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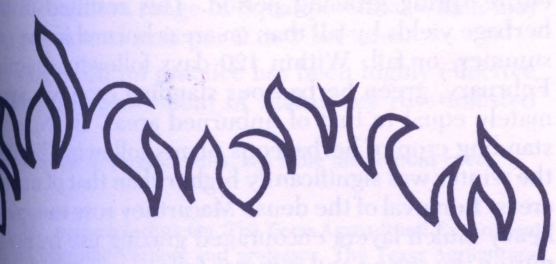
Burning for Improvement of Macartney Rose-Infested Coastal Prairie

METRIC UNITS — ENGLISH EQUIVALENTS

Metric Unit	*English Equivalent*
Centimeter	0.394 inch
Hectare	2.47 acres
Kilogram	2.205 pounds
Kilogram per hectare	0.893 pounds per acre
Kilometer	0.62 statute mile
Kilometer per hour	0.62 miles per hour
Liter	0.264 gallons
Meter	3.28 feet
Square meter	10.758 square feet
(*Degrees centigrade* × 9/5) + 32	*Degrees fahrenheit*

CONTENTS

METRIC UNITS —
ENGLISH EQUIVALENTS 2
SUMMARY 4
INTRODUCTION 5
MATERIALS AND METHODS 6
Description of the Study Area 6
Experimental Burns 7
RESULTS 7
Relationship of Fire Characteristics to Fuel Load and Environmental Conditions During Burning 7
Response of Macartney Rose to Burning 9
Response of Herbaceous Vegetation to Burning 9
Forage Utilization Following Burning 12
The Fire Plan 12
DISCUSSION AND CONCLUSIONS 14
ACKNOWLEDGMENTS 14
LITERATURE CITED 15



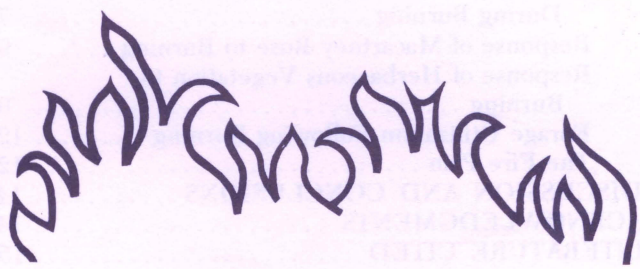
SUMMARY

Infestations of Macartney rose, a problem on more than 200,000 hectares of Texas Coastal Prairie, seriously reduce range forage production, restrict livestock movement, and hinder effective management of the rangeland. Since Macartney rose is apparently a volatile fuel, fire was studied as a potential improvement practice for rangeland infested with this troublesome plant.

Under a narrow range of wind speeds, 13 to 24 kilometers per hour, Macartney rose canopy reduction immediately following burning was directly related to the amount of dead herbaceous standing fuel (fine fuel load) and fuel moisture content. Season of burning functioned to determine the fine fuel load and the proportion of fine fuel as dead standing crop.

Although the Macartney rose canopies were completely removed, the percentage of plants killed by fire was negligible. After top removal by burning, Macartney rose canopy replacement occurred from resprouts originating from the plant bases. Elongation rate of new canes averaged 3 to 4 centimeters per month, regardless of season of burning. Macartney rose canopy replacement, based on canopy cover, averaged 10 to 15 percent per month following burning. Although canopy cover at 1 year after burning usually equalled the preburn cover, plant growth form was altered. Macartney rose canopies tended to assume a low spreading growth habit following burning as contrasted to the more upright growth habit of unburned plants. This change in growth form (reduction of the brush growth below the tops of the grass) improved access to forage by livestock in burned pastures.

Burning in winter effectively reduced the Macartney rose canopy for short-term gains in brush control and allowed the native range grasses to take advantage of the entire spring growing period. This resulted in higher herbage yields by fall than on areas burned in the spring, summer, or fall. Within 120 days following burning in February, green herbaceous standing crop was approximately equal to that of unburned areas. By November standing crop of herbaceous plants following burning in the winter was significantly higher than that of unburned areas. Removal of the dense Macartney rose canopies and heavy mulch layers encouraged grazing use by livestock during the spring and summer following winter burning.



Burning for Improvement of Macartney Rose-Infested Coastal Prairie

*R. A. Gordon and C. J. Scifres**

A native of China and Formosa, Macartney rose (*Rosa bracteata* Wendl.) was introduced into the United States in the early 1800's as hedge rows. It escaped cultivation in Texas, Oklahoma, Arkansas, and Louisiana. Also known as "Cherokee" and "rose hedge," Macartney rose has become a severe management problem in southeast Texas, especially on the Coastal Prairie and Marshes, a resource area of highly productive rangeland and farmland. Macartney rose also occupies extensive areas of the Pineywoods, Post Oak (*Quercus stellata* Wangenh.) Savannah, and Blackland Prairies of Texas (1).

A woody perennial with trailing thorny canes (Figure 1), Macartney rose produces white flowers 5 to 7 centimeters[1] in diameter (3). The plant evidently is of minor browse value although young leaves, canes, and floral parts are occasionally browsed by cattle (5). Seed germinate readily after passing through the digestive tracts of animals (9), and the manure affords an excellent environment for seedling establishment. The species may also spread asexually by canes which root at nodes after being pressed into moist soil.

Since it is a vigorous evergreen and the Coastal Prairie is typified by a growing season in excess of 300 days, Macartney rose may cover extensive areas in a short time. Dense clumps may exceed 3.5 meters in height and 6 meters in diameter (Figure 1). On heavily infested range, Macartney rose canopy cover many exceed 75 percent (12), and forage production is virtually eliminated beneath the canopies. Since livestock are restricted to grazing primarily those areas between Macartney rose plants, carrying capacities on heavily infested range may be reduced to one animal unit per 8 hectares compared with good condition range of equal potential which may support one animal unit per 2 to 3 hectares.

No single control practice has been highly effective for long-term improvement of Macartney rose-infested rangeland. The canopies are only temporarily reduced by mechanical practices such as raking and stacking, shredding, or roller chopping (9). Young Macartney rose plants and seedlings often can be effectively controlled with a single application of 2,4-D applied at 1 pound per acre. However, mature plants may require three or more consecutive applications of 2,4-D for effective control. Macartney rose regrowth is more difficult to control than is the undisturbed growth form (9). After application of herbicides, standing dead Macartney rose canes can result in a greater management problem relative to care of livestock than did the original growth (12). Also, multiple herbicide applications are costly and greatly reduce the production of forbs in the grassland community. Many broadleaved species are valuable for grazing, especially by wildlife, and for upland game bird habitat (13).

