred in August following fairly consistent rainfall for a 3-month period (Figure 9). Herbage production was reduced significantly in De-

cember to a level not significantly different from that in July and August. The most rapid growth rate, based on herbage production on the loamy sand sites, 104 kilograms per hectare per day, occurred from December 1975 to late February 1976 (Figure 9). Average growth rate of gulf cordgrass within burned areas on the loamy sand sites for the entire period of evaluation was 5 kilograms per hectare per day. Burning followed by grazing stimulated production of over 21,500 kilograms per hectare of gulf cordgrass herbage on the loamy sand site. This may be compared to the end-of-season standing crop on unburned areas of 1,365 kilograms per hectare. Therefore, the productivity of gulf cordgrass range was greatly enhanced by burning.

Herbage utilization averages for the three loamy sand sites following burning generally followed production trends (Figure 9). Average utilization from February 1975 to June was not significantly increased in August, corresponding to the significant increase in production for that month. Average utilization levels from August to termination of the study were not significantly different.

Herbage utilization on the site burned October 23, 1974, was significantly greater than on the other loamy sand sites. Utilization of gulf cordgrass regrowth by cattle following burning on this site was probably greatly influenced by a watering facility located on the site. Cattle utilized an estimated 3 kilograms per hectare per day of gulf cordgrass herbage on the loamy sand sites. Based on a requirement of 12 kilograms per day air-dry forage to sustain an animal unit, carrying capacity for the 12 months was about 1 animal unit per 4 hectares (1 animal unit per 10 acres). The greatest utilization following burning of the loamy sand sites occurred on the February 26, 1976, sample collection date, 32 kilograms per hectare per day over a 70-day period.

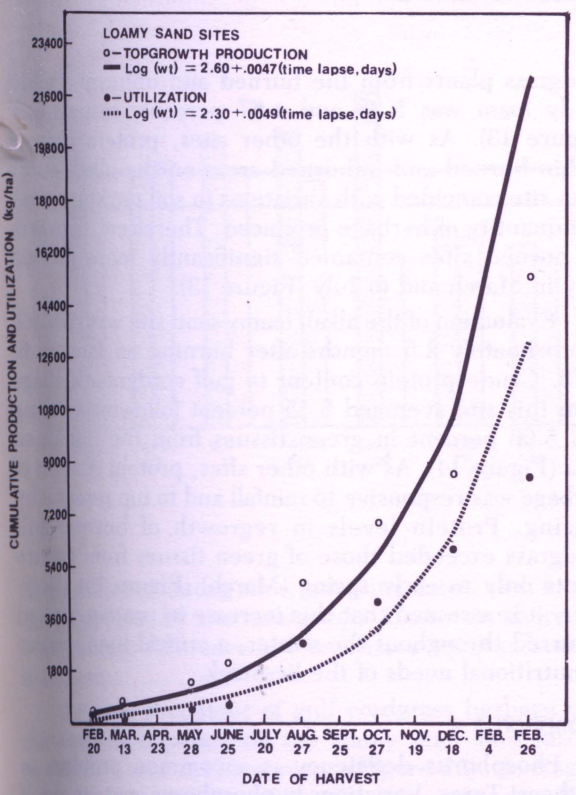

Figure 9. Cumulative production and utilization (kilograms per hectare) of burned gulf cordgrass topgrowth on the loamy sand site, burned in fall 1974.

Herbage production average for the period of study on the alkali sandy loam site burned in spring 1974 was 4 kilograms per hectare per day (Figure 10). The greatest herbage production of gulf cordgrass on the area occurred on the February 26 sampling, approximately 21 months following burning. Trends in herbage production on the alkali sandy loam site followed those on the loamy sand sites. However, only about half as much gulf cordgrass was produced on the alkali sandy loam compared to the loamy sand.

Utilization of gulf cordgrass herbage on the alkali sandy loam site varied as on the loamy sand sites (Figure 10). Greatest utilization rate was 34 kilograms per hectare per day from December 18 to February 26, 1976, approximately 21 months following burning. Average utilization of burned gulf cordgrass regrowth for the period of evaluation was 2.5 kilograms per hectare per day on the alkali sandy loam site.

Average production of gulf cordgrass herbage on the alkali loamy sand site, burned in winter 1975 was 6 kilograms per hectare per day (Figure 11). Trends in production were similar to those for other sites. Greatest growth rate of gulf cordgrass on the alkali loamy sand site, 46 kilograms per hectare per day, was recorded from December 18 to February 26, 1976, 13 months following burning.

Utilization of gulf cordgrass regrowth by cattle averaged 4 kilograms per hectare per day on the alkali sandy loam site for the period of evaluation (Figure 11). As was with other sites, the greatest utilization of gulf cordgrass topgrowth by cattle on the alkali loamy sand site was in late February 1976, 13 months following burning.

Protein, Phosphorus, and Digestible Energy Levels of Gulf Cordgrass Herbage Following Burning

Protein

Since gulf cordgrass tissues were clipped at a 2.5-centimeter stubble height, nutrient variations in burned and unburned plants were highly dependent upon the quantity of older growth present at the date of sampling. From initiation to conclusion of the study, as the amount of older growth increased, protein levels decreased. Early in the study, however, particularly during March, utilization by cattle was apparently adequate to maintain the gulf cordgrass in an immature state.

Crude protein content of gulf cordgrass herbage varied considerably within and among loamy sand sites but generally declined with increasing age of regrowth (Figure 12). The highest average protein content for a single date, 11.2 percent, occurred in March 1975, the first date of sampling but 5 months following burning of the site. Protein content of gulf cordgrass from one of the three sites averaged 13.7 percent at that time. This increase in protein content was not apparent in April, the spring following burning. Average crude protein content of gulf cordgrass regrowth on the loamy sand sites burned in fall 1974 was 5.23 percent compared to 5.08 percent for green tissues from unburned mature plants.

