B-1408
September 1982

Ecology and Management of Huisache on the Texas Coastal Prairie

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

CONTENTS

Ecology and Management of Huisache on the Texas Coastal Prairie

AUTHORS

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

J. L. MUTZ, assistant research scientist, The Texas Agricultural Experiment Station (Corpus Christi)

D. L. DRAWE, assistant director, the Rob and Bessie Welder Wildlife Foundation, Sinton, Texas

FOREWORD

Huisache (pronounced WE-sah-chee) is recognized by range livestock producers as an aggressive, difficult-to-manage woody species. Conversely, huisache is also thought to possess some positive attributes, primarily as browse, mast, and cover for wildlife. Because of its abundance and tenacity in south Texas flora, the species has been studied for many years. Various research reports on its ecology and management have been published.

This publication (1) compiles information about huisache, (2) presents recent findings, and (3) identifies areas for additional study. It can serve as a useful reference for range resource/wildlife habitat managers who desire to manage huisache stands effectively, and it may stimulate additional research on various aspects of the problem. Much of the research reported here was conducted from 1975 to the present on the Rob and Bessie Welder Wildlife Foundation Refuge near Sinton, Texas. The authors express special thanks to the trustees, administration, and staff of the Foundation for their cooperation. Also, contributions of Texas A&M University Range Science graduate students and technical personnel, including O. E. Bontrager, G. A. Rasmussen, R. A. Masters, R. A. Gordon, W. C. Mohr, J. W. McAtee, and R. P. Smith are gratefully acknowledged. The efforts of Julia R. Scifres in manuscript preparation and typing are deeply appreciated.

C. J. Scifres
J. L. Mutz
D. L. Drawe

Published as Welder Wildlife Foundation Contribution No. 101.

CHAPTER 1

DESCRIPTION AND DISTRIBUTION OF HUISACHE

Description of Huisache

Huisache (*Acacia farnesiana* [L.] Willd.) usually occurs as a multistemmed shrub or tree less than 6 meters (m)[1] tall (Fig. 1.1), and occasionally as trees greater than 10 m tall. The multistemmed growth form is the result of disturbance of the top growth of single-stemmed trees. Fragrant, orange-yellow to orange flowers (Jones, 1975) usually appear in February-March as 2 to 5 heads, each 1.7 millimeters (mm) in diameter (Vines, 1960). The fruit is a persistent, cylindric, woody, straight or slightly curved legume, 5 to 8 centimeters (cm) long (Fig. 1.2). The legumes may be reddish brown but are more likely black. Seeds are ovoid, olive color to brown, shiny with relatively hard coats, and usually no more than 3 mm wide and 5 mm long (Scifres, 1975). Scifres (1975) described mature, dry seeds as usually weighing about 55 milligrams (mg) and having an average volume of about 0.05 cubic centimeters (cm^3).

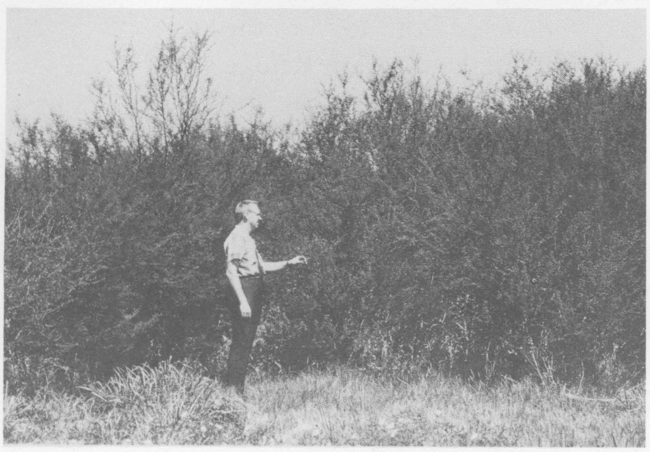

Figure 1.1. Huisache usually occurs as a multistemmed shrub or small tree (upper photo), usually the result of damage to, or removal of, the tops of single-stemmed trees; and may form dense stands on rangeland (lower photo, courtesy R.E. Meyer).