The steady increase in cost of chemical and mechanical range improvement practices necessitated the investigation of effective, less costly practices such as burning for improvement of Macartney rose-infested rangeland. Fire is a natural factor, and probably no range site has developed without its influence (4, 16). Prescribed burning, in contrast to wildfires, is the systematic firing of land when favorable weather and vegetation characteristics are expected to maximize benefits (16). Seed of many plants germinate readily following range burning, and seedling establishment is facilitated by contact with mineral soil rather than with superficial layers of organic debris. Mulch, that layer of dead plant material on the soil surface, contains nutrients that are largely unavailable for growth until released slowly and, usually incompletely, by decay. By contrast, burning releases nutrients rapidly and more completely than natural decomposition, resulting in a short-term fertilizing effect (18). During moist seasons, soil temperatures increase following burning, and nitrification is stimulated (19).

Prescribed burning may be effective for controlling parasites of large mammals on Coastal Prairie rangeland (8). Insects and fungi that are facultative parasites often must live in plant debris until conditions become favorable for attacking living hosts (4).

[1] To convert metric to English units, see table inside front cover.

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Figure 1. Undisturbed Macartney rose infestations near Bloomington in the Coastal Prairie of Texas.

Fire has been used as a management tool in the southeastern United States to reduce brush cover and maintain forbs and grasses in a vigorous growing condition, increasing food availability for bobwhite quail (*Colinus virginianus* L.) and wild turkey (*Meleagris gallopavo* L.) (10, 14, 15).

Scifres (12) proposed a system incorporating burning in winter with use of herbicides for improving Macartney rose-infested rangeland. Regardless of application rate, aerial sprays of 2,4,5-T ((2,4,5-trichlorophenoxy)acetic acid) + picloram (4-amino-3,5,6-trichloropicolinic acid) (1:1) applied in the fall were more effective than 2,4,5-T, 2,4-D ((2,4-dichlorophenoxy)acetic acid) or dicamba (3,6-dichloro-*o*-anisic acid), applied alone or in combination, for reducing density of live Macartney rose plants. Prescribed burning following the most effective chemical treatments (1.12 to 1.68 kilograms per hectare of 2,4,5-T + picloram) increased topgrowth control of Macartney rose compared to spraying alone and provided acceptable control levels for at least 3 years. However, there was no available research concerning potential variation in response of Macartney rose to season of burning. Previous research emphasized the use of herbicides followed by fire, and winter was arbitrarily chosen for installation of burns (12). Therefore, information was needed relative to season of prescribed burning for maximum initial canopy reduction of Macartney rose which had not been sprayed, maintenance of topgrowth control, and optimum production of range forage.

In 1975, research was initiated to study burning alone as a potential improvement method for Macartney rose-infested rangeland. Specific objectives were to (a) evaluate the extent and rate of regrowth of Macartney rose following burning at various seasons as related to selected environmental conditions, fuel characteristics, and stage of plant growth, (b) determine the duration of Macartney rose topgrowth suppression following burning, (c) evaluate range forage production and utilization following burning, and (d) develop an effective fire plan for prescribed burning on the Coastal Prairie.

MATERIALS AND METHODS

Description of the Study Area

The research site was in northwestern Calhoun County approximately 5 kilometers southeast of Bloomington, Texas. The area is level to gently undulating, primarily a Blackland range site, and no more than 1 meters above sea level. Climax vegetation is tall grass prairie supporting big bluestem (*Andropogon gerardi* Vitman var. *gerardii*), little bluestem (*Schzachryium scoparium* (Michx.) Nash var. *frequens* (F. T. Hubb) switchgrass, (*Panicum virgatum* L.), and yellow Indian grass (*Sorghastrum nutans* (L.) Nash.) as the principal decreasers. Increasers include longtom (*Paspalum lividum* Trin.), knotroot bristlegrass (*Setaria geniculata* (Lam.) Beauv.), brownseed paspalum (*Paspalum plicatulum* Michx.), and several low-growing species of *Panicum* and *Dicanthelium*. Rattail smutgrass (*Sporobolus indicus* (L.) R.Br.), broomsedge bluestem (*Andropogon virginicus* L.), snow-on-the-prairie (*Euphorbia bicolor* Engelm. and Gray), spiny aster (*Aster spinosus* Benth.), and bushy sea-oxeye (*Borrichia frutescens* (L.) DC.) are herbaceous invaders. Bermudagrass (*Cynodon dactylon* (L.) Pers.) and dallisgrass (*Paspalum dilatatum* Poir.), introduced grasses common on adjacent tame pastures, have encroached upon portions of the study area.

The primary soils, Lake Charles and Victoria clay, are montmorillonitic, basic in reaction (pH 8.5) and less than 10 percent sand, more than 60 percent clay and less than 1 percent organic matter in the surface 15 centimeters (11). The soils are weakly developed, very slowly permeable, drouthy in summer, and often saturated from late fall to early spring. Average annual rainfall is about

centimeters, and the annual frost-free period is 300 days (6). The heavy infestations of Macartney rose on most of the area were treated with 2.24 kilograms per hectare of 2,4-D in 1966 and with 1.12 kilograms per hectare of the herbicide annually from 1967 through 1971. Several undisturbed strips had been maintained to provide cover for the abundant white-tailed deer (*Odocoileus virginianus* L.) population. The pasture in which the experimental plots are located is usually grazed by cattle from late spring to late fall.

Experimental Burns

Burns were installed as headfires at 2- to 3-month intervals beginning in February 1975. The experiment was designed as a randomized complete block with four replications. Plots were 61 by 91.5 meters (approximately 0.45 hectares) and separated by disced buffer strips 9 meters wide.

Prior to burning, two 30.5-meter permanent transect lines, 6.5 meters apart, were established diagonally across each plot. Foliar cover interception by live Macartney rose was recorded prior to burning and periodically following the fires (2). Interceptions spaced less than 1.27 centimeters apart along the lines were recorded as continuous canopy cover. Average cane length of Macartney rose regrowth (from ground line with cane extended) following burning was measured for each interception.

The permanent lines established for monitoring Macartney rose canopy cover replacement were also utilized for placement of inclined 10-point frames for determination of herbaceous plant basal cover (1). Basal contacts from 10 permanent sampling areas were taken 3.05 meters apart along each line at 2-month intervals following each burn.

