DOC
TA245.7
873
o.1191

B-1191
October 1978

Range Vegetation After Mechanical Brush Treatment on the Coastal Prairie

LIBRARY
DEC 12 1978
Texas A&M University

The Texas Agricultural Experiment Station, Neville P. Clarke, Director, College Station, Texas, The Texas A&M University System

[Blank Page in Original Bulletin]

Contents

Authors

Mutz, J. L., assistant range scientist, The Texas Agricultural Experiment Station, Corpus Christi

Scifres, C. J., professor, The Texas Agricultural Experiment Station (Department of Range Science)

Drawe, D. L., assistant director, The Rob and Bessie Welder Wildlife Foundation, Sinton, Texas

Box, T. W., dean, College of Natural Resources, Utah State University, Logan

Whitson, R. E., associate professor, The Texas Agricultural Experiment Station (Departments of Range Science and Agricultural Economics)

Summary

In 1963, several mechanical brush management practices were installed on a Blackland range site which supported a "Chaparral-bristlegrass" community of the Rob and Bessie Welder Wildlife Refuge near Sinton. The original plots have since been maintained free of major disturbances (except for a maintenance burn in 1974), allowing a direct comparison of vegetation changes after 14 years. In 1971, huisache on a portion of each plot was removed by oiling, allowing evaluation of its impact on vegetation improvement. Vegetation changes were assessed relative to changes in botanical composition. Although botanical composition changes have occurred in brush cover during this period (reflecting major changes in rainfall pattern), the total canopy cover in 1977 was remarkably similar to that in 1963. With increasing wetness since 1963 and associated extended inundation of lowlands and swales, a portion of the honey mesquite cover has been replaced by huisache, lime pricklyash, blackbrush acacia, bluewood, and other species, regardless of treatment.

Roller chopping and shredding, for the most part, did not change brush canopy cover or range condition appreciably after 14 years even though a maintenance burn was installed in 1974. Based on past research accounts and present stature of the woody plants, life of shredding or roller chopping treatments probably did not exceed 5 years, using shrub canopy coverage as a criterion. Improvement in herbaceous vegetation may last somewhat longer but probably does not exceed 7 years. Extent of improvement following scalping the rangeland with a "KG" blade was intermediate between that of the simple top removal treatments and root plowing.

Reduction of brush canopy cover on root-plowed areas and those treated with root plowed and raking combined averaged 57 percent in 1977, based on comparison with adjacent untreated areas. However, successional change of herbaceous vegetation was relatively slow on root-plowed rangeland. Composition of herbaceous vegetation following initial soil disturbance from root plowing in 1963 was roughly equivalent to that of untreated plots in 1977. Huisache increased in importance over the study period, regardless of treatment, but the relative change was most dramatic following root plowing. Removal of huisache in 1971 by oiling allowed development of only a 5- to 8-percent total canopy cover of brush compared to 27.7 percent on areas root plowed only and to 48.6 percent on untreated plots.

Present livestock carrying capacities, estimated as a function of herbaceous composition and brush cover, differ among treatments, primarily because of differential brush control effectiveness. Where the only treatment was huisache oiling, carrying capacity is estimated to be one animal unit per 23.5 acres yearlong. On shredded, roller-chopped, and scalped areas where the huisache was oiled, carrying capacity is one animal unit per 15.5 to 16 acres. Carrying capacity on root-plowed areas is one animal unit per 14.1 acres and on areas root plowed and raked is one per 12.6 acres. The importance of huisache on livestock production on the Coastal Prairie is exemplified by reduced carrying capacities following simple top removal methods or scalping (one animal unit per 22.4 to 22.[illegible] acres) and following root plowing (one animal unit per 17.9 acres) where the huisache was not oiled.

Range Vegetation After Mechanical Brush Treatment on the Coastal Prairie

Brush and its management on rangeland is a problem that can best be approached from an ecological perspective within a well-defined economic framework (Scifres, 1977). The goal of brush management is to manipulate the range vegetation such that optimum proportions and amounts of native plants are restored and sustained relative to potential for a given range site. Thus, brush management is applied to expedite secondary succession on rangeland. Compared to row crop agriculture (maintenance of a monoculture, usually of annual plants, by depending on a system of intensive inputs) which strives to retard succession, success in range improvement depends on a low level of synthetic inputs applied over a relatively long period. Consequently, long-term vegetation change most accurately reflects the degree of success from range improvement treatments. Monitoring of vegetation change on rangeland through time following manipulation is the only means of fully understanding the ecological impact and potential utility of any brush management practice. However, maintaining continuity in a brush management project over several years is difficult. Rarely does one have the opportunity to evaluate vegetation 10 or more years after installation of range improvement practices.

Initial influence of the selected brush management techniques, shredding, roller chopping, scalping with "KG" blade, root plowing, and the combination of root plowing and raking, may be summarized as follows (Powell, 1966; Powell and Box, 1967):

1. The brush control methods which minimized soil disturbance, shredding and roller chopping, most effectively improved successional stage and increased forage production for the first and second years after treatment.
2. Soil disturbance from root plowing or scalping retarded plant succession and caused large fluctuations in annual forage production.
3. Brush cover was initially reduced by more than 50 percent by the treatments with greatest reductions after root plowing and root plowing followed by raking. Root-plowing treatments, however, increased the cover of pricklypear.

Based on these results, Powell and Box (1967) concluded that complete eradication of brush in south Texas was not feasible. They suggested that a systematic brush management program would more likely be successful in continually increasing range forage quantity and quality.

The objective of this research was to evaluate and discern the management implications of changes in Coastal Prairie vegetation 14 years after application of several mechanical brush control practices to a mixed-brush *(Prosopis-Acacia)* infestation.

BRUSH MANAGEMENT IN SOUTH TEXAS: AN OVERVIEW

Excessive woody plant cover lowers range forage production and availability throughout the West. However, nowhere is the interest in brush control more keen than in the Rio Grande Plains and Coastal Prairie, the "brush country," of Texas. Since livestock and wildlife are the primary economic products of these rangelands, brush management programs are directed towards optimizing economic returns by maintaining a balanced mix of vegetation that will sustain these different kinds of animals.

Until the early 1970's, most brush management in south Texas was accomplished mechanically with heavy equipment. Energy was relatively inexpensive, and herbicides did not effectively control many of the species in the mixed-brush complex. Although 2,4,5-T [(2,4,5-trichlorophenoxy)acetic acid] effectively controlled honey mesquite,[1] associated woody species of the genera *Acacia, Condalia, Lycium, Aloysia, Zanthoxylum, Celtis, Diospyros* and others were not effectively controlled at conventional rates of the phenoxy herbicide. In fact, it was generally believed that controlling honey mesquite alone with 2,4,5-T released herbicide-tolerant species, creating more troublesome management problems than originally existed.

As new herbicides were developed, chemical control of south Texas brush appeared more promising. A benzoic acid herbicide, dicamba (3,6-dichloro-*o*-anisic acid), broadened the spectrum of species controlled somewhat compared to phenoxy herbicides. With the advent of picloram (4-amino-3,5,6-trichloropicolinic acid) and its commercial availability in combination with 2,4,5-T, brush spraying became

[1]Scientific names follow Gould (1975) and are presented in Appendix for plants mentioned in text.

more widely adopted in south Texas. The introduction of new compounds such as tebuthiuron [*N*-(5-[1,1-dimethylethyl]-1,3,4-thiadiazol-2-yl)-*N*-*N*'-dimethylurea], effective for control of some woody species which are not highly susceptible to most sprays, may lend impetus for expanded herbicide use in the area (Scifres, Mutz, and Hamilton, 1978). Systems have been developed for chemical brush management which are compatible with maintenance of quality wildlife habitat in south Texas (Beasom and Scifres, 1977) and which are economically acceptable (Whitson, Beasom, and Scifres, 1977). However, even with the improved brush control levels following applications of 2,4,5-T + picloram, followup brush management may be required within 5 years after treatment (Scifres , Durham, and Mutz, 1977).