Huisache leaves are pinnately compound, alternate, 2.5 to 10 cm long (Fig. 1.2), and deciduous but usually with significant defoliation occurring only after a hard frost. Huisache leaves persist on plants in most years on the Coastal Prairie, and Jones (1975) describes huisache as evergreen. The pinnae occur as 2 to 8 pairs (Vines, 1960), each pair with 10 to 24 pairs of leaflets. The leaflets are linear with an acute or obtuse apex, about 2 to 6 mm long and about 1 mm wide, bright green, and smooth.

Mature huisache leaves are papillose and covered with scaly wax deposits (Meyer and Meola, 1978), but young leaflets have only a thin cuticle. Stomata occur on both surfaces of the leaflets, and are of similar densities on lower surfaces (162 per square millimeter [mm^2]) and upper surfaces (180/mm^2) (Meyer and Meola, 1978). A few long, pointed hairs occur on both surfaces of some leaves.

The twigs are smooth and with pairs of straight, rigid spines usually 2.50 to 2.75 cm long. Huisache wood is reddish brown.

Jones (1975) prefers the latin name *Acacia smalli* Isely, over *A. farnesiana* (L.) Willd. for huisache. However, the specific epithat, *farnesiana*, after Cardinal Odoardo Farnese (1573-1626) (Vines, 1960) is used here. Vines (1960) prefers the common name "sweet acacia" to huisache to minimize confusion with other *Acacias*. He lists more than 30 common names applied to huisache in the United States and Latin America. However, "huisache" appears adequately established in south Texas to continue as the colloquial reference.

Figure 1.2. The fruit of huisache is a persistent, reddish brown to b[lack] legume (photo courtesy Soil Conservation Service).

[1]Conversions from metric to English units are given in appendix A.

Distribution of Huisache

Huisache occurs throughout Central America and northern South America to the Guianas (Vines, 1960). A survey published about 18 years ago (Smith and Rechenthin, 1964) indicated that huisache occurred on about 1.1 million hectares (ha) in Texas, and that approximately 6 percent of that area supported stands with 20 percent or greater canopy cover ("heavy canopy cover"). The present range of huisache does not appear to have changed significantly since 1964, but livestock producers and biologists believe the density and cover of huisache has intensified within its range. The species is concentrated in the Coastal Bend, but occurs from Brazos County on the north to Cameron County in the extreme southern tip of Texas and west to Maverick County (Fig. 1.3).

The origin of huisache is obscure, but it was a conspicuous component of Texas vegetation in early 1800's. Jones (1975) indicates that increased abundance of huisache and other shrubs in the Coastal Bend may be closely correlated with permanent settlement by Irish colonists in the late 1820's, especially in the present locality of San Patricio in Nueces County. Increased grazing pressure, decreased frequency of prairie fires, and scattering of seeds by animals apparently increased the abundance of shrubs such as huisache. These disturbances are often cited as, at least partially, responsible for the "brush problem" over the entirety of south Texas (Scifres, 1980). Because of early accounts of huisache in the Coastal Bend, and since it occurs in both hemispheres and extends southward from Texas into Mexico, there appears no support for the senior author's earlier conclusion (Scifres, 1975) that huisache is an introduced species. The preponderance of evidence indicates that it should be considered a native, and it is so listed by most authorities (Gould, 1975).

The ranges of huisache and twisted acacia (*Acacia tortuosa* [L.] Willd.) (also listed as *A. schaffneri*, "Schaffner acacia" by some authors [Vines, 1960]) overlap, and the species are often confused. Similarities in growth form confound the problem, and twisted acacia may be known locally as "huisache chino" or "huisachillo" (Vines, 1960). However, there is little twisted acacia, compared to huisache, on the Coastal Prairie. Twisted acacia becomes increasingly abundant westward from the Coastal Bend into the South Texas Plains, with a concomitant decrease in relative abundance of huisache. Huisache retreats to mesic sites in the western South Texas Plains (the authors have observed trees greater than 15 m tall in drainages a few kilometers [km] north of Laredo [Fig. 1.4]).