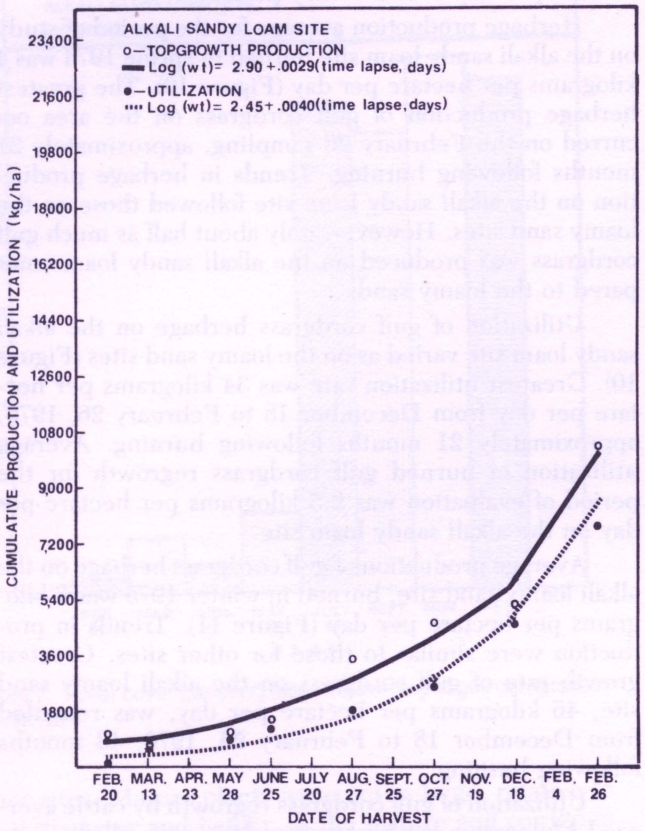

Figure 10. Cumulative production and utilization (kilograms per hectare) of burned gulf cordgrass topgrowth on the alkali sandy loam site, burned in spring 1974.

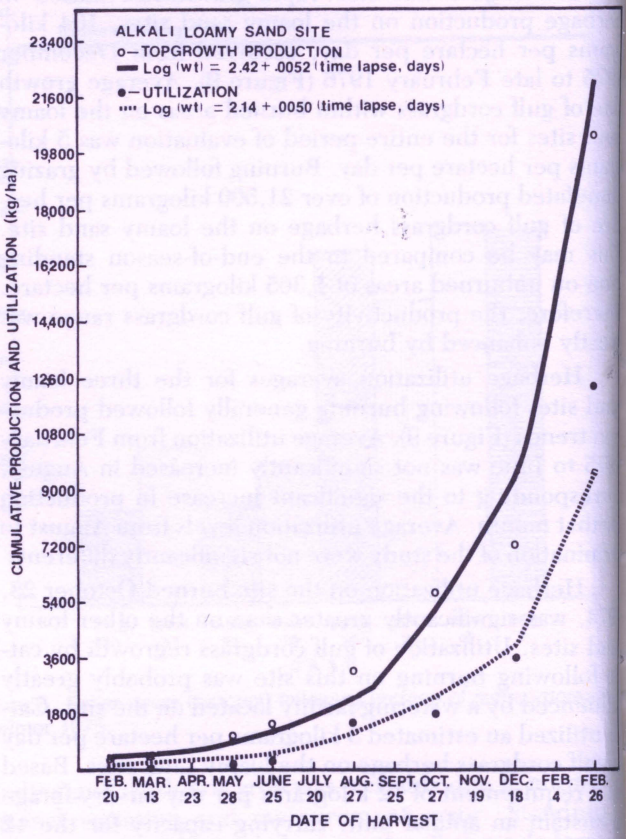

Figure 11. Cumulative production and utilization (kilograms per hectare) of burned gulf cordgrass topgrowth on the alkali loamy sand site burned in winter 1975.

The highest average crude protein of gulf cordgrass tissues, 5.52 percent, occurred on the site burned on October 23, 1974. Average crude protein content of green tissues from adjacent unburned plants for the study period was 5.10 percent. Variation in protein content of herbage among sampling dates was similar among the areas burned in fall 1974. Site and treatment were not significantly different; however, date of sampling and treatment by date interaction were significant.

Protein content of gulf cordgrass regrowth following burning was significantly greater than levels of unburned gulf cordgrass tissues on loamy sand sites in March and May (Figure 12). Crude protein content, however, in gulf cordgrass regrowth following burning did not significantly exceed that of burned plants at any other sampling date. Apparently, the lack of spring rainfall did not allow rapid growth of burned plants, thus lowering protein content of regrowth in April. In addition, during the early to mid-spring, other grasses and forbs became sufficiently available to provide grazing animals with alternate forage. With decreased grazing pressure, gulf cordgrass herbage consisted of maturing regrowth with a concomitant decrease in nutritional components.

The alkali sandy loam site was burned approximately 3 months prior to burning of the loamy sand sites, and therefore supported the oldest vegetative regrowth of the sites studied. Average protein content of gulf cordgrass plants from the burned and unburned alkali sandy loam was 5.38 and 4.67 percent, respectively (Figure 13). As with the other sites, protein content within burned and unburned areas on the alkali sandy loam site coincided with variations in soil moisture, age, and quantity of herbage produced. Therefore, regrowth on burned sites contained significantly more protein only in March and in July (Figure 13).

Evaluation of the alkali loamy sand site was initiated approximately 2.5 months after burning on January 6, 1975. Crude protein content in gulf cordgrass herbage from this site averaged 5.45 percent following burning and 5.06 percent in green tissues from the unburned area (Figure 14). As with other sites, protein content of herbage was responsive to rainfall and to top removal by grazing. Protein levels in regrowth of burned gulf cordgrass exceeded those of green tissues from mature plants only in early spring (March) (Figure 14). However, it is assumed that this increase in protein content occurred throughout the winter, a critical time relative to nutritional needs of the livestock.