Prescribed burning offers potential for protracting the initial brush control effectiveness achieved with herbicides and reducing costs of repeated treatment with chemicals (Box and White, 1969; Scifres and Merkle, 1975; Scifres, 1975). Like herbicides, controlled and prescribed burning are gaining favor for range improvement in south Texas. Apparently, range burning is considered economically superior to other methods in certain situations and provides benefits in addition to brush suppression (Gordon and Scifres, 1977). Prescribed burning promotes use of forages which are otherwise not utilized efficiently by livestock (Oefinger and Scifres, 1977), improves food availability (seed crops of herbaceous plants for upland game birds and succulent regrowth browse for white-tailed deer [*Odocoileus virginianus*] [Gordon and Scifres, 1977]) for wildlife, and may reduce the impact of parasites on range animal populations. Continued research and producer experience will undoubtedly result in more widespread application of fire for range improvement. However, even with recent technological advances in herbicides and fire, many brush management programs in south Texas continue to focus on mechanical methods.

Mechanical brush management methods can be categorized, relative to action on woody plants, as those which are designed to simply remove current year's topgrowth and as those which remove the entire woody plant. Shredding and roller chopping, methods of simple top removal, kill only those woody species which are not capable of resprouting from basal stem segments, roots, or rhizomes. Methods such as grubbing, root plowing, and chaining are designed to remove entire plants. However, if improperly applied, chaining may also result in simple top removal and should be followed by raking and stacking of debris for maximum range improvement (Scifres, Mutz, and Durham, 1976).

Variables such as treatment life expectancy (relative to brush cover replacement and concomitant carrying capacity adjustment) and initial costs vary considerably among mechanical brush management practices. Also, since degree of soil disturbance varies among methods, the rate of improvement in herbaceous vegetation and associated livestock carrying capacities vary within a given set of edaphic and climatic conditions.

Although methods of simple top removal such as shredding and roller chopping cause minimal surface disturbance and are relatively rapid and inexpensive, they typically result in relatively short-term brush suppression when applied without provisions for followup brush management procedures. For example, huisache sprouts attained half their original height within 5 months after top removal (Powell, Box, and Baker, 1972). Although sprout growth rate was highly dependent on rainfall, canopy replacement was probably complete within 5 years. Significant biotic suppression of sprout growth (increased use by insects and mammals compared to their use of mature branches) may occur the season of top removal. White-tailed deer utilize succulent branch tips, leaves, and mast crops of woody plants including huisache, twisted acacia, and honey mesquite (Drawe, 1968). Although only transient advantages, browse value is improved and visibility on rangeland is increased following simple top removal of brush (Box and Powell, 1965; Powell and Box, 1966).

Contrasted to methods such as shredding or roller chopping, root plowing causes maximum surface soil disturbance, is relatively slow and expensive, but usually results in comparatively long-term brush suppression. Soil disturbance usually encourages an influx of annuals, especially annual grasses and broadleaved weeds, which may dominate the herbaceous vegetation for two to three growing seasons, depending on rainfall, soils, and the species and abundance of residual perennial grasses. Thus, carrying capacity may not be maximized until 5 or more years after root plowing. The maximum treatment effect may then be realized for an additional 5 years. Carrying capacity may then steadily decline for an additional 5 to 7 years under over-grazing and no followup improvement practices. Good grazing management and additional improvement efforts such as prescribed burning may significantly increase the longevity of maximum range improvement following root plowing.

The "KG" blade, similar to brush dozers, is designed to skim the ground surface and shear off woody plants leaving the top growth in stacks or windrows (Drawe, 1977). This method removes the brush topgrowth nearer the ground line than conventional methods of simple top removal and causes more surface soil disturbance.

The combination of prescribed burning and mechanical brush control offers much promise in south Texas. On the Welder Foundation, brush cover was significantly reduced when areas were burned 4 years after mechanical treatment (Box and White, 1969; White, 1969). Fire may be effectively combined with any mechanical method which releases herbaceous production to improve the fine fuel load and continuity (Dodd and Holtz, 1972). Relatively cool fires ("maintenance burns") applied within 2 to 4 years after installation of mechanical practices will usually

control woody resprouts and invading seedlings. If woody plant infestations are relatively dense and composed primarily of mature individuals, a hot fire ("reclamation burn") may be required for range improvement.

THE STUDY AREA

The Coastal Prairie, tall grass prairie in the climax state, is a major division of the Gulf Prairies and Marshes Area (Gould, 1975). Climax grasses include big bluestem, yellow Indiangrass, seacoast bluestem, eastern gamagrass, various species of *Panicum*, and gulf muhly. Herbaceous invaders include threeawns, horsetail conyza, western ragweed, bushy bluestem, tumblegrass, and whorled dropseed. Woody species include honey mesquite, huisache, blackbrush acacia, spiny hackberry, lotebush, bluewood, lime pricklyash, wolfberry, and several others.

Growing season of the Coastal Prairie is about 300 days. The area is typified by warm temperatures, coastal air movements, and high relative humidity. Rainfall averages about 37 inches annually, with highs during late spring and early fall.

The study was located on a Blackland range site supporting a "Chaparral-bristlegrass" community (Box and Chamrad, 1966). The woody plant component is typified by various mixtures of blackbrush acacia, honey mesquite, huisache, twisted acacia, agarito, creeping mesquite, spiny hackberry, lotebush, bluewood (often referred to as "brazil" [Box and Chamrad, 1966]), Texas persimmon and lime pricklyash (Figure 1). Drawe, Chamrad, and Box (1978), comparing site photographs taken in 1939 with those taken in 1960 and 1969, decided that these woody plant stands are relatively stable. Herbaceous vegetation underneath the woody mottes is generally limited to scattered plains bristlegrass plants and forbs. Vegetation between the mottes on heavily grazed areas is usually dominated by buffalograss, Roemer threeawn, and filly panicum. Common curlymesquite is also common between the brush mottes. Under light grazing, silver bluestem, little bluestem, meadow dropseed, Texas cupgrass, lovegrass tridens, Texas wintergrass, and other tall- and midgrasses dominate. According to Drawe et al (1978), silver bluestem, meadow dropseed, plains bristlegrass, and sourgrass are the first grasses to increase when stocking rates are decreased on overstocked areas. Species diversity and abundance of forbs vary seasonally, but upright prairie-coneflower and spotted beebalm usually occur on undisturbed interspaces between the brush mottes. The high forage production during the growing season provides excellent grazing, but nutritional value of the forages is low during late fall and winter.

Plains bristlegrass, buffalograss, and common curlymesquite apparently produce the bulk of forage on the site (Box, 1960). Plains bristlegrass apparently becomes of less importance, and filly panic becomes one of the more important species from midsummer (July) until early fall (September). During winter and early spring, Texas wintergrass produces a substantial amount of green forage. Based on harvests in 1957 and 1958, air-dry grass standing crop was approximately 2,100 pounds per acre for the fall-early winter period (Sept.-Dec.), about 100 pounds per acre for the late winter-spring period (Dec.-Mar.), 2,200 pounds per acre for the spring-summer period (Mar.-June), and about 900 pounds per acre for the summer-fall period (June-Sept.) (Box, 1960).

This community occurs on nearly level uplands typified by Victoria clay. Other series present in minor amounts may include Monteola clay, Orelia sandy clay loam, Orelia fine sandy loam, or Willacy fine sandy loam. Victoria clay is a member of the fine, montmorillonitic, hyperthermic family of Udic Pellusterts. These soils have high water-holding capacities and shrink-swell characteristics. The surface 6 inches are dark gray clays with weak, very fine, subangular blocky structure. A mulch of fine, discrete aggregates occurs on the surface. The surface soil is typically hard, highly plastic and sticky with a few fine strongly cemented calcium carbonate concretions and snail shell fragments, and is moderately alkaline. These highly fertile soils are widely used as cropland.