Huisache stands reach maximum development on blackland soils of the Coastal Bend. Huisache has apparently increased dramatically on these sites and adjacent areas during the last 2 decades. Some of this increase may be the result of widespread use of mechanical brush management practices, such as rootplowing, which disturb the soil and favor the rapid development of huisache stands (Mutz et al., 1978). However, there is also the hypothesis that the environment of the Coastal Prairie has become progressively wetter during the past 25 years, and that such a trend toward increased precipitation favors huisache over other woody plants. That proposition is considered in Chapter 2.

Summary and Conclusions

Huisache usually occurs as a multistemmed shrub or small to medium-sized tree, the former growth form usually resulting from top growth disturbance. Huisache is distributed throughout Central America and northern South America and occurs in greatest abundance in Texas on the Coastal Prairie and eastern portion of the South Texas Plains. Huisache occurs primarily in the wetter valleys and low lands in the western portion of the South Texas Plains and is replaced largely by twisted acacia in the mixed-brush complexes on the dry uplands. Huisache abundance has apparently increased on the Coastal Prairie during the past 2 decades, perhaps in response to soil disturbance by mechanical brush control methods and/or a trend toward increasing annual precipitation.

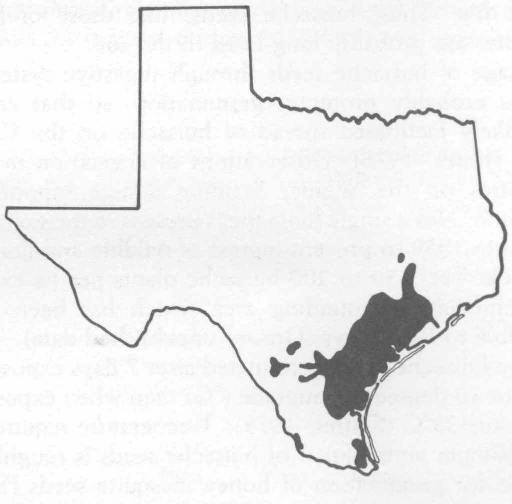

Figure 1.3. Generalized distribution of huisache in Texas (adapted by the authors from that of Smith and Rechenthin, 1964).

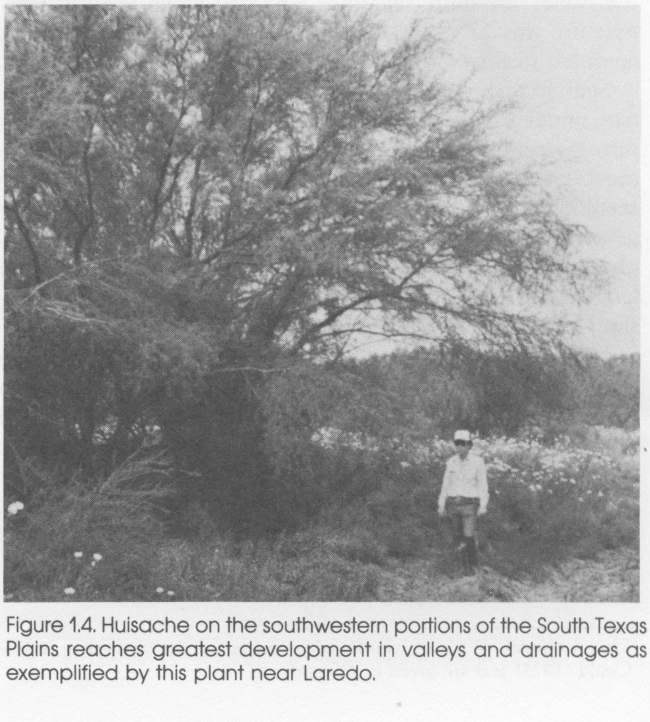

Figure 1.4. Huisache on the southwestern portions of the South Texas Plains reaches greatest development in valleys and drainages as exemplified by this plant near Laredo.