Immediately prior to each burn, ten 0.25-meter-square sampling areas, equidistantly spaced diagonally across each plot at 7-meter intervals, were harvested to a 2.5-centimeter stubble height. Standing herbaceous fuel was hand separated into green and dead. Mulch was arbitrarily divided into fine ($\leq$ 0.3 centimeter diameter) or coarse ($>$ 0.3 centimeter diameter) classes. All fuel samples were sealed in aluminum cans, air-dried at 65 degrees centigrade for 48 hours and weighed. Air-dry moisture content of standing herbaceous growth and mulch, and oven-dry (105 degrees centigrade for 48 hours) moisture content of soil were determined on three samples from each plot. Soil samples were recovered from 0 to 2.5, 2.5 to 15, and 15 to 30 centimeters deep. Environmental conditions, including relative humidity, air temperature at 2 meters above ground line, soil temperature at 2.54 centimeters deep, and wind velocity and direction at 2 meters above ground line, were monitored during each burn.

After the plots were backfired on the leeward side(s) to 15 to 31 meters, the headfire was ignited on the windward side. Duration of the burn, as recorded for this study, began when the headfire was ignited and ended when the headfire and backfire met.

Asbestos cards supporting fire sensitive Tempil[2] pellets behind mica sheets were used to estimate maximum temperature attained during the burns. Three temperature monitoring stations, each consisting of mica sheets with pellets placed at 0, 30, and 45 centimeters above ground level, were placed in each plot. Immediately following the burns, percentage of the plot area burned and percentage Macartney rose canopy reduction were visually estimated.

Five portable exclosures were established in each plot to allow periodic evaluation of range forage production and utilization following the burns (13). The exclosures, constructed from 10-gauge welded wire with 10- by 10-centimeter openings, were approximately 1.5 meters tall and 1 meter in diameter. The term "forage utilization" will be used herein to relate net forage loss — the combination of influences such as weathering, trampling, consumption by wild animals and insects as well as forage consumption by livestock. The exclosures were placed on a diagonal line perpendicular to the permanent lines established for evaluation of Macartney rose canopy replacement. Herbaceous vegetation in 0.25-meter square sampling areas was harvested to a 2.5-centimeter stubble from the center of each exclosure. Approximately 4 meters from each exclosure, a 0.25-meter-square area was harvested from the grazed vegetation. Green herbaceous topgrowth, separated into live grasses, forbs, and woody plants, standing dead herbaceous material, and coarse and fine mulch, was air-dried and weighed. Differences in herbaceous standing crop between protected and grazed samples were used to estimate forage utilization for that grazing period. Harvests from within each exclosure were used to estimate production. After harvesting, the exclosures were moved a predetermined distance along the permanent line to begin another grazing period.

Forb response in burned areas previously occupied by the Macartney rose canopy was assessed in May and September 1975 and in April 1976. Four lines were established from the base of four, randomly selected Macartney rose plants, outward in the four cardinal directions until the perimeter of the original Macartney rose canopy was intercepted. Forb height and density by species were recorded in contiguous sampling areas, 0.6 by 0.6 meter, along each line.

RESULTS

Relationship of Fire Characteristics to Fuel Load and Environmental Conditions During Burning

Herbaceous fuel for burns in the winter consisted almost totally of dead standing material since the warm season grasses, which afforded the bulk of fine fuel, were dormant (Table 1). Spring growth increased the total standing herbaceous fuel in April and June, compared to the fine fuel load in the winter, and decreased the proportion of total fine fuel afforded by standing dead material.

[2]Manufactured by Tempil, Div. of Big Three Industries, So. Plainfield, N.J.

TABLE 1. AIR-DRY FUEL LOAD (KILOGRAMS PER HECTARE), EXCLUDING GREEN MACARTNEY ROSE, IMMEDIATELY PRIOR TO BURNING COASTAL PRAIRIE AT VARIOUS DATES NEAR BLOOMINGTON, TEXAS, IN 1975

Burning date (1975-76)	Fuel components					
	Fine fuel					
	Standing					
	Green	Dead	Mulch	Total	Coarse mulch[a]	Total fuel
Feb. 28	T[b]	3,460	3,723	7,183	16	7,199
April 15	3,064	2,096	3,620	8,780	8	8,788
June 3	3,944	2,243	4,396	10,583	30	10,613
Oct. 15	2,824	1,368	2,976	7,168	10	7,178
Jan. 10	T[b]	4,150	2,293	6,443	21	6,464

[a]Fine mulch was less than or equal to 0.3 centimeter in diameter; coarse mulch was greater than 0.3 centimeter in diameter.
[b]Trace amounts of green matter were noted but could not be effectively separated.

There was also a reduction in the amount of dead standing fine fuel available in the fall compared to that in the winter, presumably due to drying, collapse, and deterioration of the standing herbaceous material. The amount of fine mulch tended to be greater in the summer than during other seasons of burning. Relatively low amounts of coarse mulch, consisting primarily of broken Macartney rose canes from previous herbicide applications in the 1960's, were present (Table 1). The estimated contribution of coarse mulch is biased somewhat since the area directly under Macartney rose plants could not be sampled.

Burns installed in the winter (February 1975 and January 1976) were conducted under bright skies with an average wind velocity of 13 kilometers per hour and occasional gusts of 19 kilometers per hour (Table 2). Burns installed in January were conducted with wind from the southeast and 38 percent fuel moisture content as contrasted to the February burns with winds from the northwest and fuel moisture content of 15 percent. Flame heights exceeded 8 meters, and rate of movement of the fire front exceeded 14.5 meters per minute (Table 3). Effective area burned (that blackened by fire) was 80 to 95 percent. Average maximum temperature of the flame front reached 337 degrees centigrade at ground line and 316 degrees centigrade at 46 centimeters above ground line (Table 2). During the same time of year, under the same monitoring system and at the same location in another study, maximum temperatures of 566 degrees centigrade were achieved at 15 centimeters above ground line (7). The reasons for the consistently lower temperatures in the present study are not clear.

Burns in the spring (April) were conducted with wind speeds averaging 24 kilometers per hour (Table 2), but rate of fire front movement was only 8.7 meters per minute (Table 3). Although air temperature was 6 degrees centigrade higher during burns in April than during burns in February, relative humidity was 70 and 58 percent, respectively. Also, over half of the fine fuel load was afforded by green herbage (Table 1). These factors resulted in fuel moisture percentage in April being almost twice that in fuel available for burning in February (Table 2). Rate of fire front movement in the summer (June), with 35 percent fuel moisture and lower wind velocity (15 kilometers per hour) than the burns in April, averaged 7.4 meters per minute (Table 3). Higher fuel moisture content reflected the increased contribution of green herbaceous top growth to total fine fuel during burning in June (Tables 1 and 2). The slowest burn, conducted in the fall (October) (Table 3), was installed under a 16 kilometer-per-hour wind speed, 48-percent fine fuel moisture content, and 66-percent relative humidity (Table 1). About one-third of the fine fuel load was afforded by green material. Maximum flame height attained during burning in October was approximately 4 meters. The fire was slow and relighting was required on two of the four plots. However, once adequately ignited, the average maximum temperatures were equal to or higher than in burns installed in the winter (Table 2).