Phosphorus

Phosphorus deficiency is a common problem in southeast Texas. Variations in phosphorus content of gulf cordgrass herbage generally followed the same trend as for protein content. Phosphorus content was signifi-

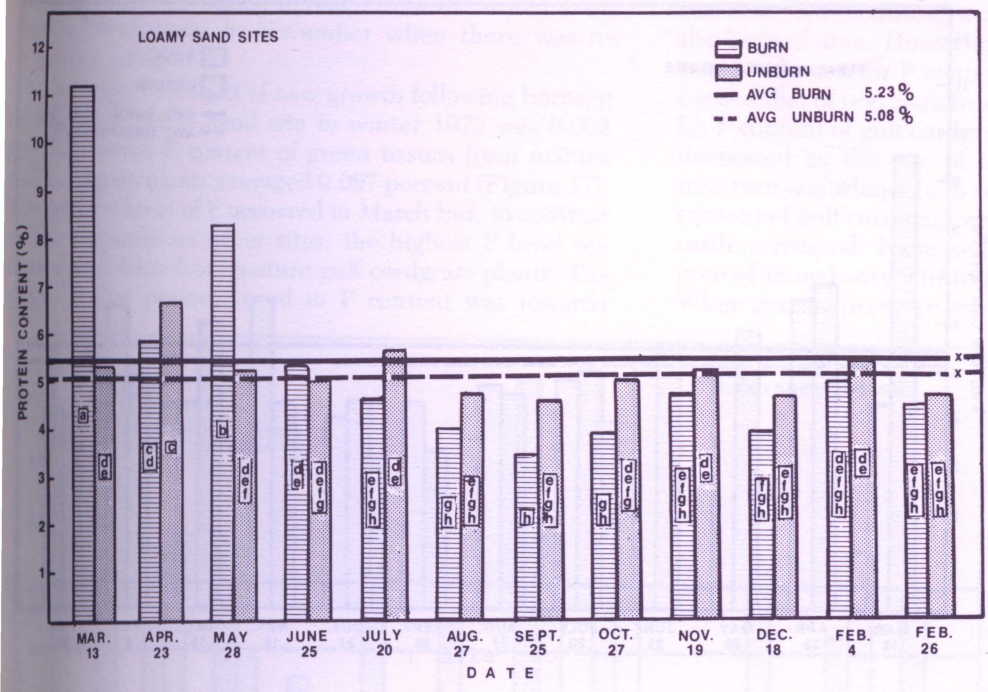

Figure 12. Protein content (percent) of unburned gulf cordgrass topgrowth and of regrowth following burning in fall 1974 on loamy sand sites. (Means followed by the same letter are not significantly different at the 95-percent level of probability among dates according to Duncan's Multiple Range Test.)

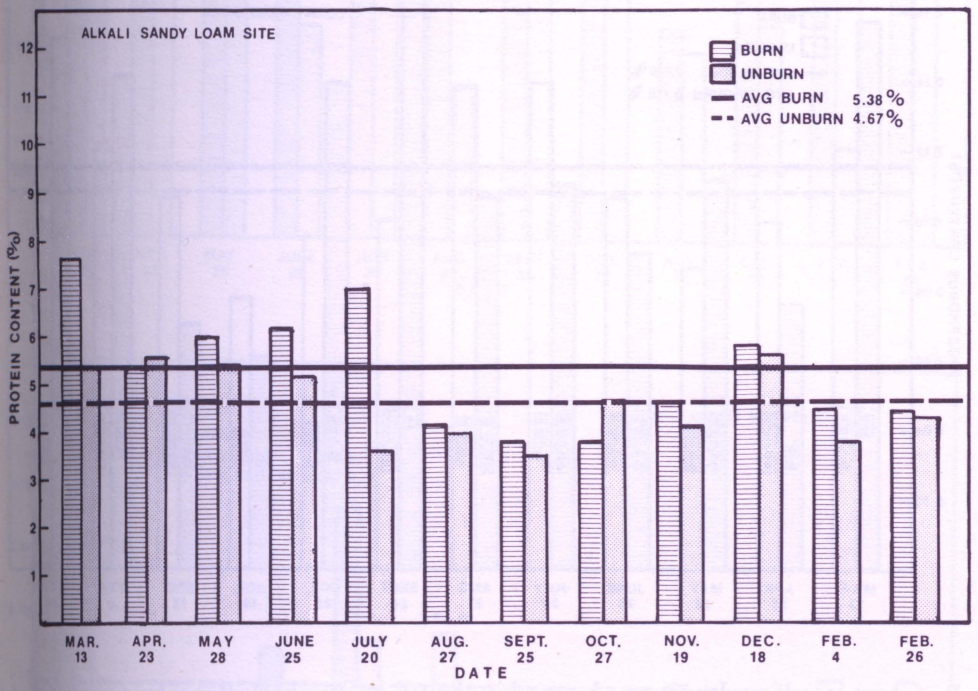

Figure 13. Protein content (percent) of unburned gulf cordgrass topgrowth and of regrowth following burning in spring 1974 on the alkali sandy loam site.

cantly different among sites, sampling dates, and, for the sampling date, by site interaction. However, there was no significant difference in P levels as a result of burning treatment.

Average P content of gulf cordgrass herbage over the evaluation period on the loamy sand sites burned in fall 1974 was 0.116 percent (Figure 15). Average P content of mature grass from the same area was 0.108 percent. Phosphorus content was apparently highly dependent on site with enforcement of regrowth by burning causing only a slight difference. Regrowth on burned loamy sand sites contained more phosphorus than mature tissues in the spring (March) and fall (September through October) of 1975 and winter (February) of 1976.

Regrowth of gulf cordgrass on the loamy sand site burned October 23, 1974, tended to contain the greatest amount of P, 0.128 percent, for the study period. The P content of unburned stands of gulf cordgrass on the same area averaged 0.123 percent, indicating the influence of site apparently to be of more importance than burning