CHAPTER 2

GERMINATION, VEGETATIVE GROWTH, AND FACTORS AFFECTING STAND DEVELOPMENT OF HUISACHE

Seed Germination Requirements

Germination requirements of huisache seeds are similar to those for honey mesquite[2] seeds. Scifres (1975) reported that huisache seeds apparently have a thick hard seed coat. Only about 10 percent of the seeds (those with insect punctures and other imperfections which penetrate the coat but do not kill the embryo) germinated, even under optimal conditions. Soaking huisache seeds for 90 minutes in concentrated sulfuric acid was required for germination (70-75 percent) to approximate that of seeds which were nicked with a file. Thus, huisache seeds, like those of honey mesquite, are probably long-lived in the soil.

Passage of huisache seeds through digestive systems of animals probably promotes germination, so that animals have likely facilitated spread of huisache on the Coastal Prairie (Jones, 1975). Observations of vegetation in three exclosures on the Welder Wildlife Refuge support this deduction. Not a single huisache is present in the exclosures erected in 1959 to prevent ingress of wildlife and domestic livestock. Yet, 150 to 200 huisache plants per ha exist on the immediate surrounding area which has been freely accessible to herbivores (Drawe, unpublished data).

More huisache seeds germinated after 7 days exposure to constant 30 degrees Centigrade (°C) than when exposed to 16, 21 or, 38°C (Scifres, 1975). Temperature requirement for maximum germination of huisache seeds is roughly the same as for germination of honey mesquite seeds (Scifres and Brock, 1969). If the parallel between these species follows, soil temperature will also strongly regulate success of huisache seedlings. For example, more than 80 percent of the honey mesquite seedlings emerged when the soil temperature was 27°C, while only 20 percent of the seedlings emerged from soil at 18°C (Scifres and Brock, 1972).

Similar to honey mesquite seeds, huisache seeds germinate under a range of soil water availabilities if the temperature is optimal (Scifres, 1975). Water stress is apparently most critical to establishment success during the early seedling growth stages of huisache. For example, percent germination of huisache seeds was not reduced by 4 atmospheres (atm) of water tension at 30°C, but seedling root lengths were significantly reduced by 2 atm moisture tension.

Maximum germination of huisache seeds occurs in the range, pH 6 to 8 (Scifres, 1975). Moreover, germination was not retarded by 1,250 parts per million (ppm) sodium chloride in aqueous solution. Although seedling root growth was retarded by 625 ppm of salt in laboratory experiments, huisache is apparently relatively salt tolerant and grows on sandy clay loam-clay soils along the coast line.

Some cover is evidently necessary for seed coat contact with moisture and for anchorage of the huisache seedling root to ensure establishment (Scifres, 1975). For example, although darkness was not a requisite for germination, only 3 percent of huisache seeds germinated on the soil surface in greenhouse experiments. Moreover most seedlings emerged when seeds were planted 2 cm deep in soil. Cover of huisache seeds by moist mulch would probably be adequate for germination if the soil temperature is within the optimum range.

Seedling Growth

Little research has been conducted on huisache in the juvenile growth stage. Growth (height, number of leaves) of huisache seedlings was more rapid during simulated long-days (16 hours) than short-days (8 hours) under controlled-environment conditions where day-night temperatures were 32 and 24°C, respectively (Baur and Swanson, 1968). Soil phosphorus levels for optimal growth of huisache seedlings were lower than required for honey mesquite seedlings, but growth responses to soil nitrogen levels were similar for both species.