Duration of burn (inversely related to rate of fire front movement) was correlated more closely with fuel moisture content and amount of dead standing herbaceous material (fine fuel) than with air temperature, relative humidity, and moisture content of the mulch. Duration of

TABLE 2. ENVIRONMENTAL CONDITIONS DURING BURNING OF MACARTNEY ROSE-INFESTED COASTAL PRAIRIE AT VARIOUS DATES NEAR BLOOMINGTON, TEXAS

Burning date (1975-76)	Wind		Temp. (C)		Relative humidity (%)	Fuel moisture content (%)	Avg maximum fire temperature (C)		
	Speed (kph)	Direction	Air	Soil			0 cm	30 cm	46 cm
Feb. 28	13	N	22	19	58	15	337	323	316
April 15	24	SE	28	20	70	29	267	309	253
June 3	15	S	30	20	65	35	a	a	a
Oct. 15	16	SE	20	23	66	48	357	329	343
Jan. 10	13	SE	19	18	57	38	260	288	288

[a]Data not taken.

TABLE 3. ESTIMATED MACARTNEY ROSE CANOPY REDUCTION (%) IMMEDIATELY FOLLOWING BURNING AND RATE OF THE FIRE FRONT MOVEMENT NEAR BLOOMINGTON, TEXAS

Burning date (1975-76)	Canopy reduction (%)	Rate of burn (m/min)
Feb.	49[a]	14.7
April	83	8.7
June	78	7.4
Oct.	78	4.0
Jan.	96	14.5

[a]Canopy reduction approximately 2 weeks following burning was 90 percent.

burn was negatively correlated with the amount of dead standing fine fuel ($r = -0.66$). Percent moisture of fuel was positively correlated with duration of burning ($r = 0.79$). The lack of correlation of rate of fire front movement with wind speed was expected since a relatively narrow range of wind speeds was used (Table 2).

Based on these data, burning in the winter when the fine fuel was composed totally of dormant herbaceous matter of low moisture content resulted in the most rapid burn rates. Burning in the spring or summer with a high proportion of green fine fuel resulted in slower, but not necessarily hotter, fires. In the Coastal zone, burning in the fall apparently will result in much slower fires than during other seasons, a response to the low proportion of the fuel load afforded by dead standing fine material (only 1,368 kilograms per hectare in this study) (Table 1), and a higher fuel moisture content (Table 2).

Response of Macartney Rose to Burning

Macartney rose canopy reduction (Table 3) was not effectively correlated with environmental conditions at the time of burning, probably as a result of (a) an inability to visually assess small differences in burndown and (b) the relatively high effectiveness of most burns in reducing Macartney rose topgrowth. The lowest initial canopy reduction occurred following the February burn. However, heat scorch from the burn resulted in removal of 90 percent or more of the Macartney rose canopy within 2 weeks after the fires, regardless of date of burning.

Regrowth of Macartney rose was initiated within 2 weeks, regardless of burn date. Canopy reestablishment relative to the original cover occurred at 6 to 8 percent per month (Table 4). Average cane elongation was 3.9 centimeters per month with little apparent variation attributable to time of burning (Table 5). Characteristically, Macartney rose regrowth developed vertically to approximately 15 to 20 centimeters before the canes bent and growth continued laterally. Where debris from burned Macartney rose was still intact, regrowth trellised over the dead canes, resulting in greater canopy heights than on areas with complete burndown.

Response of Herbaceous Vegetation to Burning

Although burning did not kill the Macartney rose plants, top removal by the fires greatly reduced the influence of the woody plant on the herbaceous species. The effect of the fires on the Macartney rose, removal of the "rough" (dead standing herbaceous growth), and reduction in the heavy mulch cover which can retard development of herbaceous plants (10) apparently promoted rapid growth of herbaceous species. New growth was quickly initiated following the winter burn and increased rapidly during the first 2 weeks of March 1975. Although production of green herbaceous growth in April was less on areas burned in February than on unburned plots, production on burned areas equalled that of unburned areas by July 1 (Table 6). Cumulative precipitation by April was about 59 percent of normal for that period but was above average by July. However, soil moisture content was 37 percent in the surface 2.5 centimeters at the same time of the winter burn, apparently adequate for initiation of new spring growth.

Burning in April removed the early spring production so that standing herbaceous crop in July was significantly less than on unburned plots or on those burned in February. Conditions were relatively dry preceding the burn in April, and soil moisture content in the surface 2.5 centimeters was only 15 percent. However, rainfall was higher than normal following the burn and until late summer. These data suggest that the dry conditions preceding the spring burn and relatively low soil moisture at

TABLE 5. MEAN PLANT HEIGHT (CM), CANE LENGTH (CM), AND AVERAGE CANE ELONGATION RATE OF MACARTNEY ROSE BY APRIL 1976 FOLLOWING BURNING AT VARIOUS DATES NEAR BLOOMINGTON, TEXAS

Burning date (1975-76)	Plant height (cm)	Cane length (cm)	Cane elongation rate (cm/mo)
Feb.	29	55	4.2
April	19	41	3.4
June	17	40	3.9
Oct.	13	19	3.2
Jan.	10	13	4.6

TABLE 4. MACARTNEY ROSE CANOPY REPLACEMENT AS A PERCENTAGE OF THE ORIGINAL CANOPY COVER BY VARIOUS DATES FOLLOWING BURNING OF COASTAL PRAIRIE NEAR BLOOMINGTON, TEXAS

Burning date (1975-76)	Evaluation date						
	1975					1976	
	April	May	July	Sept.	Nov.	March	April
Feb.	4	45	57	62	76	99	97
April	–	7	23	39	66	74	71
June	–	–	5	41	71	70	67
Oct.	–	–	–	–	1	21	40
Jan.	–	–	–	–	–	14	25