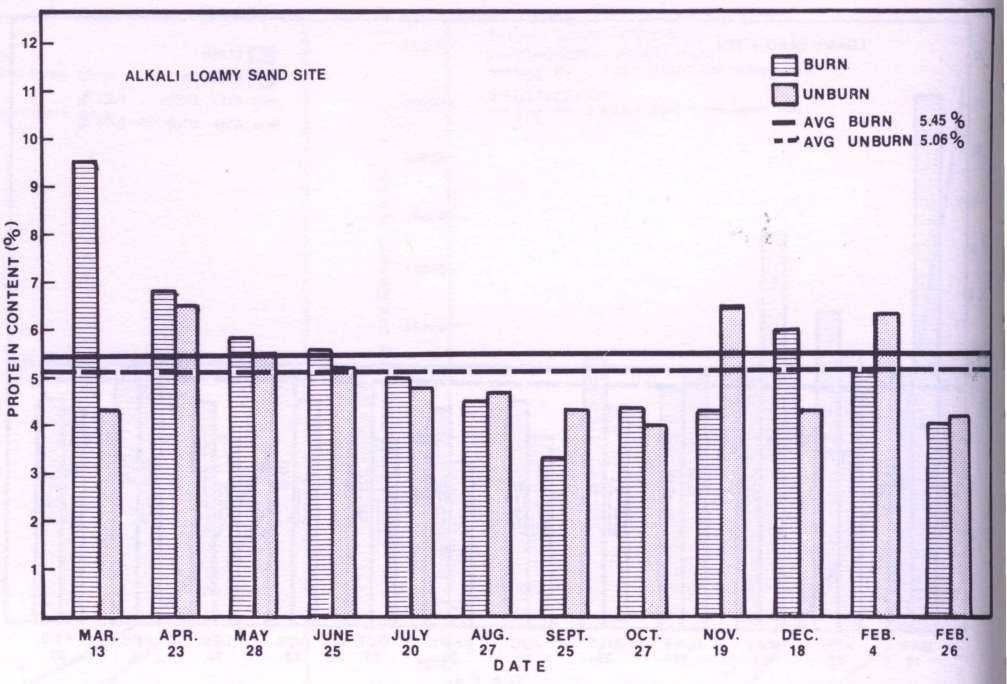

Figure 14. Protein content (percent) of unburned gulf cordgrass topgrowth and of regrowth following burning in winter 1975 on the alkali loamy sand site.

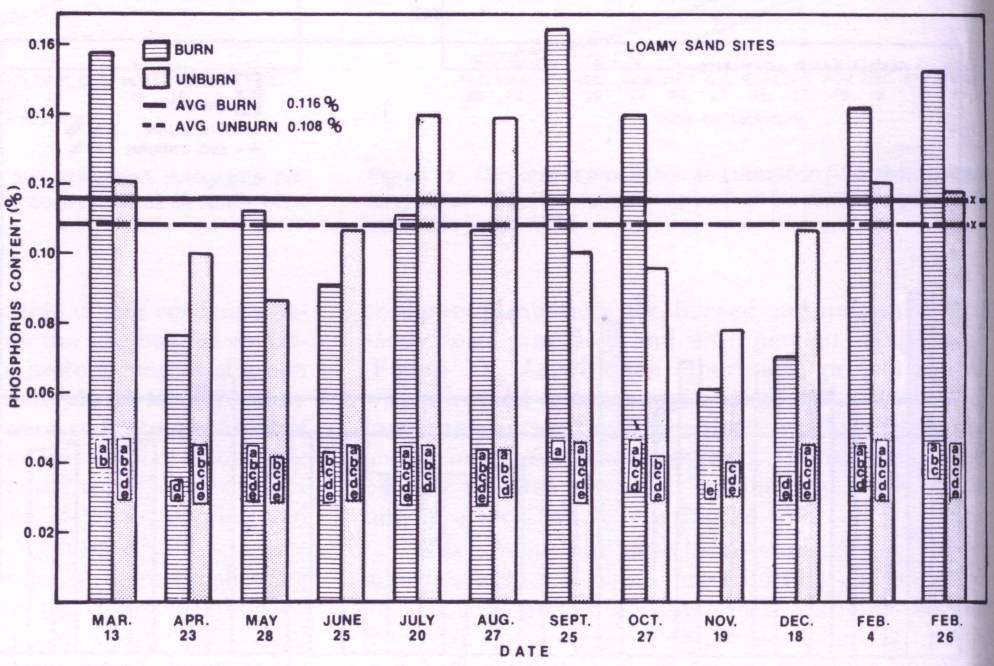

Figure 15. Phosphorus content (percent) of unburned gulf cordgrass topgrowth and of regrowth following burning in fall 1974 on the loamy sand sites. (Means followed by the same letter are not significantly different at the 95-percent level of probability among dates according to Duncan's Multiple Range Test.)

treatment. However, average P content of gulf cordgrass herbage from the loamy sand site burned November 9, 1974, was 0.125 percent for the burned area and 0.102 percent for herbage from the unburned area.

Average P content from the loamy sand sites burned in fall 1974 never attained the 0.18-percent on a 90-percent dry-matter basis recommended for wintering mature beef cattle during pregnancy (27). The highest average P content on the loamy sand sites, 0.161 percent, occurred during September within burned areas after 2 months of fairly constant rainfall and after burning the previous fall in the late October or early November. The P content of gulf cordgrass herbage on burned areas dropped in the fall (November) after a dry period and at the beginning of seasonally cool temperatures (Figure 15).

The P content of herbage on the alkali sandy loam site burned in spring 1974 tended to follow soil moisture availability and grazing trends, except on March 13 when P content of unburned plants tended to be higher than that of burned regrowth (Figure 16). The highest level of P was attained in September in regrowth on the burned area, approximately 16 months after burning, and after a 2-month period of fairly constant rainfall. Phosphorus levels of plants on the burned area decreased with decreased precipitation in October, and P

content of gulf cordgrass herbage from unburned areas decreased abruptly in November when there was no recorded rainfall.

Average P content of new growth following burning of the alkali loamy sand site in winter 1975 was 0.092 percent, while P content of green tissues from mature gulf cordgrass plants averaged 0.097 percent (Figure 17). The highest level of P occurred in March but, in contrast to the response on other sites, the highest P level occurred in foliage from mature gulf cordgrass plants. Except for that period, trend in P content was towards increased levels during warm, moist periods and within the burned area. However, during drier periods, it was not uncommon for P content of mature gulf cordgrass to exceed that of regrowth from the burned area. Apparently, P content of gulf cordgrass regrowth, as with protein, decreased as the age of tissues increased. When soil moisture was adequate to support rapid growth, nutrient content of gulf cordgrass was increased and utilization by cattle increased. Increased utilization maintained a degree of immaturity within burned gulf cordgrass plants. When grazing pressure was reduced as alternative forage