Vegetative Growth Characteristics

Huisache, like honey mesquite, regrows from stem buds upon top removal. New sprouts rapidly develop from residual stem tissues below ground when the top is removed to the soil surface, but huisache sprouts do not develop from root tissues. Bontrager et al. (1979) reported that the depth to which the stems must be removed to kill huisache plants increased as basal trunk diameter increased. Plants 1 to 4 cm in diameter were killed by removing stems to 5 to 10 cm deep, whereas huisache plants with trunks 6 to 15 cm diameter required removal to as deep as 20 cm to prevent regrowth. These depths coincided with junction of stems with the first lateral root.

The stage in a huisache seedling's development that it assumes perennating character has not been clearly defined under field conditions. Bovey and Meyer (1974) reported that removing the tops of 1 to 18-weeks-old greenhouse-grown seedlings to ground level killed 96 to 100 percent of huisache or honey mesquite. Regrowth potential of honey mesquite seedlings depends on the point of top removal in relation to the cotyledonary node (Scifres and Hahn, 1971). Honey mesquite seedlings only 7 days old survived top removal if the cotyledonary buds were left intact to develop new stems. Similar responses may result following top removal of huisache because of growth similar between the two species.

Powell et al. (1972) measured growth rates of huisache sprouts after cutting tops from plants of known ages on the

[2]Latin binomials of plants mentioned in the remainder of the text follow Gould (1975) and are given in Appendix B.

Rob and Bessie Welder Wildlife Refuge. New sprouts originated from stem tissue at or slightly below the soil surface. Within 5 months after cutting huisache, the new sprouts were almost half as tall as the parent plants (23.3 dm) at the time of cutting. The experiment was conducted in 1965 when annual precipitation was 19 cm less than the annual average of 1956-1980, and the last year of the driest 5-year period during the 25 years (Table 2.1). Thus, the results are probably conservative relative to the vegetative regrowth potential of huisache during wet periods.

Rasmussen (1981) reported that new sprouts grew at rates exceeding 1 m/year following burning of huisache on the Welder Refuge in 1980, and that growth slowed only during dry periods. Although huisache is classified as a cool-season plant (Gould, 1975), Rasmussen (1981) reported that sprout elongation normally ceased during the winter months.

Powell et al. (1972) emphasized the importance of biotic pressures on ultimate development of huisache sprouts. Eighty-five percent of cut plants had at least one sprout damaged by insects or animals. Terminal height of undamaged sprouts was 7.9 dm, almost twice that of sprouts with tips that had been eaten by animals and insects. Major impacts by insects were inflicted by tree hoppers and twig gridlers (*Oncideres* spp.), also referred to as long-horned wood boring beetles (*Ceramoycidae*). Rasmussen (1981) attributed damage inflicted by insects on new huisache growth following burning primarily to feeding of the leaf-footed bug (*Mozena obtusa*) and twig gridler. All of these insects also attack honey mesquite (Ueckert et al., 1971; Ueckert, 1973).

Rainfall Patterns on the Coastal Prairie and Huisache Stand Development

Records for 1956 through 1980 from the Rob and Bessie Welder Wildlife Foundation Refuge near Sinton were evaluated as an example of rainfall trends on the Coastal Prairie. Huisache abundance has increased dramatically on the Refuge since the mid-1950's (Drawe, personal observation).

The 25-year annual rainfall average (1956-1980) on the Refuge is 89.7 cm with a low of 38 cm in 1956 (near the end of the drought of the 1950's), and a high of 125.1 cm in 1973 (Table 2.1). Annual rainfall in 6 of 10 years from 1956 through 1965 was less than the average of the last 25 years, whereas rainfall in 7 to 10 years from 1971 through 1980 exceeded the long-term annual average.

Annual rainfall was inspected further by arbitrarily grouping the data into 5-year increments. On this basis, precipitation from 1956 through 1960 was near the 25-year average, but the standard deviation (15 percent of the average for the 5-year period) was greater than with any other 5-year group. This variation was the result of the driest year and one of the wetter years (1960) during the last 25 years occurring during the 5-year period.