TABLE 6. AIR-DRY YIELDS (KG/HA) OF TOTAL HERBACEOUS STANDING CROP FOLLOWING BURNING OF MACARTNEY ROSE INFESTED COASTAL PRAIRIE NEAR BLOOMINGTON, TEXAS[a]

Burning date (1975-76)	Harvest date (1975-76)				
	April 20	July 1	Aug. 17	Nov. 21	May 18
None	2147 b	2766 f	4145 mn	1556 t	2093 y
Feb.	618 a	2856 f	4830 n	1928 u	2702 y
April	–	1833 e	3400 m	1403 t	2443 y
June	–	549 d	1974 l	1038 s	2535 y
Oct.	–	–	–	160 r	1286 y
Jan.	–	–	–	–	1107 y
Cumulative ppt. (cm)	10.36	46.96	62.42	79.74	126.98
Departure from normal (cm)[b]	−7.30	+10.85	+11.23	−1.76	–

[a]Means within each column followed by the same letter do not differ significantly ($P \geq 0.5$), using Duncan's New Multiple Range Test.
[b]Based on rainfall records from the U. S. Weather Bureau at Victoria, Texas.

the time for burning may have restricted the rate of response of the herbaceous vegetation to fire.

Removal of spring production by burning in June was also evidenced by significantly reduced herbaceous standing crop on July 1, 1975, compared to other treatments. By late summer (August 17), plots burned in February yielded 4,830 kilograms per hectare of standing crop, the highest production for that evaluation date and for the study. However, production of herbaceous topgrowth following burning in June was reduced for the entire summer and into the fall compared to earlier burns or unburned areas. Warm season grasses, the major contributors to botanical composition of the vegetation, were entering dormancy by time of evaluation in November. Cumulative rainfall by the fall evaluation was near normal. Plots burned in February supported significantly more standing crop in November than did other treatments. However, total green herbaceous production decreased in November compared to that of evaluations in August, regardless of burn date. This is a natural occurrence due to weathering during the fall.

By May 1976, almost a year and a half following the first winter burn, standing crop was not significantly different among plots regardless of burning treatment (Table 6). Although, standing crop tended to be lower in May 1976, where burns were installed the previous October and January, the reduction was not significant.

Forb production on Coastal Prairie is typically highly variable and relatively low compared to grass production. Forb production increased dramatically following burning in late February 1975 compared to unburned Coastal Prairie (Table 7). Annual forbs such as Texas croton (*Croton texensis* Muell. Arg.), snow-on-the-prairie, pink rosegentian (*Sabatia campestric* Nutt.), and dayflower (*Commelina anomala* (Torr.) Woodson) were especially prominent following the February burning. Standing crop of forbs in mid-summer (July 1975) was approximately three times greater on areas burned in February than on those burned in April, June, or on unburned areas. Forb release, apparently a short-term effect of burning, was not apparent by late summer (August 1975). Forb production decreased dramatically during the hot summer months, regardless of time of burn. Forb production in May 1976 was highly variable although burne areas tended to support higher forb production than di unburned areas.

As previously mentioned, herbaceous vegetation essentially eliminated under the heavy Macartney ro canopies. Over half of the land surface area on the stu site may be covered by the woody plant canopies (1 Removal of the Macartney rose topgrowth by burni opened these areas for establishment of herbaceous fo age species. Immediately following burning, a hea layer of white ash was deposited on the circular are previously covered by the dense Macartney rose canop Following burning in February, vegetation change these areas followed a typical pattern of secondary su cession, initially supporting numerous Texas croton a knotroot bristlegrass seedlings. As the herbaceous veg tation recovered from burning, location of the origi Macartney rose plants was evidenced by circular p terns composed almost solely of robust Texas croton. height and density during the initial months followi the February burn varied directly with the apparent d gree of potential competition of other species. For i stance, at 0.6 meter from the center of the origi Macartney rose plants, Texas croton averaged 3.3 pla per meter square with an average height of 3.8 c timeters (Figure 2). This zone supported acti Macartney rose regrowth, typically erect with no m

TABLE 7. AIR-DRY YIELDS (KG/HA) OF FORB STANDI CROP FOLLOWING BURNING OF MACARTNEY ROSE- FESTED COASTAL PRAIRIE NEAR BLOOMINGTON, TEXA

Burning date (1975-76)	Harvest date				
	1975				1976
	April 20	July 1	Aug. 17	Nov. 21	May 1
None	0 a	56 e	13 l	0 r	7 x
Feb.	56 b	163 f	26 l	52 s	22 x
April	–	54 e	18 l	0 r	34 x
June	–	57 e	28 l	19 rs	94 x
Oct.	–	–	–	1 r	63 x
Jan.	–	–	–	–	39 x

[a]Means within each column followed by the same letter do not di fer significantly ($P \geq 0.05$), using Duncan's New Multiple Range Test.

than 0.5-meter lateral growth originating from base of the burned plant, within 2 weeks following burning. From 0.6 to 2.5 meters from the center of the original Macartney rose plant, Texas croton density exceeded 11 plants per meter square with an average height of over 90 centimeters. At the time of evaluation in May, Macartney rose regrowth had not extended into the 0.6-to 2.5-meter zone. At 2.5 to 3.1 meters from the center of the burned Macartney rose canopy, Texas croton height drastically decreased, 45.7 compared to 95.3 centimeters; and the density decreased to 6.4 plants per square meter. Both density and height of the Texas croton decreased gradually to a distance of 4.9 to 5.5 meters from the center of the original Macartney rose canopy. No Texas croton occurred within the stands of perennial grasses beyond the original Macartney rose canopy perimeter. With time following the burn, the circular areas became reoccupied with Macartney rose and with perennial grasses such as brownseed paspalum, silver bluestem, and little bluestem. Observations in fall 1975 and spring 1976 showed no difference in forb presence in these areas compared to presence in the interspaces between the original Macartney rose plants.

The percentage of bare ground was dramatically increased by burning, primarily by removal of the mulch cover; however, by mid-summer there were no differences in percentage of bare ground between plots burned in February and April 1975. As would be expected, the greatest amount of bare ground occurred on the most recent burn (June). Unburned plots, characterized by mulch accumulation, maintained a high percentage of ground cover regardless of evaluation date. By May 1975, percentage of bare ground was reduced on all burned areas except those installed in October. The reductions were largely attributed to mulch deposits during the winter and the spring growth response which increased the density of live grass culms. Reestablishment of herbaceous vegetation following the October burns was slow during the winter months; this increased the chances of mulch being scattered by winds. Throughout the study period, mulch cover was typically highest in unburned plots, and occasionally accumulations exceeded 2.5 centimeters deep.