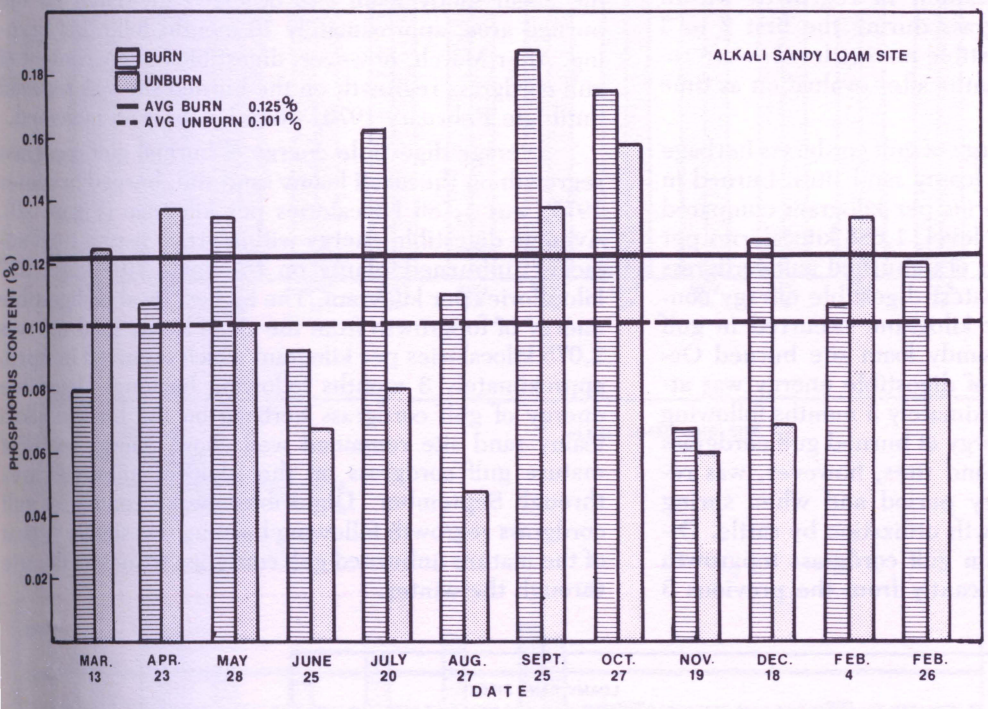

Figure 16. Average phosphorus content (percent) of unburned gulf cordgrass topgrowth and of regrowth following burning in spring 1974 on the alkali sandy loam site.

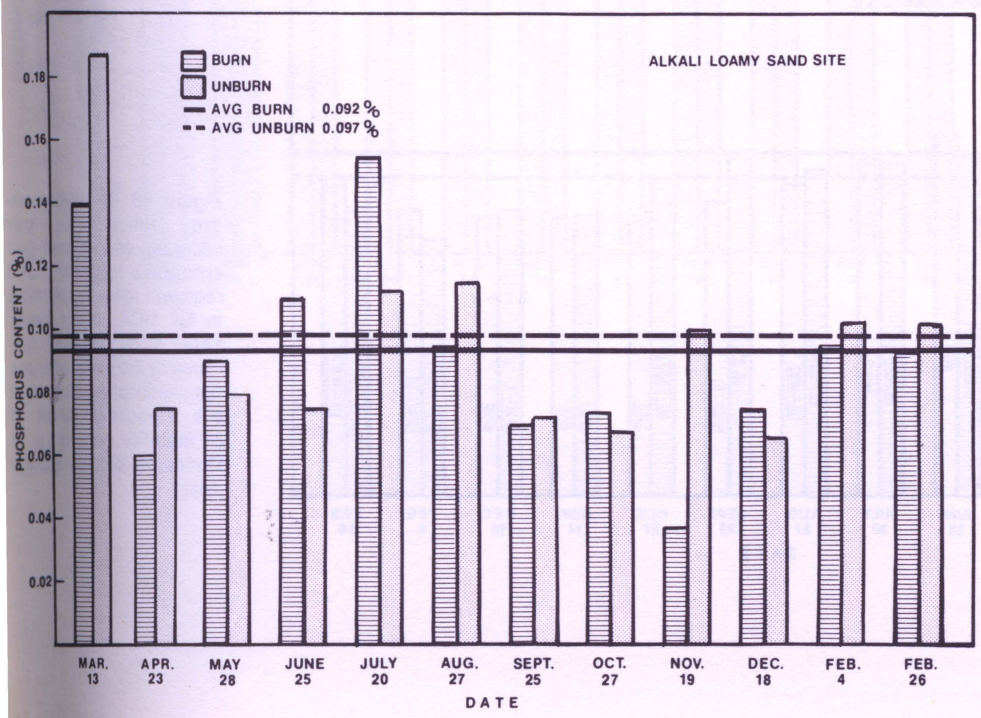

Figure 17. Phosphorus content (percent) of unburned gulf cordgrass topgrowth and of regrowth following burning in winter 1975 on the alkali loamy sand site.

became available on upland sites, the gulf cordgrass was allowed to mature slowly with a concomitant decrease in nutrient levels.

Digestible Energy

Variation in digestible energy content of herbage from unburned gulf cordgrass plants and of regrowth following burning was not significant among sites. Differences in levels of available digestible energy, however, were significant due to burning treatment and among sampling dates. Highest levels of digestible energy were generally attained in regrowth within burned areas of gulf cordgrass during the first 2 to 3 months of evaluation. Digestible energy levels were reduced, however, 3 to 4 months after evaluation as time after burning increased.

Average digestible energy of gulf cordgrass herbage for the study period on the loamy sand sites, burned in fall 1974 was 1,799 kilocalories per kilogram compared with the significantly lower level, 1,688 kilocalories per kilogram, from green tissues of unburned gulf cordgrass plants (Figure 18). The greatest digestible energy content, 2,382 kilocalories per kilogram, occurred in gulf cordgrass herbage on the sandy loam site burned October 23, 1974. This level of digestible energy was attained during March, approximately 5 months following burning. The digestible energy of burned gulf cordgrass regrowth from the loamy sand sites, however, was reduced during the early dry period and when spring "green up" reduced topgrowth utilization by cattle. Digestible energy levels within gulf cordgrass topgrowth dropped, though not significantly from the previous 3 months, beginning in November and were maintained at reduced levels during the winter when growth was suppressed by cool temperatures. With warming temperatures in late February 1976, digestible energy of gulf cordgrass regrowth tended to increase on the loamy sand site.