Seasonal rainfall in the Coastal Bend is "fairly uniformly distributed throughout the year with slight highs in September and in late spring" (Gould, 1975). The pattern during 1956 through 1960 deviates from that generality somewhat because of the relatively dry summers (July rainfall averaged only 0.8 cm and August averaged 6.9 cm). However, September rainfall during that 5-year period averaged 9.4 cm (10.4 percent of the annual average).

Rainfall patterns from 1961 through 1965 (Fig. 2.1), the driest 5-year period of those inspected (Table 2.1), reflected that considered to be "normal." However, more rainfall was received from 1966 through 1980 than during the previous 5 years, and the rainfall was not evenly distributed within years. During the latter 15 years, annual rainfall in only 4 years was less than the 25-year average (Table 2.1). About 69 percent of the rainfall was received from April through September, and 40 percent of the annual precipitation occurred from July through September.

Thus, there appears to be a trend toward increased wetness on the Welder Refuge with higher amounts of rainfall received annually during the last 15 years than in the previous 10 years. Also, a greater proportion of the annual precipitation occurred during the "growing season," especially summer and early fall. For example, the proportion of average annual rainfall received from April through September was 54 percent during 1956-1960, 58 percent during

TABLE 2.1. ANNUAL RAINFALL (cm), DEVIATIONS FROM THE 25-YEAR AVERAGE, AND 5-YEAR AVERAGES AND THEIR DEVIATIONS FROM THE 25-YEAR AVERAGE FOR 1956-1980 ON THE ROB AND BESSIE WELDER WILDLIFE REFUGE NEAR SINTON, TEXAS

Year	Rainfall (cm)	Deviation from 25-year average* (cm)
1956	38.0	−51.7
1957	105.4	+15.7
1958	98.8	+ 9.1
1959	88.9	− 0.8
1960	119.3	+29.6
Average	90.1 ± 13.9	+ 0.4
1961	66.8	−22.9
1962	47.0	−42.7
1963	42.5	−47.2
1964	92.0	+ 2.3
1965	70.7	−19.0
Average	63.8 ± 8.9	−25.9
1966	81.3	− 8.4
1967	109.3	+19.6
1968	122.4	+32.7
1969	85.9	− 3.8
1970	102.7	+13.0
Average	100.3 ± 7.6	+10.6
1971	99.4	+ 9.7
1972	99.8	+10.1
1973	125.1	+35.4
1974	100.4	+10.7
1975	77.7	−12.0
Average	100.3 ± 7.5	+10.8
1976	124.6	+34.9
1977	77.7	−12.0
1978	77.3	−12.4
1979	100.4	+10.7
1980	90.0	+ 0.3
Average	94.0 ± 8.8	+ 4.3

*The average annual rainfall on the Welder Wildlife Refuge for 1956-1980 was 89.7 ± 4.81 cm.

1961-1965, 66 percent during 1966-1970, 74 percent during 1971-1975, and 65 percent during 1976-1980 (Fig. 2.1). Rainfall during 1981, the wettest year on record for the Welder Wildlife Refuge, was nearly 128 cm, of which 89 cm were received from April through September.

Analysis of the influence of any environmental factor on species success must consider the impact of extremes as well as "average" conditions if logical conclusions are to be drawn. Since weather on the Refuge is dictated by gulf air masses, extremes are more likely to be wet than dry, because of the influence of tropical storms. Standard deviations of rainfall for the three arbitrary 5-year groups from 1966 through 1980 were 8 to 9 percent of the average contrasted to standard deviations of 14 to 15 percent of the averages for 1956 through 1965.