As expected, green grass basal cover fluctuated with season as well as with time after burning. By November, highest basal cover of green grass occurred where burns had been installed the previous February or April; this probably reflected the original higher density of common bermudagrass and longtom. Ground cover (data not shown) of forbs on burned areas in November generally reflected overall trends in forb production (Table 7) except on those areas burned in October. Although forb production on areas burned in October was lower than that on other areas, forbs afforded more of the ground cover. This difference occurred because forbs typical of the October burn, particularly yellow woodsorrel (*Oxalis dillenii* Jacq.), were mat-like in growth form, whereas those following burns in other season were erect in growth form.

Mulch cover is important in buffering the soil surface against temperature extremes and in reducing rate of moisture loss (17). However, excessive mulch cover, exemplified by unburned areas in this study, can restrict growth and development of new seedlings and delay soil warming in spring. Mulch accumulations by May following burning in February averaged 1,529 kilograms per hectare. The highest accumulations following other burn

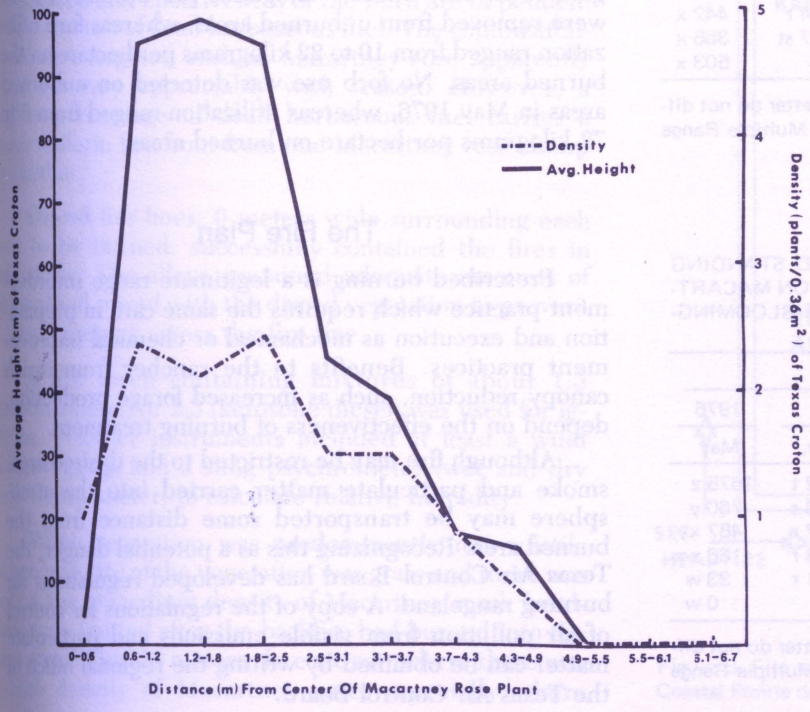

Figure 2. Mean height and density of Texas croton on burned areas previously covered by Macartney rose canopies on April 20, 1975, near Bloomington, Texas. The areas were burned in February.

dates averaged 638 kilograms per hectare after the fires in April (Table 8). At this same time, the untreated area supported over 2,800 kilograms per hectare of mulch.

Removal of dead standing herbaceous material, of little value to grazing animals, to allow replacement with green forage growth is considered an attribute of burning. Dead standing herbaceous growth was effectively reduced by all burns, and the reduction was still apparent in May, 17 months following the earliest burns (Table 9). Replacement of the dead standing topgrowth is important to restore the mulch cover to adequate levels following burning.

Forage Utilization Following Burning

On August 17, 1975, utilization of herbaceous topgrowth was greatest following February burns (Table 10). Livestock were allowed to use the pasture containing the burned areas from June 5 to August 31, 1975, and from November 11, 1975, to March 31, 1976. Thus, the burned areas were subjected to differential deferment periods following burning, ranging from about 4 months with the winter burn to essentially no deferment for the summer burn. Forage utilization on plots burned in February represented approximately 45 percent of the standing crop in contrast to 23 percent utilization on adjacent unburned areas.

TABLE 8. AIR-DRY YIELDS (KG/HA) OF MULCH AT VARIOUS DATES FOLLOWING BURNS ON MACARTNEY ROSE-INFESTED COASTAL PRAIRIE NEAR BLOOMINGTON, TEXAS[a]

Burning date (1975-76)	Harvest date 1975 April	July	Aug.	Nov.	1976 May
None	3276 b	3924 g	3979 m	3554 u	2806 z
Feb.	475 a	301 e	290 l	1332 t	1529 y
April	–	910 e	257 l	542 rs	638 x
June	–	1670 f	108 l	264 r	442 x
Oct.	–	–	–	1107 st	365 x
Jan.	–	–	–	–	503 x

[a]Means within each column followed by the same letter do not differ significantly (P ≥ 0.05), using Duncan's New Multiple Range Test.

TABLE 9. AIR-DRY YIELDS (KG/HA) OF DEAD STANDING HERBACEOUS MATERIAL FOLLOWING BURNS ON MACARTNEY ROSE-INFESTED COASTAL PRAIRIE NEAR BLOOMINGTON, TEXAS[a]

Burning date (1975-76)	Harvest date 1975 April	July	Aug.	Nov.	1976 May
None	3560 a	1366 f	993 m	1422 t	1675 z
Feb.	71 b	25 e	34 l	756 s	760 y
April	–	0 e	0 l	267 r	487 xy
June	–	41 e	0 l	88 r	166 wx
Oct.	–	–	–	271 r	33 w
Jan.	–	–	–	–	0 w

[a]Means within each column followed by the same letter do not differ significantly (P ≥ 0.05), using Duncan's New Multiple Range Test.

TABLE 10. DIFFERENCES IN TOTAL HERBACEOUS GROWTH YIELDS (KG/HA) FROM PROTECTED AND GRA AREAS DURING GRAZING PERIODS FOLLOWING BUR OF COASTAL PRAIRIE NEAR BLOOMINGTON, TEXAS[a]

Burning date (1975-76)	Harvest date Aug. 17, 1975	May 15, 1976
None	928 a	1562 y
Feb.	2184 b	1755 y
April	1616 ab	1609 y
June	1165 ab	2125 y
Oct.	–	879 x
Jan.	–	724 x

[a]Means within each column followed by the same letter do no fer significantly (P ≥ 0.05), using Duncan's New Multiple F Test.