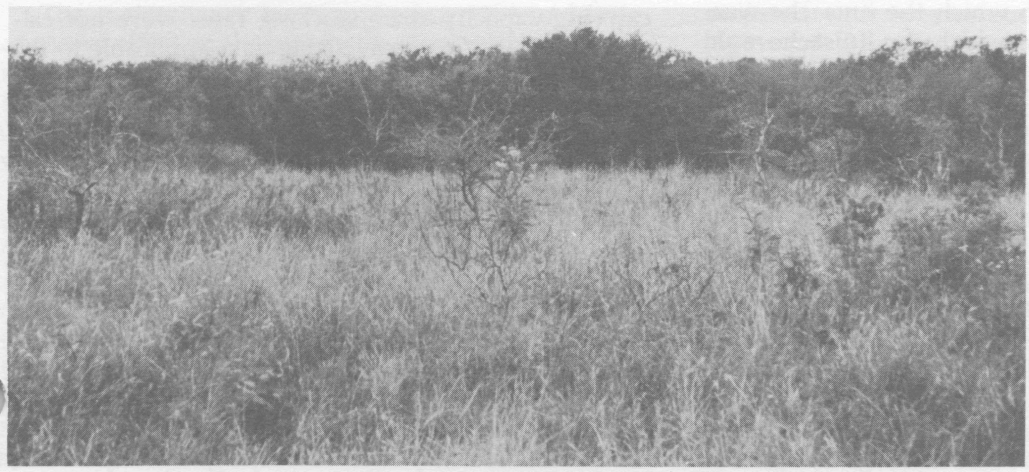

Figure 1. Mixed-brush stand in November 1977 on the Rob and Bessie Welder Wildlife Refuge where huisache was oiled in 1971.

MATERIALS AND METHODS

The Original Study

In June 1963, three locations were selected in a "Chaparral-bristlegrass" community on the Rob and Bessie Welder Wildlife Refuge on the Coastal Prairie. The refuge is located approximately 8 miles north of Sinton in San Patricio County, Texas. The pasture containing the study was grazed yearlong at the rate of one steer per 17 acres and supported white-tailed deer at the rate of one animal per 6 acres. Brush control treatments, each applied to two 20-acre plots during late June and early July 1963, included shredding, roller chopping, "scalping" with a "KG" blade, root plowing or root plowing, followed by raking. The original experiment, designed as a randomized complete block, included comparison of fertility treatments, but those subplots are not considered in this analysis. Strips 225 feet wide were burned across the original treatments in 1965 and 1966 (Box and White, 1969); those treatments also were not included in this evaluation. In 1971, the huisache on approximately one-third of each area was selectively treated by oiling. In 1974, the entire management unit containing the study plots was burned in an attempt to suppress woody plant cover and remove excess mulch. Species composition and woody species canopy cover were recorded prior to mechanical treatments and in the summers of 1964 and 1965. Also, herbage standing crop by species was determined on each plot to within 10 percent of the mean by a weight-estimated method (McIntyre, 1952) in late August 1964 and 1965.

Based on species composition by weight, a "herbage score" was determined for each plot. Herbage score was based on "relative desirability" for grazing, utilizing relative proportions of forage species, and is comparable to standard determinations of range condition. Particulars of the method will be discussed in the following section.

Procedures for 1977 Evaluations

Inasmuch as possible, data compatible with those collected at initiation of the study were collected during mid-August 1977. The plots were stratified to assure separation of areas on which the huisache was oiled in 1971 from those on which the huisache was not treated. Burning treatments installed in 1965 and 1966 were not considered. Ten line transects, 100 feet long, were randomly placed on the areas where only the original mechanical brush control practice had been applied, and ten transects were placed on the adjacent area where the huisache had been oiled in each plot. Since the entire area was burned in 1974, there was no way to avoid confounding of that treatment with the mechanical practices. Canopy cover of woody plants was recorded by species and converted to relative values for comparison of botanical composition differences.

Development of range condition estimates are usually based on weight or foliar coverage by species (Dyksterhuis, 1949). However, prior to and during this evaluation, the pasture containing the plots was subjected to grazing at one animal unit per 12 acres. Therefore, basal contacts using an inclined 10-point frame were utilized to estimate species composition. This method avoids the influence of short-term effects of weather and preferential top removal by grazing. Its weakness is that the role of broadleaved species is biased downward and the role of sodgrasses is usually biased upward. Also, basal cover is not necessarily directly related to top growth production. Fifty 10-point frame samples were recovered from the portion of each plot where the huisache plants were not oiled and 50 from the portion where the huisache was oiled in 1971.

A herbage score was developed for each treatment according to the original method as described by Powell (1966). Species included in the calculations and percentage allowable of each deviate somewhat from local Soil Conservation Service guides presently used (Table 1). However, the scoring system appeared to have a high degree of utility, and valid comparisons depended on uniformity in use of the system. A work sheet was developed for each plot which included percentage composition by species and percentage of that composition allowable in calculating the herbage score. The percentage allowable values were summed, and a range condition value was assigned to each plot. Carrying capacities were estimated from local Soil Conservation Service guides as follows:

Herbage score	Closest associated range condition class	Carrying capacity (acres/A.U.)
24-34	Low Fair	17
35-42	Fair	15
43-50	High Fair	13
51-58	Low Good	
59-66	Good	12
67-75	High Good	10

The original herbage scoring system (Powell, 1966) included the influence of the brush cover on carrying capacity since stocking rates were not calculated. There are no available data applicable to the study area to facilitate accurate adjustments in carrying capacity for brush cover. Therefore, brush cover and forage cover were assumed to be directly related — any land surface covered by brush was assumed void of usable forage. This method resulted in conservative estimates of carrying capacity since some forage species do exist within the brush mottes and no browse value was assigned the woody plants. The method is probably biased more toward single-stemmed species such as huisache under which some forage will grow as contrasted to mixed brush mottes which allow little, if any, forage species to exist. By this method, a plot with a herbage score of 45 (high fair condition and potential carrying capacity of one

Table 1. Percentage of various forage species allowable in calculation of herbage score in August 1977 following various mechanical brush control treatments in 1963 and/or oiling of huisache in 1971 on the Rob and Bessie Welder Wildlife Refuge near Sinton, Texas. (Adapted from the scheme of Powell [1966]).

Desirable grasses (All allowable in herbage score)	Less desirable grasses (Allowed in percentages shown in parentheses)	Undesirable (invader) grasses (No amount accepted)	Perennial forbs (Total 5 percent allowed)
Big cenchrus[a]	Buffalograss(10)[b]	Common Bermudagrass	Bundleflower
Bunch cutgrass	Common curlymesquite (10)[b]	Fringed chloris	Texas snoutbean
Hairyseed paspalum	Filly panicum[c] (5)[d]	Texas grama	
Little bluestem	Green sprangletop (5)[a]	Threeawns	
Lovegrass tridens	Knotroot bristlegrass (5)[d]	Tumble windmillgrass	
Mourning lovegrass	Longtom (10)[a]	Whorled dropseed	
Sideoats grama	Meadow dropseed (10)		
Silver bluestem	Pink tridens (5)		
Sourgrass	Plains bristlegrass (5)		
	Texas cupgrass (10)		
	Texas wintergrass (10)		
	Vine mesquite (5)		
	White tridens (5)		

[a]Species not listed by Powell (1966) or Soil Conservation Service Technical Guide but listed by Gould and Box (1965) and encountered in 1977 evaluations.

[b]Up to 10 percent total allowable for buffalograss and common curlymesquite in combination.

[c]*P. halli* var. *filipes* according to Gould (1975).