Average digestible energy of gulf cordgrass on the alkali sandy loam site, burned in spring 1974, was 1,91 kilocalories per kilogram compared to 1,733 kilocalorie per kilogram in mature herbage (Figure 19). The highes level of digestible energy in gulf cordgrass herbage o the alkali sandy loam site occurred in March on th burned area, approximately 10 months following burning. After March, however, digestible energy content gulf cordgrass regrowth on the burned site was reduce until late February 1976, when levels again increased.

Average digestible energy of burned gulf cordgra regrowth on the alkali loamy sand site, burned in winte 1975, was 1,786 kilocalories per kilogram (Figure 20 Average digestible energy within green tissues from ad jacent unburned plants on the same site was 1,58 kilocalories per kilogram. The highest level of digestibl energy of topgrowth from the alkali loamy sand site wa 2,075 kilocalories per kilogram which occurred in Apri approximately 3 months following burning. Digestibl energy of gulf cordgrass herbage on the burned alka loamy sand site remained well above energy levels o mature gulf cordgrass on the adjacent unburned are through September. Digestible energy content of gul cordgrass regrowth following burning was similar to tha of the mature unburned gulf cordgrass tissues on the site through the winter.

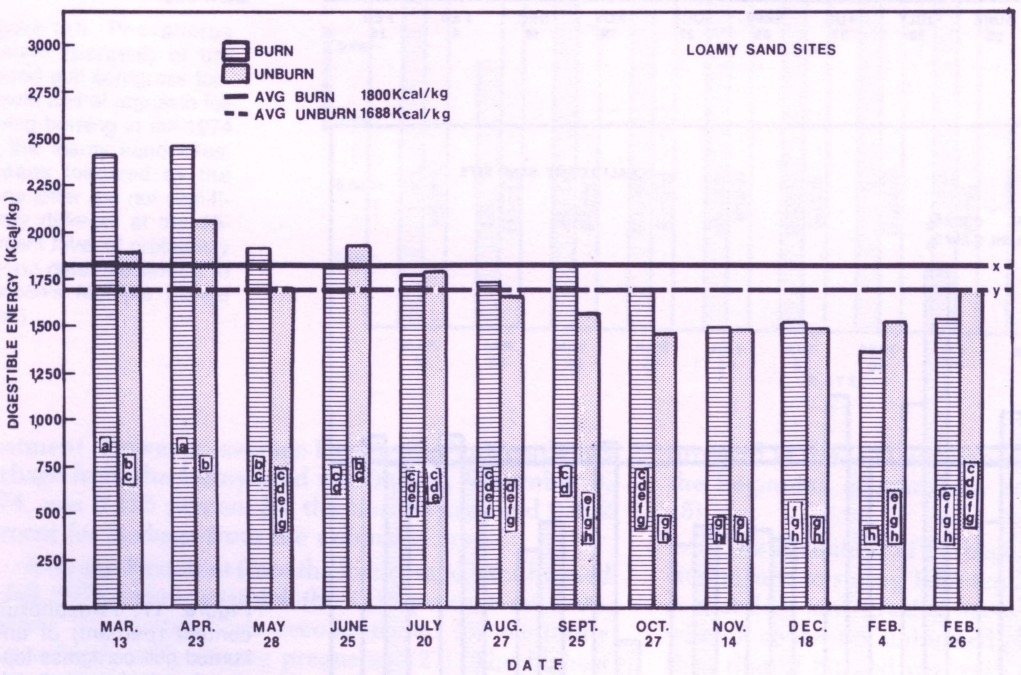

Figure 18. Digestible energy (kilocalories per kilogram) of unburned gulf cordgrass topgrowth and regrowth following burning in fall 1974 on the loamy sand sites. (Means followed by the same letter are not significantly different at the 95-percent level of probability according to Duncan's Multiple Range Test.)

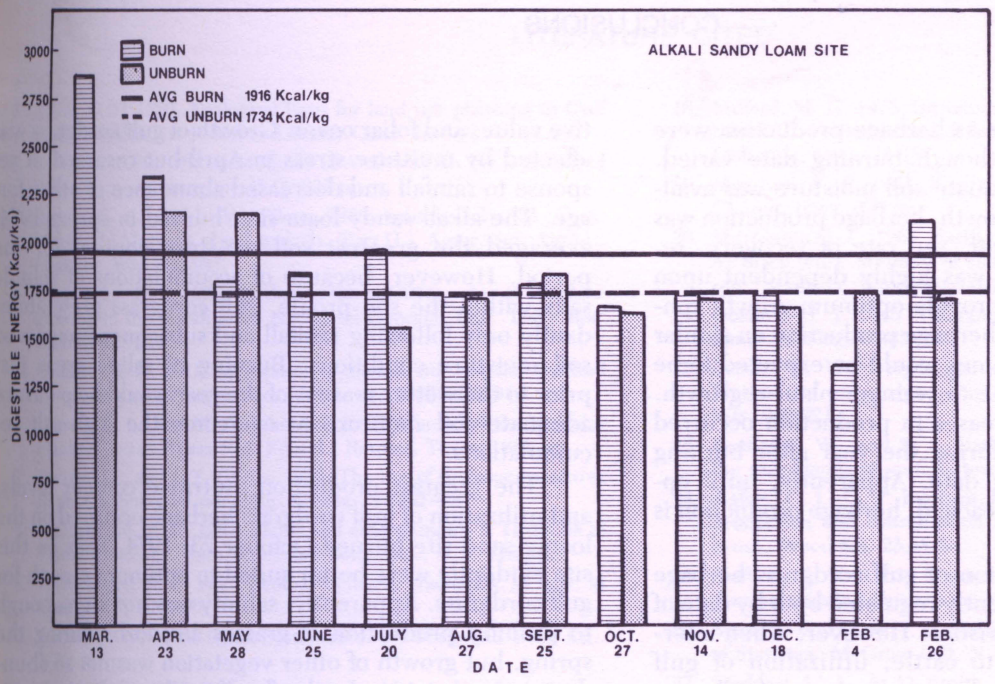

Figure 19. Digestible energy (kilocalories per kilogram) of unburned gulf cordgrass topgrowth and of regrowth following burning in spring 1974 on the alkali sandy loam site.