Forage utilized by August following burns in totaled 1,616 kilograms per hectare, and 1,165 kilog per hectare were removed from the plots burne June. Although utilization of forage by these dates not significantly greater from burned than from burned plots, total forage production was lower bec of the short period from burning until evaluation. sequently, percentage total utilization by August burning in June represented approximately 48 an percent, respectively, of the forage utilized among burned plots and those burned in the previous ruary, April, or June. Forage utilized by May after b ing in October or January, representing livestock us only one growing season, was significantly lower from other treatments. However, percentage fo used was relatively high since utilization represente and 65 percent of the forage produced, respectivel

Although there was a trend for increased us forbs on the burned areas, there were no signifi differences in forb utilization regardless of treatmer the August 1975 and May 1976 evaluation dates. By *gust 1975, only about 9 kilograms per hectare of* were removed from unburned areas, whereas forb u zation ranged from 10 to 22 kilograms per hectare on burned areas. No forb use was detected on unbur areas in May 1976, whereas utilization ranged from 72 kilograms per hectare on burned areas.

The Fire Plan

Prescribed burning is a legitimate range impr ment practice which requires the same care in prep tion and execution as mechanical or chemical impr ment practices. Benefits to the rancher from b canopy reduction, such as increased forage product depend on the effectiveness of burning treatment.

Although fire may be restricted to the desired a smoke and particulate matter carried into the at sphere may be transported some distance from burned area. Recognizing this as a potential danger, *Texas Air Control Board has developed regulations* burning rangeland. *A copy of the regulations for cont of air pollution from visible emissions and particulat matter can be obtained by writing the regional office o* the Texas Air Control Board.

Environmental conditions govern the effectiveness prescribed burning. Generally, relative humidity uld be low since fire is faster and hotter in a drier osphere. In the Coastal Prairie, however, relative midity is typically higher than in most other regions of xas. Based on this research, 50 to 70 percent relative midity was acceptable as long as fuel moisture per-ntage was not drastically increased.

Wind speed is important in carrying the fire front d maintaining effective flame height. Based on this search, minimum wind speed should range between and 16 kilometers per hour. Maximum wind speed ould not exceed 29 kilometers per hour since excessive gh winds can reduce success by sweeping the fire too ickly over the vegetation and increasing the danger at a prescribed burn will become a wildfire. Uni-rmity of wind velocity is desirable. Sometimes, gusty onditions generate fire whirlwinds, creating "fire torms" that can cross fire lines.

North winds are characteristically drier, although uccessful burning can be executed with south winds of dequate speed. If the area to be burned, for example, is ordered by a road along the south side, correct wind direction can be used to an advantage. Here, by burning with a south wind, the risk of smoke crossing the road is reduced.

High moisture content of the vegetation may pre-vent the fire front moving uniformly across the area. Based on this research, two windy, sunny days following rain was adequate time to lower moisture to that re-quired for effective burning. A small test area with a properly disced perimeter was ignited when it was un-certain as to whether the moisture of the vegetation was low enough for a successful burn.

The time of year is important for a successful burn since speed and effectiveness of the burn are dependent on the amount of dead herbaceous fuel. The combustibil-ity of an evergreen such as Macartney rose apparently does not vary appreciably with season. However, a higher percentage of dead herbaceous fuel carries a more uniform fire front from one Macartney rose clump to another.

Disced fire lines, 6 meters wide surrounding each area to be burned, successfully contained the fires in this study. The alleys contained adequate amounts of mineral soil mixed with the disced vegetation to prevent it from creeping across the fire line.

A fire torch containing mixtures of about 1:3 (gasoline:diesel) or 2:3 (kerosene:diesel) was used for ig-nition. Weather instruments included at least a wind velocity gauge and a sling psychrometer (wet and dry bulb thermometer) to calculate relative humidity.

When vegetation was predominantly non-volatile (when majority of the vegetation was grass and there was only a low to medium density of Macartney rose), head-fires were ignited after the backfire had burned into the area about 15 to 18 meters. In contrast, where there was a high density of Macartney rose, especially where plants had no previous improvement practices applied, a backfire of 31 meters was installed before lighting the headfire. An alternative plan is to backfire during moist weather. Backfiring in the fall to at least 31 meters followed by a winter headfire, for example, reduces the possibility that the fire will escape.

After the backfire was ignited, the entire fire line was checked to insure uniform burning before authorization was given to light the headfire. Areas such as bermudagrass patches and cattle trails presented discontinuities in the fuel cover and were sometimes difficult to burn. These areas were re-ignited since they could later serve as fuel for the headfire.

When the wind was perpendicular to the fire line, only one side was ignited. Personnel began at the middle and ignited the fire front outward. Frequently, however, the wind was moving in a diagonal fashion. In these instances, personnel began backfiring at the leeward corner and progressed along each of the two sides (Figure 3). A similar approach was taken for the headfire along the windward sides. This technique provided an even flame front which afforded few, if any, control problems.

As a general rule, burns were patrolled for 24 hours after burnout. Stumps, logs, bunchgrasses, and manure that continued to burn along the edge of the fire were broken up to reduce fuel density. Special care was taken in extinguishing fires found in low areas such as in root systems below the soil surface.

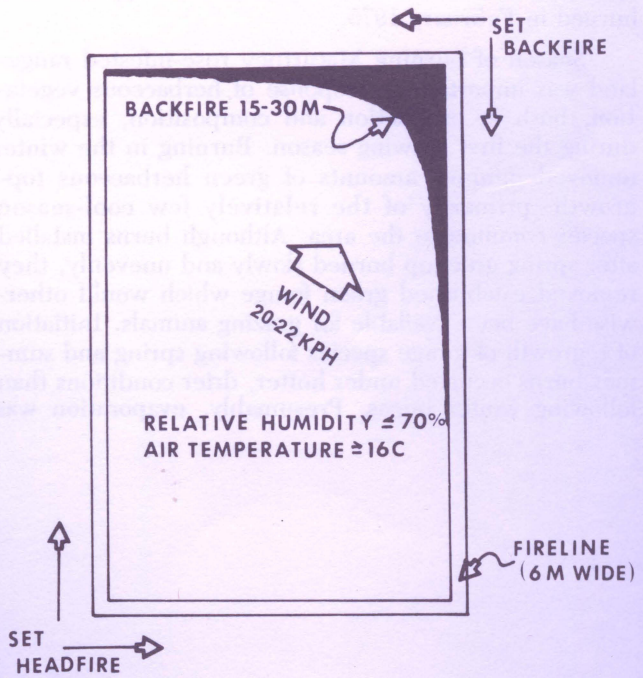

Figure 3. Fire plan as implemented for installation of burns on the Coastal Prairie during 1975-76.