[d]A total of 5 percent of any combination of filly panicum and knotroot bristlegrass was allowed.

animal unit per 13 acres) and a brush cover of 33 percent would be assigned a carrying capacity of $\left[13 \times \frac{100}{100 - 33}\right] = 19.4$ acres per animal unit. The final calculated values were tested by sight estimating standing crop in November 1977 and reviewing published research on forage production trends for the site (Box, 1960). Comparative carrying capacities were calculated on the basis that 26 pounds per day is required to sustain an animal unit and that 25 percent of the forage produced annually is usable by the animals. These values were in general agreement with carrying capacities based on the herbage scores. On the average, the estimates varied between the two methods by less than 10 percent.

RESULTS AND DISCUSSION

Brush Cover and Composition

The maintenance burn applied in 1974 had little apparent effect on the woody plant population. Occasional charred logs were found during the evaluations, but burned stumps were generally less than 0.25 inch in diameter, indicating that only the smaller woody plants were severely damaged.

Brush canopy cover in 1963 on untreated plots was 48.6 percent (Powell, 1966) with honey mesquite (38.4 percent), huisache (2.2 percent), blackbrush acacia (1.2 percent), agarito (1.2 percent), and tasajillo (1.5 percent) the primary species. The remainder of the cover consisted of twisted acacia, spiny hackberry, lotebush, bluewood, Texas persimmon, Berlandier wolfberry, pricklypear, creeping mesquite, and lime pricklyash. Twisted acacia was the only species encountered in 1963 that was not recorded in 1977 (Table 2). Twisted acacia essentially replaces huisache in the western portions of south Texas, and its presence in 1963 may have been the result of previous rainfall patterns.

That these woody plant stands are relatively static as proposed by Drawe et al (1978), at least relative to total canopy cover, may be evidenced by the similarity of cover values, 48 percent in 1977 compared to 48.6 percent in 1963. However, there were differences in botanical composition of the brush stand. Where the huisache was oiled but no mechanical treatment was applied, honey mesquite provided a considerably lower percentage of the composition (Table 2). On a relative basis, honey mesquite furnished 79 percent of the total brush cover in 1963 (Powell, 1966) and only about 16 percent in 1977. This cover differential was compensated by an increase in species such as blackbrush acacia, 2.5 percent in 1963 and 27.4 percent 14 years later. Substantial increases also occurred with species such as lime pricklyash and bluewood. All other species except creeping mesquite increased in canopy cover by 2 to 3 percent.

The decline of honey mesquite may be explained partially by rainfall conditions preceding each evaluation. Relatively dry conditions, with the exception of 1960, prevailed for the 5-year period preceding installation of the experiment (Table 3). For the 5-year period including 1963, annual precipitation averaged 7.91 inches below the annual average for 1957 through 1976. These dry conditions persisted until 1966, after which annual rainfall was above the 20-year average with the exceptions of 1969 and 1975. During the 5-year period preceding reevaluation of the experiment (1972 through 1977), annual rainfall averaged 4.93 inches above the 20-year average of

Table 2. Relative botanical composition (%) of woody plant stands based on canopy cover in August 1977 after mechanical brush control treatments in 1963 and/or oiling of huisache in 1971 on the Rob and Bessie Welder Wildlife Refuge near Sinton, Texas.[a]

	Huisache oiled					
Common name	No treatment	Shredded	Roller chopped	Scalped	Root plowed	Root plowed and raked
Agarito	6.9	6.5	5.9	0	7.2	0
Blackbrush acacia	27.4	16.6	12.2	5.7	19.1	11.4
Brazil (bluewood)	11.3	3.3	8.5	0.7	4.8	0
Carolina wolfberry	0.6	0.8	1.6	0	3.6	9.4
Creeping mesquite	1.5	0.2	0	0	3.6	1.9
Huisache	8.6	4.1	3.7	9.4	19.1	30.3
Honey mesquite	15.9	46.6	47.3	78.2	14.3	30.2
Lime pricklyash	13.6	5.7	48.8	3.8	19.1	7.6
Lotebush	4.0	2.8	1.6	18.8	0	1.9
Spiny hackberry	4.6	9.3	9.1	0.6	6.0	5.7
Tasajillo	0	0.4	0	0	0	0
Texas persimmon	5.6	3.7	5.3	0	3.6	1.9
Absolute canopy cover (%)	48.8	24.7	18.8	16.0	8.4	5.3

	Huisache not oiled					
Common name	No treatment	Shredded	Roller chopped	Scalped	Root plowed	Root plowed and raked
Agarito		6.5	6.7	8.1	0.7	0
Blackbrush acacia		26.6	13.9	14.4	2.2	0
Brazil (bluewood)		3.0	2.6	4.4	0	0
Carolina wolfberry		0	0	0	0	3.6
Creeping mesquite		0	0	0	1.5	0
Huisache		33.6	22.4	31.7	80.3	83.3
Honey mesquite		14.8	33.4	21.5	5.1	12.0
Lime pricklyash		10.4	12.9	15.3	5.4	0
Lotebush		0.9	3.1	0.2	3.3	0
Spiny hackberry		2.6	5.0	4.4	0.4	0
Texas persimmon		1.6	0	0	1.1	1.1
Absolute canopy cover (%)		43.2	41.9	43.2	27.7	27.6

[a]The area containing the research plots was maintenance burned in 1974.

36.62 inches. Thus, lowlands which were dry preceding and during the original experiment held water for extended periods each year, especially during the spring growing season. Honey mesquite does not tolerate inundation except for short periods (Scifres, 1973), and on lowland areas (significant in area on cumulative basis) along the coast, honey mesquite was killed by inundation following hurricane Beulah (Scifres and Mutz, 1975). Kill of honey mesquite by flooding was evidenced by remnants of trees on the lowlands on the Welder Refuge during the 1977 evaluations (Figure 2). Honey mesquite on the study plots varied from 2.1 to 3.1 feet tall, and there was no difference in height of honey mesquite on untreated plots and that of regrowth on treated plots (Table 4). The lowland areas were excluded from the 1977 evaluation but were undoubtedly included in the original evaluation. Honey mesquite was present in proportions originally reported only on areas receiving the scalping treatment (Table 2).

Huisache is apparently adapted to moist sites and favored by wet years. The year after installation of the study, huisache contributed 4.6 to 8.7 percent to the woody plant cover on all plots except those roller chopped (12 percent) or root plowed and raked (23.2

Table 3. Annual rainfall on the Rob and Bessie Welder Wildlife Refuge near Sinton, Texas from 1957 to 1976.

	Precipitation (inches)	
Year	Total	Deviation from 20-yr average
1957	41.51	+ 4.89
1958	38.90	+ 2.28
1959	35.02	− 1.60
1960	46.96	+10.34
1961	26.30	−10.32
1962	18.51	−18.11
1963	16.75	−19.87
1964	36.23	+ 0.39
1965	27.87	− 8.75
1966	32.02	− 4.60
1967	43.05	+ 6.43
1968	48.17	+11.55
1969	33.81	− 2.81
1970	40.43	+ 3.81
1971	39.14	+ 2.52
1972	39.30	+ 2.68
1973	49.06	+12.64
1974	39.54	+ 2.92
1975	30.59	− 6.03
1976	49.06	+12.44
Average	36.62	

percent) (Powell, 1966). The dramatic increase in huisache cover on the Welder Wildlife Refuge prompted management personnel to begin an oiling operation in 1971. Oiling held the relative proportions to 3.7 to 9.4 percent except on the root-plowed plots (Table 2). Root plowing of mixed brush on the more fertile soils of the Coastal Prairie may result in almost solid stands of huisache within 5 to 7 years, especially under higher than normal rainfall. Huisache cover presently accounts for more than 80 percent of the total brush canopy cover on the root-plowed plots which were not subjected to the oiling treatment (Table 2). This allowed total woody canopy cover to increase to over 27 percent since treatment in contrast to brush covers of 5.3 to 8.4 percent on root-plowed plots where the huisache was oiled. In comparison, huisache canopies account for 22.5 to 33.6 percent of the total brush cover following other treatments where the species was not oiled (Figure 3).