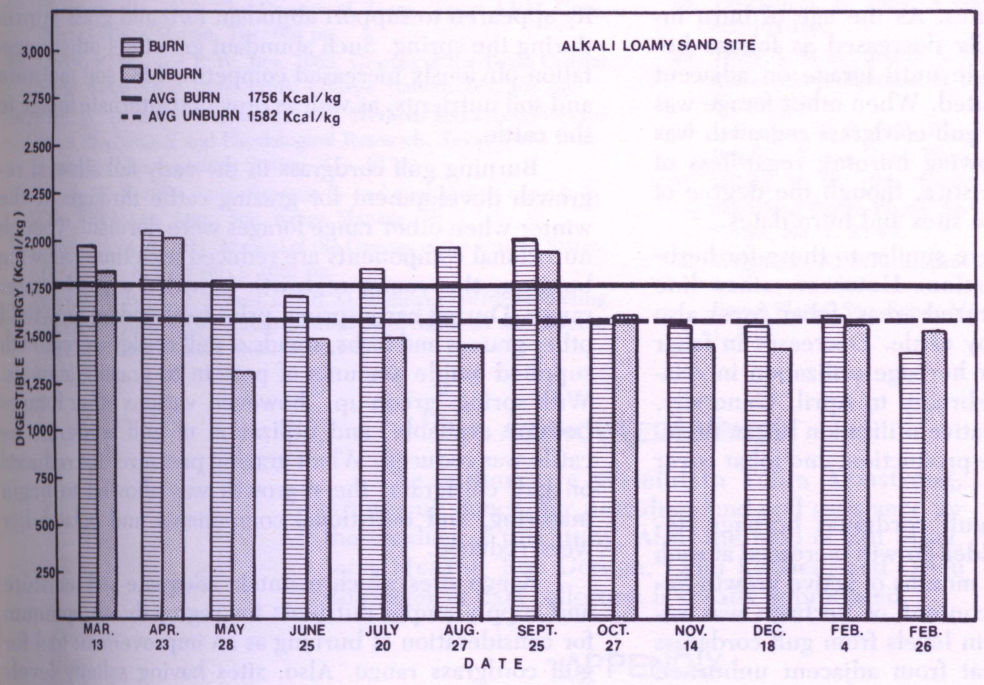

Figure 20. Digestible energy (kilocalories per kilogram) of unburned gulf cordgrass topgrowth and of regrowth following burning in winter 1975 on the alkali loamy sand site.

Trends for gulf cordgrass herbage production were similar across all sites although burning date varied. During periods when adequate soil moisture was available for gulf cordgrass regrowth, herbage production was greatly enhanced. However, the rate of recovery, regardless of burning date, was highly dependent upon site characteristics which provide optimum growth conditions. Generally, rate of herbage production on similar sites burned at different times would be expected to be greater on later burns, due to younger plant regrowth. However, substantial increases in production occurred in the early spring and during the year after burning regardless of the burning date. Apparently, until optimum foliar expansion is reached, herbage production is only moderate.

The extent of utilization of gulf cordgrass herbage following burning is apparently regulated both by date of burn and by site characteristics. However, when alternate forage is available to cattle, utilization of gulf cordgrass is reduced regardless of burn or site characteristics. Herbage utilization following burning, however, was similar among sites. As the age of burn increased, utilization generally decreased as foliage became coarse and unpalatable until forage on adjacent sites became seasonally limited. When other forage was not available, utilization of gulf cordgrass regrowth was increased on all sites following burning regardless of burn date or site characteristics, though the degree of utilization varied among the sites and burn dates.

Foliar cover trends were similar to those for herbage production and utilization. However, since line transects were placed in grazed areas, foliar cover also reflected use of the grass by cattle. Decreases in foliar cover also reflected greater herbage utilization in relation to production from February to April. Generally, after April and May, cumulative utilization began to decrease in respect to herbage production, and foliar cover began to increase.

Nutrient content of gulf cordgrass herbage decreased as the quantity of older growth increased at each sampling date. After 4 or 5 months of active growth following burning, protein content of herbage was reduced. During June, protein levels from gulf cordgrass burned in the fall and that from adjacent unburned plants were nearly equal, after which protein of treated plants was consistently below those levels within the unburned plants. It was at this time, 7 months after fall burning, that the herbage utilization began to slow in relation to production. Phosphorus levels were generally below maintenance levels for cattle, and variations in this nutrient were not significantly affected by burning. Digestible energy of gulf cordgrass regrowth following burning may attain almost 2,800 kilocalories per kilogram.

Lack of rainfall and availability of alternate forage for the first 3 months of study were reflected in reduced gulf cordgrass herbage production and utilization, nutritive value, and foliar cover. Growth of gulf cordgrass w affected by moisture stress in April but resumed in r sponse to rainfall and decreased abundance of other f age. The alkali sandy loam site, burned in spring 197 averaged the greatest soil moisture content for t period. However, because of accumulations of solub salts within the soil profile, gulf cordgrass grew abu dantly only following rainfall and subsequent improv soil moisture conditions. Burning of saline areas ju prior to the wetter seasons of the year would help ensu adequate soil moisture to overcome the high salt a cumulations.

The greatest production, nutritive content leve and utilization of gulf cordgrass herbage occurred on t loamy sand site burned October 23, 1974. Soils on th site evidently were better suited to optimum growth f gulf cordgrass. Apparently, salinity was not high enou to prohibit production of grasses and forbs during th spring, but growth of other vegetation was not so abu dant as to restrict growth of gulf cordgrass by compe tion for soil moisture and nutrients. Sites of lower sali ity appeared to support abundant forb and grass grow during the spring. Such abundant growth of other veg tation obviously increased competition for soil moistu and soil nutrients, as well as provided alternate forage the cattle.

Burning gulf cordgrass in the early fall allowed r growth development for grazing cattle throughout th winter when other range forages were dormant. Thou nutritional components are reduced with time followi burning, the young regrowth provided a good winte range. During early spring, prior to abundant growth other grasses and forbs, stands of gulf cordgrass regrow supplied ample amounts of protein to grazing anima With spring "green up," however, various other forag became available, and utilization of gulf cordgrass b cattle was reduced. When grazing pressure was reduc on gulf cordgrass, the regrowth was allowed to beg maturing, and nutritional components and palatabili were reduced.