DISCUSSION AND CONCLUSIONS

Regardless of season, prescribed burning was effective in initially removing the Macartney rose canopies and releasing range forage plants on the Coastal Prairie. Uniformity and speed of the fire front, within the narrow range of wind speeds used, was most influenced by total fine fuel load, moisture content of fine fuel, and proportion of dead standing herbaceous material in the fine fuel. Burning during the winter when warm season grasses, the majority of the fine fuel, were dormant, removed only the Macartney rose canopies and dead herbaceous material. Prescribed burning in the spring and summer, when the fine fuel content of green herbaceous material was higher, tended to reduce the rate of movement of the flame front and decreased uniformity of movement. Relighting of the green fine fuel often was required to carry the fire front between Macartney rose clumps.

Areas released from the Macartney rose canopy cover by burning immediately became available for grass and forb establishment, and livestock access to forage was improved. The fires did not, however, kill the Macartney rose, and basal sprouting occurred regardless of season of burning. Although canopy replacement averaged from 6 to 8 percent per month, canopy heights at 1.5 years following burning were much lower than pretreatment heights. Also, much of the herbaceous topgrowth within areas once occupied by the original canopy was still accessible for grazing use and was taller than the Macartney rose regrowth. The reduced canopy height of Macartney rose also facilitated handling of livestock. In May 1976, cattle could easily be located without hindrance of the Macartney rose canopy on areas burned in February 1975.

Season of burning Macartney rose-infested rangeland was important to response of herbaceous vegetation, both in production and composition, especially during the first growing season. Burning in the winter removed minimal amounts of green herbaceous topgrowth, primarily of the relatively few cool-season species common to the area. Although burns installed after spring greenup burned slowly and unevenly, they removed established green forage which would otherwise have been available for grazing animals. Initiation of regrowth of forage species following spring and summer burns occurred under hotter, drier conditions than following winter burns. Presumably, evaporation was greater from the blackened surfaces with no insulation from mulch or shade from foliar cover. Although burning in the fall allowed herbaceous regrowth to occur during cooler conditions with a greater probability of receiving rainfall, herbaceous production was slow following the burns and subsequently restricted with the beginning of winter. However, from a management standpoint, burning some areas in the fall could be advantageous in promoting animal condition prior to the winter stress period. Calving in October and November increases the demand for quality forage when the majority of forage plants are mature and/or entering dormancy.

Winter burning not only resulted in highest total herbaceous production but evidently also provided the best conditions for forb establishment. Broadleafed herbaceous vegetation is an important component of livestock diets but is a critical requirement for some wildlife species. For instance, certain forbs are preferred diet items of the white-tailed deer on Coastal Prairie. The deer tended to concentrate on areas burned in February, especially those which were near protective cover. Game birds such as dove (*Zenaidura macroura* L.) and bobwhite quail, observed many times in burned areas, utilized seed from forbs such as Texas croton. During all burnings, various species of birds gathered behind the flame front and fed on insects made easily accessible by mulch removal. In the spring months, fawns and nesting birds were observed using the burned areas.

Prescribed burning must be incorporated as part of the overall ranch plan for maximum effectiveness, and provisions for deferment following burning are as crucial to successful improvement as fire itself. Usually, deferment is the time necessary for a grass plant to develop 4 to 6 true leaves under satisfactory growing conditions. If only a portion of a fenced area is burned, the stocking rate should be adjusted to the burned area, not the entire pasture. A second deferment period in May, following winter burning, can be instrumental in ensuring establishment of herbaceous vegetation during the accelerated spring growth period.

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LITERATURE CITED

1. Arny, A. C., and A. R. Schmid. 1942. A study of the inclined point quadrat method of botanical analysis of pasture mixtures. Amer. Soc. Agron. Jour. 34:238-247.
2. Canfield, R. H. 1941. Application of the line interception method sampling range vegetation. Jour. Forestry 39:338-394.
3. Correll, D. S., and M. C. Johnston. 1970. Manual of vascular plants of Texas. p. 754. Texas Research Foundation, Renner, Texas.
4. Daubenmire, R. 1967. *Plants and Environment:* A Textbook of Plant Autecology. John Wiley and Sons, Inc., New York. 422 p.
5. Durham, A. J. 1975. The botanical and nutritive composition of winter diets of cattle grazing on the Texas gulf coast. MS Thesis. Texas A&M University, College Station. 73 p.
6. Gould, F. W. 1975. Texas plants. A checklist and ecological summary. Texas Agr. Exp. Sta. MP-585. 121 p.
7. Hoffman, G. O., R. H. Haas, and B. E. Jeter. 1964. Macartney rose control in Texas. Texas Agr. Exp. Sta. MP-745. 11 p.
8. Isaac, L. A. 1963. Fire — a tool, not a blanket rule in douglas-fir ecology. Proc. Tall Timbers Fire Ecol. Conf. 2:1-17
9. McCully, W. G., G. O. Hoffman, and B. E. Jeter. 1959. Possibility of controlling Macartney rose. Texas Agr. Exp. Sta. Prog. Rep. 2093. 4 p.
10. Miller, H. A. 1963. Use of fire in wildlife management. Proc. Tall Timbers Fire Ecol. Conf. 2:19-20.
11. Polk, D. B. Jr. 1974. Evaluation of four grasses for seeding on south Texas rangeland. MS Thesis, Texas A&M University, College Station. 61 p.
12. Scifres, C. J. 1975. Systems for improving Macartney rose-infested Coastal Prairie rangeland. Texas Agr. Exp. Sta. MP-1225. 12 p.
13. 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.
14. Stoddard, H. L., Sr. 1963. Bird habitat and fire. Proc. Tall Timbers Fire Ecol. Conf. 2:163-175.
15. Stoddard, H. L., Sr. 1963. Maintenance and increase of the eastern wild turkey on private lands of the coastal plain of the deep southeast. Bull. No. 3. Tall Timbers Res. Sta. Tallahassee, Florida. 49 p.
16. Vallentine, J. F. 1971. Range development and improvements. Brigham Young Univ. Press., Provo, Utah. p. 15.
17. Weaver, J. E., and N. W. Rowland. 1952. Effects of excessive natural mulch on development, yield and structure of native grassland. Bot. Gaz. 114:1-19.
18. Wright, H. A. 1968. Effect of spring burning on tobosa grass. J. Range Manage. 22:425-427.
19. Wright, H. A. 1974. Range burning. J. Range Manage. 27:5-11.

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