Compared to original stands, the change in relative proportion of the brush cover furnished by huisache the past 14 years has been relatively minor except on root-plowed plots where the oiling treatment was applied (Table 5). Where oiling was not practiced, the relative contribution by huisache has increased by 11 to 25 percent following mechanical

Figure 2. Depression on which honey mesquite was killed by extended inundation on the Welder Wildlife Refuge.

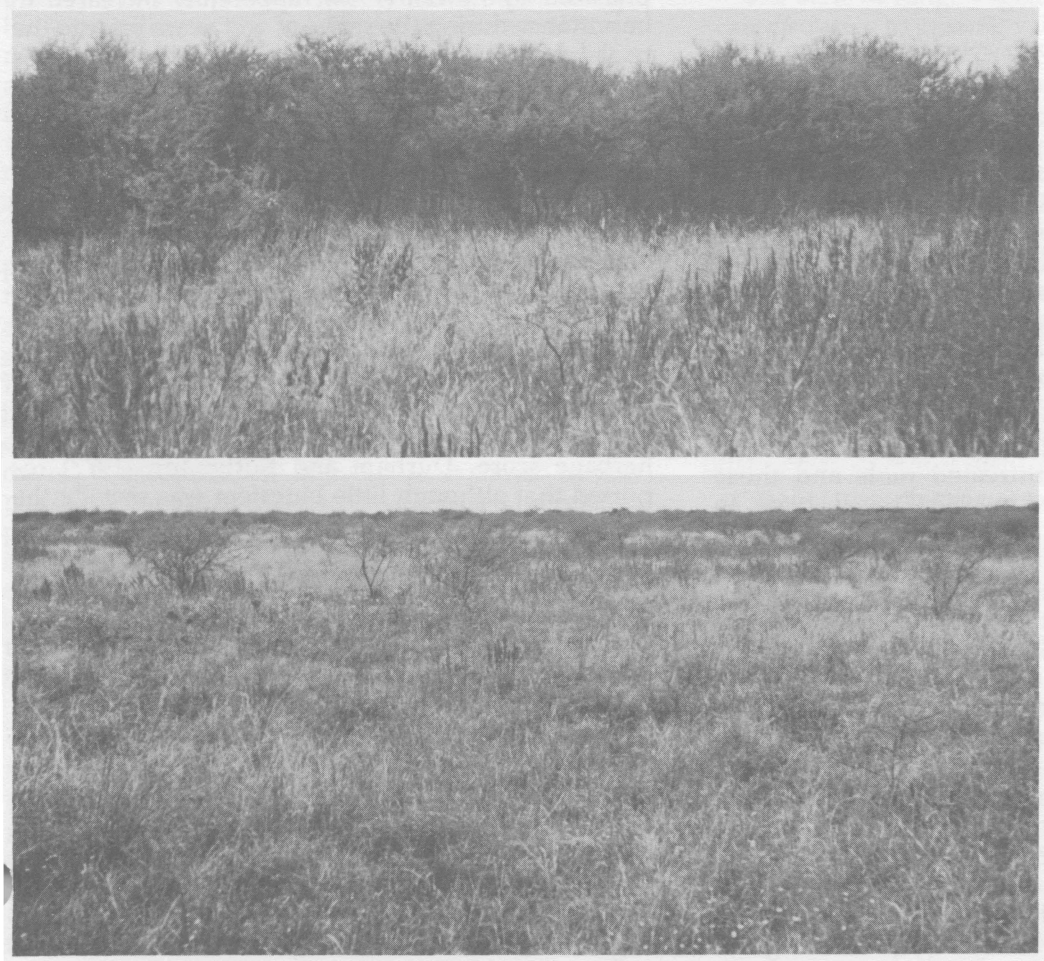

Figure 3. Hiusache formed almost solid stands following root plowing of Coastal Prairie in 1963 on the Welder Wildlife Refuge (upper photo). Oiling of areas in 1971 which were root plowed in 1963 effectively reduced the presence of huisache (lower photo).

Table 4. Height (ft) of honey mesquite encountered in August 1977 on the various areas mechanically treated in the summer of 1963 on the Rob and Bessie Welder Wildlife Refuge near Sinton, Texas.[a]

Treatment	Huisache treatment	
	Oiled	Not oiled
None	2.5	—
Shredded	2.3	3.1
Roller chopped	2.1	3.0
Scalped	2.1	2.4
Root plowed	2.1	2.3
Root plowed and raked	2.4	2.5

[a]The area containing the research plots was maintenance burned in 1974.

Table 5. Change in relative botanical composition (%) represented by huisache by August 1977 after mechanical treatments in 1963 and/or oiling in 1971 on the Rob and Bessie Welder Wildlife Refuge near Sinton, Texas.[a]

Treatment	Huisache treatment[b]	
	Oiled	Not oiled
None	+ 4	—
Shredded	− 5	+25
Roller chopped	− 8	+11
Scalped	+ 1	+24
Root plowed	+15	+76
Root plowed and raked	+ 7	+60

[a]The area containing the research plots was maintenance burned in 1974.

[b]Values rounded to nearest whole number.

treatments other than root plowing. Following root plowing, huisache now provides 60 to 76 percent more of the relative cover than immediately after treatment. These data and recent observations indicate that huisache may be considered one of the primary, if not the most serious, brush problems on the Coastal Prairie. Brush management methods which disturb the soil surface apparently release huisache to increase in the absence of competition from other woody plants.

Lime pricklyash was relatively unaffected by mechanical treatment. It provided 1.1 to 2.5 percent of the brush cover on untreated plots and those shredded or roller chopped in 1963 (Powell, 1966). In 1977, relative foliar cover averaged 9.1 percent, and ranged from 3.8 to 19.1 percent among the treatments, except on plots which were root plowed and raked (Table 2). Even after adjustment to absolute ground cover, a notable increase in lime pricklyash has occurred since installation of the experiment. The relative cover of lime pricklyash was reduced by chaining, raking, and stacking on sites similar to those in the present study (Scifres et al, 1976), but the species is a root sprouter and must be completely uprooted for effective control. Texas persimmon, bluewood, and lotebush responded similarly to lime pricklyash. These species are also difficult to control with other brush control procedures such as herbicides (Scifres et al, 1977) and may present significant livestock management problems where their abundance exceeds that necessary for quality wildlife habitat.

Herbaceous Vegetation and Range Condition

Some differences in herbaceous vegetation were expected between species composition in 1977 and that in 1963 and 1964 since rainfall conditions differed considerably. Chamrad and Box (1965) evaluated the influence of drouth in 1963 on mortality of grasses on the Welder Refuge. Mortality of grasses was lowest on Victoria clay sites compared to that on Nueces fine sand or Miguel fine sandy loam. Mortality also varied among species within sites from 34.7 percent for silver bluestem on Victoria clay to 76.8 percent for seacoast bluestem on Miguel fine sandy loam. On Victoria clay, the highest mortality, 51.9 percent, occurred with filly panicum. Mortality of seacoast bluestem was 48.7 percent and of buffalograss 43.4 percent.