Range sites which maintain adequate soil moistu and supply ample nutrients for regrowth are optimu for consideration of burning as an improvement tool f gulf cordgrass range. Also, sites having salinity leve that do not restrict gulf cordgrass growth but that d limit growth of other vegetation may be desirable whe total production potential is considered. Burning of sui productive sites on a rotational type system could poss bly supply grazing animals with palatable, nutritio range forage on a year-round basis. Burning in the fall desirable from the standpoint that palatable forage available to cattle during the winter. Also, regrowth productive sites during the spring, following burning the fall, is conducive to increased nutritional value gulf cordgrass, thus supplying grazing animals with n tritional forage prior to the availability of alternate f age.

LITERATURE CITED

1. Allen, P. F. 1950. Ecological basis for land use planning in Gulf Coast Marshlands. J. Soil and Water Cons. 5:57-67.
2. A.O.A.C. 1960. Official Methods of Analysis (9th Ed.). Assoc. of Agr. Chem. Washington, D.C. 832 pp.
3. Bower, C. A., and L. V. Wilcox. 1965. Soluble Salts. *In*. C. A. Black (ed.) Methods of soil analysis. (Part II.). Amer. Soc. Agron., Madison, Wis. 936-937.
4. Burkholder, P. R. 1956. Studies in the nutritive value of *Spartina* growing in the marsh areas of Coastal Georgia. Bull. Torry Bot. Club 83:327-534.
5. Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. J. Forestry 39(4):388-394.
6. Correll, D. S., and M. C. Johnston. 1970. Manual of the Vascular Plants of Texas. Texas Res. Found., Renner, Texas. 1881 pp.
7. Cottam, G., and J. T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology 37:451-460.
8. Daubenmire, R. F. 1967. Plants and environment; A Textbook of Plant Autecology. John Wiley and Sons, Inc., N.Y. 422 pp.
9. Daubenmire, R. F. 1968. Ecology of fire in grasslands. *In* Adv. in Ecol. Res. 5:209-266.
10. Gould, F. W. 1968. Grass Systematics. McGraw-Hill Book Co., N.Y. 337 pp.
11. Gould, F. W. 1975. Texas plants. A checklist and ecological summary. Texas Agr. Exp. Sta. MP-585 (Rev.):121 pp.
12. Gould, F. W. 1975. The Grasses of Texas. Texas A&M Univ. Press, College Station, Tex. 653 pp.
13. Gould, F. W., and T. W. Box. 1965. Grasses of the Texas Coastal Bend. Texas A&M Univ. Press, College Station, Tex. 189 pp.
14. Hall, W. C., and J. Hacskaylo. 1963. Methods and Procedures for Plant Biochemical and Physiological Research. Texas A&M Univ. Exchange Store, College Station, Tex. 81 pp.
15. Hinds, W. T. 1976. Range fires can be bad medicine on some soils. (Abs.) 29th Ann. Mtg., Soc. Range Manage. 56.
16. Hitchcock, A. S. 1971. Manual of the Grasses of the United States. Dover Co., N.Y. (2 vols.). 1051 pp.
17. McAtee, J. W., C. J. Scifres, and R. D. Oefinger. 1976. Predicting topgrowth yield of gulf cordgrass from basal diameter and volume measurements. Southw. Nat. (In Press).
18. Milford, M. H. 1975. Introduction to Soils and Soil Science. Laboratory Exercises. (2nd Ed.). Kendall and Hunt Publ. Co., Dubuque, Iowa. 11-18.
19. Morrison, F. B. 1961. Feeds and Feeding. Morrison Publ. Co., Clinton, Iowa. 696 pp.
20. Mortensen, J. L. 1965. Partial extraction of organic matter. *In* C. A. Black (ed.). Methods of soil analysis (Part II). Amer. Soc. Agron., Madison, Wis. 1401-1407.
21. Oosting, H. J. 1945. Tolerance to salt spray of plants of coastal dunes. Ecology 26:85-89.
22. Peech, M. 1965. Hydrogen-ion activity. *In* C. A. Black (ed.). Methods of soil analysis (Part II). Amer. Soc. Agron., Madison, Wis. 920-921.
23. Penfound, W., and E. S. Hathaway. 1938. Plant communities in the marshlands of southeastern Louisiana. Ecol. Mon. 8:1-56.
24. Scifres, C. J., G. P. Durham, and J. L. Mutz, 1977. Range forage production and consumption following aerial spraying of mixed brush. Weed Sci. 25:48-54.
25. Shiftlet, T. N. 1963. Major ecological factors controlling plant communities in Louisiana marshes. J. Range Manage. 16:231-234.
26. Steel, R. G. D., and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill, N.Y. 481 pp.
27. Stoddart, L. A., A. D. Smith, and T. W. Box. 1975. Range Management. (3rd Ed.). McGraw-Hill Book Co., N.Y. 532 pp.
28. Taschidjian, E. 1954. A note on *Spartina* protein. Econ. Bot. 8(2):164-165.
29. Tilley, J. M. A., and R. A. Terry. 1963. A two-stage technique for the *in vitro* digestion of forage crops. J. British Grassl. Cos. 18:104-111.
30. Vallentine, J. F. 1971. Range Developments and Improvements. Brigham Young Univ. Press, Provo, Utah. 516 pp.
31. Voight, P. W. 1974. Improving palatability of range plants. *In* Improved Range Plants. Soc. Range Manage., Range Symposium Series, No. 1. 23-49.
32. Wright, L. N. 1974. Improving range grasses for germination and seeding establishment under stress environments. *In* Improved Range Plants. Soc. Range Manage., Range Symposium Series, No. 1. 3-22.

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APPENDIX

English Equivalents of Metric Units

Metric Unit	*English Equivalent*
Centimeter	0.39 inch
Meter	3.28 feet
Kilometer	0.62 mile
Hectare	2.47 acres
Gram	0.0022 pound
Kilogram	2.2 pounds
Kilograms per hectare	0.89 pound per acre
Centigrade	(9/5 Fahrenheit) + 32

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