The effects of weather patterns were not reflected, to the extent anticipated, in differences in herbaceous vegetation between the initial and 1977 evaluations. The primary grass species encountered by Box and Powell in 1963 were encountered in the 1977 evaluations. The greatest difference between evaluations was the frequent occurrence in 1977 of common Bermudagrass and longtom. These species, not emphasized by Powell (1966), apparently increased in importance during the series of wet years prior to the reevaluation. Longtom and common Bermudagrass were reported by Scifres and Mutz (1975) to be initial stabilizers of previously inundated lowlands in south Texas. These species grow on the immediate shorelines of inundated lowlands, and longtom stolons occasionally spread over the surface of standing water. Although they are of fair to good forage value, both species are considered invaders of the Blackland range site. However, based on its distribution and recently reported ecological role (Gordon and Scifres, 1977; Scifres and Mutz, 1975), longtom was utilized in calculating the 1977 herbage score (Table 1). Recently published information on its grazing value was further justification for not excluding longtom from the herbage score. Durham and Kothmann (1977) reported that although little bluestem was usually the dominant grass in cattle diets on the Coastal Prairie, longtom afforded from 14 to 21 percent of botanical composition of diets from February to early March. Utilization during this period ranged from 25 to 37 percent. As additional evidence for the recent influence of increased rainfall on vegetation change since initiation of the study, every plot supported significant cover of various species of rushes and sedges (Table 6), which are abundant only under relatively wet conditions.

Herbage scores changed little from 1963 to 1977 on shredded, roller chopped, or untreated plots where the huisache was oiled (Table 6). When adjusted for presence of longtom (not encountered in 1963), herbage scores in 1977 are essentially the same as re-

Table 6. Herbage score and percentage composition of herbaceous vegetation in August 1977 after installation of mechanical brush control treatments in 1963 and/or oiling of huisache in 1971 on the Rob and Bessie Welder Wildlife Refuge near Sinton, Texas.[a]

egetation class	Huisache oiled					
	No treatment	Shredded	Roller chopped	Scalped	Root plowed	Root plowed and raked
Desirable grasses[b]	75.0	84.0	80.2	74.9	69.5	66.3
Invader grasses[c]	0.2	1.4	1.4	2.1	3.1	10.7
Forbs	18.8	13.9	12.7	23.0	26.9	21.4
Rushes/sedges	6.0	0.6	5.7	0	0.5	1.6
Herbage score[d]	59.3	60.3	50.9	53.2	53.8	59.2
Change since 1964[e]	− 1.7	− 5.9	− 2.6	+12.3	+ 2.4	+35.5
	Huisache not oiled					
Desirable grasses[b]		75.4	71.0	62.3	61.1	48.0
Invader grasses[c]		0.3	0.9	18.4	16.2	19.0
Forbs		20.1	18.0	15.9	17.0	22.4
Rushes/sedges		4.2	10.1	3.4	5.7	10.6
Herbage score[d]		47.2	45.2	45.1	47.1	47.7
Change since 1964[e]		−18.9	− 8.3	− 4.2	− 4.3	+24.0

[a]The area containing the plots was maintenance burned in 1974.

[b]Included green sprangletop and big cenchrus.

[c]Included common Bermudagrass and longtom.

[d]Desirable forbs, bundleflower, and Texas snoutbean included in herbage score.

[e]Herbage score reported by Powell (1966).

ported for 1963, following no treatment except huisache oiling or the mechanical top removal treatments followed by huisache oiling. This is understandable after inspection of absolute brush covers following mechanical treatment where the huisache was not oiled (Table 2). The brush cover has been replaced, and range condition is essentially the same as when the study was initiated.

Absolute herbage scores in 1977 following root plowing or root plowing and raking differed little from those where other mechanical treatments were applied (Table 6). However, herbage scores in 1977 on root plowed and raked areas were 24 to 35.5 points higher than reported 1 year after treatment. The low initial herbage scores were attributed to extensive soil disturbance by root plowing which invariably is conducive to establishment of invaders. It should be emphasized that the herbage scores are based on relative proportions of species present and do not reflect the influence of brush canopy cover which varies considerably among the treatments (Table 2). The relatively low brush covers on the root-plowed plots are indicative of even greater potential for range improvement than reflected by 1977 evaluations.

On the portions of the plots where the huisache was not oiled, herbage scores were lower in 1977 than reported in 1963 with the exception of the root-plowing-plus-raking treatment (Table 6). On most plots, the herbage score difference was substantial even after including the contribution of longtom which was not present in 1963. Thus, huisache infestations are seriously retarding achievement of potential improvement in range condition.

The state of range vegetation in 1977 was also assessed relative to grazing value of the grasses present (Table 7). Regardless of treatment, a relatively low percentage of the grass composition was afforded by grasses of poor grazing value. Such species included Roemer threeawn, tumble windmillgrass, Texas grama, and whorled dropseed. Grass species encountered in 1963 but not encountered in 1977 included common curlymesquite and Nealley sprangletop. The only other notable differences in grasses present in 1977 compared to 1963 were that scattered little bluestem clones were encountered in 1977, and substantially higher amounts of knotroot bristlegrass were present. Presence of little bluestem indicates an upward trend in range condition, but knotroot bristlegrass is usually an indicator of yearly weather fluctuations or minor disturbances of the vegetation.

The relative contribution of grasses of good to excellent grazing value varied little among plots except for those shredded on which the huisache was oiled (Table 7). The shredded plots supported a relatively high percentage of hairyseed paspalum and relatively low amounts of longtom and common Bermudagrass. This occurrence shifted the proportion of forages in the fair grazing class downward and the proportion provided by the good to excellent class upward.

Forbs accounted for 16 to 22 percent of the botanical composition on plots where the huisache was not treated and 13 to 27 percent of the botanical composition on plots where the huisache was oiled in 1971. The variation in forb populations appeared to be more closely associated with localized site conditions and season of sampling than with specific treatment.

Table 7. Relative botanical composition (%) of grasses by grazing value after installation of mechanical brush control treatments in 1963 and/or oiling of huisache in 1971 on the Rob and Bessie Welder Wildlife Refuge near Sinton, Texas.[a]

Grazing value	Huisache oiled					
	No treatment	Shredded	Roller chopped	Scalped	Root plowed	Root plowed and raked
Good-Excellent	43.8	60.6	28.7	35.8	35.0	42.1
Fair	51.6	37.8	66.4	63.5	63.3	52.1
Poor	4.6	1.6	4.9	0.7	1.7	5.8
	Huisache not oiled					
Good-Excellent		37.6	30.6	24.5	38.0	17.2
Fair		57.6	66.2	71.6	53.8	68.9
Poor		4.8	3.2	3.9	8.2	13.9

[a]The area supporting the plots was maintenance burned in 1974.

Nineteen species of broadleaf herbaceous plants were encountered of which western ragweed, saltmarsh aster, erect dayflower, seacoast sumpweed, sawtooth fogfruit, common ruellia, prairie gerardia, and upright prairie-coneflower were the most common. Native legumes, Texas snoutbean and bundleflower, were present in low amounts (less than 0.1 percent of the composition).

Condition of the range (based on composition of herbaceous vegetation) which had not been mechanically treated but on which the huisache had been oiled was rated as high fair to low good. However, the heavy brush cover caused the estimated carrying capacity to be relatively low, one animal unit per 23.4 acres (Table 8). This conservative stocking rate was developed to allow range improvement, inasmuch as possible, without brush management. In contrast, the root-plowed plots where the huisache had been oiled were also in high fair condition but, because of the relatively low brush cover, the average estimated carrying capacity was one animal unit per 14.1 acres. The huisache oiling operation was of critical importance in determining livestock carrying capacity. The carrying capacity was significantly lower where the huisache was not oiled 8 years previously except on root-plowed plots. In that single instance, although not statistically significant, only 3.8 acres would be required per animal unit where the huisache was not oiled.

Table 8. Calculated carrying capacities (acres/animal unit, year-long) in August 1977 after installation of mechanical brush control treatments in 1963 and/or oiling of huisache in 1971 on the Rob and Bessie Welder Wildlife Refuge near Sinton, Texas.[a]

Treatment	Estimated carrying capacities (acres/A.U.)[b]	
	Huisache oiled	Huisache not oiled
None	23.4 d	
Shredded	15.9 ab	22.9 cd
Roller chopped	16.0 ab	22.4 cd
Scalped	15.5 ab	22.9 cd
Root plowed	14.1 ab	17.9 bc
Root plowed and raked	12.6 a	17.9 bc

[a]The area containing the plots was maintenance burned in 1974.

[b]Means followed by the same letter are not significantly different at the 95% level according to Duncan's New Multiple Range Test.

MANAGEMENT IMPLICATIONS

Apparently, canopy cover of mixed-brush stands on Chaparral-bristlegrass communities is relatively stable under a given set of management conditions. Shifts in botanical composition occurred over the 14-year period in response to rainfall patterns. Honey mesquite did not tolerate extended inundation, and during wet years was replaced, relative to its contribution to botanical composition based on foliar cover, primarily by huisache. Other species such as lime pricklyash and bluewood also increased, but not so dramatically as huisache.

Simple top removal by roller chopping or shredding resulted in only short-term suppression of the brush canopy and provided no lasting improvement in range condition (Figure 4). These methods must be applied systematically, either alone or in conjunction with other techniques such as burning, and repeated periodically to facilitate progressive improvement in range condition. Apparently, the maintenance burn applied in 1974 was too late after treatment to substantially improve vegetation of roller-chopped or shredded areas. Burning the year following mechanical treatment improved the level of brush suppression (Box and White, 1969), but burning apparently must be practiced regularly to maintain range improvement. These data and results from other studies indicate that simple top removal practices, if not followed with prescribed burning, should be repeated at 3- to 5-year intervals, depending on rainfall. Although simple top removal results in only short-term effects on the vegetation, some of the transient effects are of value. Shredding or roller chopping can be applied to create desirable patterns of brush suppression. This improves visibility on portions of the area which facilitates livestock handling and care while allowing maintenance of some mature brush cover. New sprouts stimulated by top removal improve browse value (Powell and Box, 1966), and reduced woody plant stature improves accessibility to the sprouts. Reduction of brush topgrowth releases herbaceous vegetation which provides fine fuel for installation of prescribed burns. The additional fuel and

Figure 4. Brush canopy cover of stands which were roller chopped (upper photo) or shredded (lower photo) in 1963 and on which the huisache was not oiled in 1971 were not different in 1977 from untreated areas on the Coastal Prairie.

localizing of the brush canopy near ground line allows maximum exposure of the woody plant topgrowth to the hottest part of grass fires.

Scalping, essentially a compromise between simple top removal methods and root plowing, does not appear to be advantageous over either of the other approaches (Figure 5). A possible contradiction would be the case of initially high brush covers where felled topgrowth would be left as litter unless raked. The "KG" blade shears the woody plants off at ground line and allows localizing of the debris without use of a brush rake. However, soil disturbance following scalping allows invasion of opportunists such as willow baccharis (Drawe, 1977) which retard the rate of range improvement.

Relative only to brush control effectiveness based on reductions in brush canopy cover, root plowing is the most effective mechanical method known. Since it removes at least a portion of the brush root system, treatment life expectancy is much longer than from other treatments. For example, the brush canopy cover 14 years after root plowing the study site is approximately 60 percent of the original cover. Where the huisache was removed by oiling, the present

Figure 5. Mixed-brush stand in November 1977 which was scalped in 1963 on the Welder Wildlife Refuge near Sinton, Texas.

canopy cover is only 15 percent of the original. Thus, a conservative treatment life estimate would be 20 years. Followup improvement efforts such as prescribed fire and/or individual-plant treatment with herbicides might suppress the brush canopy indefinitely. However, there are some distinct disadvantages of root plowing:

1. The surface soil is left extremely rough for several years following treatment. Although this facilitates water infiltration and retention, it is sometimes a problem in livestock management. Raking localizes debris following root plowing of dense brush and facilitates management.
2. The initial cost of treatment is high. Although economic returns may be favorable based on treatment life expectancy, cash flow within the operation at the desired time of treatment may limit the investment.
3. Soil disturbance is excessive, and secondary succession is reinitiated in its early stages. Thus, for several years after root plowing, low value forage species dominate the herbaceous stands. This often results in reduced stocking rates until desirable, perennial range forage species become reestablished.
4. The increase in huisache, which may form almost pure stands within a few years after root plowing, is a severe problem. Thus, huisache management is an important consideration when root plowing is accepted as the brush management alternative. Individual-plant treatments can be most economically and easily applied in the early stages of huisache infestation.
5. Root plowing essentially eliminates the brush cover and seriously reduces browse availability for an extended period. Its use requires careful planning where wildlife habitat is important to the range management strategy.

Each of these methods has particular adaptability to specific situations, and all are most effective when considered relative to land resource management objectives and when their use is carefully planned with provisions for followup treatment and proper grazing management for most effective response.

CONCLUSIONS

Absolute brush covers in mature "Chaparral-bristlegrass" communities as described on the Welder Wildlife Refuge on the Coastal Prairie are apparently relatively stable. Species composition of the stands may shift with prolonged changes in rainfall patterns. Based on a 20-year average of about 36 inches per year, honey mesquite dominated the brush stands during a 10-year period when the annual average was about 31 inches. During the next 10-year period, the annual average was over 41 inches, resulting in extended inundation of depressions. Honey mesquite, as evidenced by dead remains, did not tolerate the wet cycle and was largely replaced by huisache. During wet periods, bunchgrasses may be reduced in relative importance and water-tolerant sod formers such as longtom increase in importance.

Effects of roller chopping and shredding are short lived, and retreatments are necessary for lasting range improvement. These practices require repetition, probably at least on 3- to 5-year intervals, for maximum range improvement. Prescribed burning can be used for maintaining initial brush management effectiveness from shredding and roller chopping.

Scalping with a "KG" blade is intermediate in brush control effectiveness, soil disturbance, and response of desirable vegetation between simple top removal methods and root plowing. Utility of the method, compared to root plowing, probably would hinge on relative costs.

Root plowing provides long-term reductions in brush cover. However, range condition initially declines because of the influx of low-value range forage species. With effective followup improvement efforts and sound grazing management, the method offers a moderate to long-term approach to brush management.

Huisache is a particular problem when formulating brush management strategies for Coastal Prairie rangeland. Apparently, control of other woody species with root plowing releases huisache to dominate the woody plant stand. If root plowing is selected as a brush control alternative, the brush management program should include provisions for huisache treatment after 3 to 5 years.

ACKNOWLEDGMENTS

Jeff Powell collected the original data. These contrasts in time would not have been possible without preservation of the study plots by the Rob and Bessie Welder Wildlife Foundation. Permission from Caleb Glazener, Director of the Foundation, to pursue this work is gratefully acknowledged. The authors are grateful to Roger Smith and Clayton Phelps for their assistance in data collection and to Julia Scifres for typing and helping prepare the manuscript.

LITERATURE CITED

Beasom, S. L. and C. J. Scifres. 1977. Population reactions of selected game species to aerial herbicide applications in south Texas. J. Range Manage. 30:138-142.

Box, T. W. 1960. Herbage production in four range plant communities in south Texas. J. Range Manage. 13:72-76.

Box, T. W. 1961. Relationships between plants and soils of four plant communities in south Texas. Ecology 42:794-810.

Box, T. W. and A. D. Chamrad. 1966. Plant communities of the Welder Wildlife Refuge. Contrib. No. 5, Series B. Welder Wildlife Foundation, Sinton, TX. 28 p.

Box, T. W. and J. Powell. 1965. Brush management techniques for improved forage values in south Texas. Trans. N. Amer. Wildl. and Nat. Res. Conf. 30:285-296.

Box, T. W. and R. S. White. 1969. Fall and winter burning of south Texas brush ranges. J. Range Manage. 22:373-376.

Chamrad, A. D. and T. W. Box. 1965. Drought-associated mortality of range grasses in south Texas. Ecology 46:780-785.

Dodd, J. D. and S. T. Holtz. 1972. Integration of burning with mechanical manipulation of south Texas grassland. J. Range Manage. 25:130-136.

Drawe, D. L. 1968. Mid-summer diet of deer on the Welder Wildlife Refuge. J. Range Manage. 21:164-166.

Drawe, D. L. 1977. A study of five methods of mechanical brush control in south Texas. Rangeman's J. 4:37-39.

Drawe, D. L., A. D. Chamrad and T. W. Box. 1978. Plant communities of the Welder Wildlife Refuge. Contrib. No. 5, Series B (2nd Ed.). Welder Wildlife Foundation. Sinton, TX. 40 p.

Dyksterhuis, E. J. 1949. Condition and management of range land based on quantitative ecology. J. Range Manage. 2:104-115.

Durham, A. J., Jr. and M. M. Kothmann. 1977. Forage availability and cattle diets on the Texas Coastal Prairie. J. Range Manage. 30:103-106.

Gordon, R. A. and C. J. Scifres. 1977. Burning for improvement of Macartney rose infested Coastal Prairie. Texas Agr. Exp. Sta. Bull. 1183. 15 p.

Gould, F. W. 1975. Texas Plants. A checklist and ecological summary. Texas Agr. Exp. Sta. MP-585 (Rev.). 129 p.

Gould, F. W. and T. W. Box. 1965. Grasses of the Texas Coastal Bend. Texas A&M Univ. Press, College Station. 189 p.

McIntyre, G. A. 1952. A method for unbiased selective sampling using ranked sets. Austral. J. Agr. Res. 3:385-390.

Oefinger, R. E. and C. J. Scifres. 1977. Gulf cordgrass production, utilization and nutritional value following burning. Texas Agr. Exp. Sta. Bull. 1176, 19 p.

Powell, J. 1966. Forage production following selected mechanical brush control practices in south Texas. MS Thesis, Texas Tech Univ., Lubbock. 73 p.

Powell, J. and T. W. Box. 1966. Brush management influences forage value of south Texas woody plants. J. Range Manage. 19:212-214.

Powell, J. and T. W. Box. 1967. Mechanical control and fertilization as brush management practices affect forage production in south Texas. J. Range Manage. 20:227-236.

Powell, J., T. W. Box and C. V. Baker. 1972. Growth rate of sprouts after top removal of huisache (*Acacia farnesiana* [L.] Willd.) (*Leguminosae*) in south Texas. Southw. Nat. 17:

Scifres, C. J. 1977. Herbicides and the range ecosystem: Residues, research and the role of rangemen. J. Range Manage. 30:86-91.

Scifres, C. J. 1975. Systems for improving Macartney rose infested Coastal Prairie rangeland. Texas Agr. Exp. Sta. MP-1225. 12 p.

Scifres, C. J. (Ed). 1973. Mesquite. Growth and development, management, economics, control, uses. Texas Agr. Exp. Sta. Res. Mon. 1:84.

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.

Scifres, C. J., J. L. Mutz and G. P. Durham. 1976. Range improvement following chaining of south Texas mixed brush. J. Range Manage. 29-418-425.

Scifres, C. J. and M. G. Merkle. 1975. Herbicides and good management improves range pastures. Weeds Today. 6(1):5-7.

Scifres, C. J. and J. L. Mutz. 1975. Secondary succession following extended inundation of Texas coastal rangeland. J. Range Manage. 28:279-282.

Scifres, C. J., J. L. Mutz and W. T. Hamilton. 1978. Control of mixed brush with tebuthiuron. J. Range Manage. 31:(In press).

White, R. S. 1969. Fire temperatures and the effect of burning on south Texas brush communities. MS Thesis. Texas Tech. Univ., Lubbock.

Whitson, R. E., S. L. Beasom and C. J. Scifres. 1977. Economic evaluation of cattle and white-tailed deer response to aerial spraying of mixed brush. J. Range Manage. 30:214-217.

Appendix

SCIENTIFIC NAMES OF PLANTS MENTIONED IN TEXT

Common Name	Scientific Name
Cacti	
Pricklypear	*Opuntia* sp.
Tasajillo	*Opuntia leptocaulis*
Forbs	
Bundleflower	*Desmanthus virgatus*
Common ruellia	*Ruellia runyoni*
Erect dayflower	*Commelina erecta*
Prairie gerardia	*Gerardia heterophylla*
Saltmarsh aster	*Aster subulatus*
Sawtooth fogfruit	*Phyla incisa*
Seacoast sumpweed	*Iva annua*
Spotted beebalm	*Monarda punctata*
Texas snoutbean	*Rhynchosia texana*
Upright prairie-coneflower	*Ratibida columnaris*
Western ragweed	*Ambrosia psilostachya*
Horsetail conyza	*Conyza canadensis*
Grasses	
Big bluestem	*Andropogon gerardii*
Big cenchrus	*Cenchrus myosuroides*
Bristlegrass	*Setaria* sp.
Buffalograss	*Buchloe dactyloides*
Bunch cutgrass	*Leersia monandra*
Bushy bluestem	*Andropogon glomeratus*
Common Bermudagrass	*Cynodon dactylon*
Common curlymesquite	*Hilaria berlangeri*
Eastern gamagrass	*Tripsacum dactyloides*
Filly panicum	*Panicum hallii* var. *filipes*
Fringed chloris	*Chloris ciliata*
Green sprangletop	*Leptochloa dubia*
Gulf muhly	*Muhlenbergia capillaris* var. *filipes*
Hairyseed paspalum	*Paspalum pubiflorum*
Knotroot bristlegrass	*Setaria geniculata*
Little bluestem	*Schizachyrium scoparium*
Longtom	*Paspalum lividum*
Lovegrass tridens	*Tridens eragrostoides*
Meadow dropseed	*Sporobolus asper* var. *drummondii*
Mourning lovegrass	*Eragrostis lugens*

Common Name	Scientific Name
Grasses (continued)	
Nealley sprangletop	*Leptochloa nealleyi*
Pink tridens	*Tridens congestus*
Plains bristlegrass	*Setaria macrostachya*
Roemer threeawn	*Aristida roemeriana*
Seacoast bluestem	*Schizachyrium scoparium* var. *littoralis*
Sideoats grama	*Bouteloua curtipendula*
Silver bluestem	*Bothriochloa saccharoides* var. *longipaniculata*
Sourgrass	*Digitaria insularis*
Texas cupgrass	*Eriochloa sericea*
Texas grama	*Bouteloua rigidiseta*
Texas wintergrass	*Stipa leucotricha*
Threeawns	*Aristida* sp.
Tumblegrass	*Schedonnardus paniculatus*
Tumble windmillgrass	*Chloris verticillata*
Vine mesquite	*Panicum obtusum*
White tridens	*Tridens albescens*
Whorled dropseed	*Sporobolus pyramidatus*
Yellow Indiangrass	*Sorghastrum nutans*
Woody Plants	
Agarito	*Berberis trifoliolata*
Berlandier wolfberry	*Lycium berlandieri*
Blackbrush acacia	*Acacia rigidula*
Bluewood	*Condalia obovata*
Carolina wolfberry	*Lycium carolinianum*
Creeping mesquite	*Prosopis reptans*
Honey mesquite	*Prosopis glandulosa* var. *glandulosa*
Huisache	*Acacia farnesiana*
Lime pricklyash	*Zanthoxylum fagara*
Lotebush	*Zizyphus obtusifolia*
Spiny hackberry	*Celtis pallida*
Texas persimmon	*Diospyros texana*
Twisted acacia	*Acacia tortuosa*
Willow baccharis	*Baccharis salicina*
Wolfberry	*Lycium* sp.

Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the Texas Agricultural Experiment Station or by the Welder Wildlife Foundation and does not imply its approval to the exclusion of other products that also may be suitable.

[Blank Page in Original Bulletin]

All programs and information of The Texas Agricultural Experiment Station are available to everyone without regard to race, color, religion, sex, or national origin.

The Texas Agricultural Experiment Station, Neville P. Clarke, Director, College Station, Texas
3M—10-78