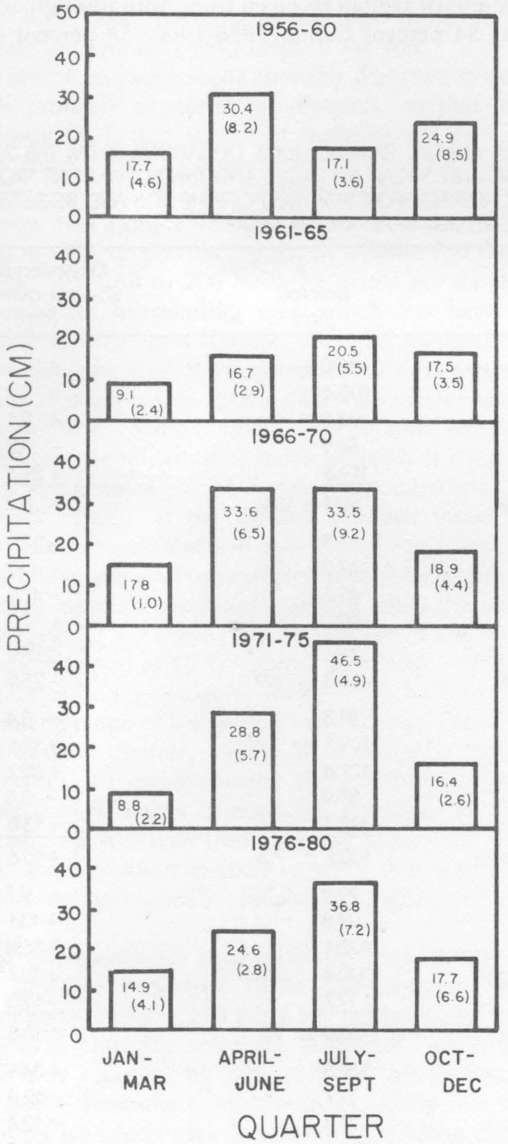

Figure 2.1. Average seasonal rainfall distribution based on arbitrary 5-year groupings for 1956 through 1980 on the Rob and Bessie Welder Wildlife Refuge near Sinton, Texas (standard deviations in parentheses).

Vegetative growth of huisache occurs any time from April through October when there is ample soil water (Rasmussen, 1981). Although the trend toward increased wetness since 1956 may only be coincidental with a perceived increase in huisache abundance, it provides an explanation for the rapid increases in size of plants on the Refuge (as much as 1 m in height per year in some studies [Rasmussen, 1981]). Indirect evidence indicates that wet cycles lend competitive advantage to huisache over other woody plants such as honey mesquite which do not tolerate flooding. Herbaceous vegetation of depressions and lowlands is presently dominated by water-tolerant sod formers such as longtom (Drawe et al., 1978), species which were considered of little importance during drier periods (Chamrad and Box, 1965).

Summary and Conclusions

Germination of freshly disseminated huisache seeds is constrained by a seed coat which apparently is impervious to water. Once the seed coat is broken, germination occurs rapidly, and a greater proportion of the seeds germinate at 30°C than at 16°C, 21°C, or 38°C. Scarified huisache seeds may germinate under the optimal temperature even when water availability is limited. Huisache seeds will germinate in light, but minimal soil cover is needed to ensure seed coat-water contact and provide anchorage for the seedling root. This cover requirement could likely be met by moist mulch as well as by mineral soil.

Huisache seedling growth was more rapid under long-days (16 hours) than short-days (8 hours) in controlled environments (daytime temperature of 32°C and dark period temperature of 24°C). Considering germination and seedling growth requirements, the environment of the Coastal Prairie is apparently conducive to huisache seedling establishment in either spring or fall.

Huisache regrows vegetatively from stem buds, but does not develop sprouts from root tissues. Since a portion of the stem occurs below ground line, plants are killed only when stems are removed to the point of juncture with the first lateral root. Huisache branches elongate rapidly following top removal, and the plants may increase their height by as much as 1 m/year.

The perceived increase in huisache abundance on the Coastal Prairie is attributed largely to a trend toward increased wetness. Analysis of rainfall records from the Welder Wildlife Refuge confirms that annual average rainfall has increased during the past 26 years, is less variable from year-to-year than in the late 1950's, and that an increasing proportion of the annual rainfall is received from April through September.

CHAPTER 3

INFLUENCE OF HUISACHE ON RANGE FORAGE PRODUCTION AND BOTANICAL COMPOSITION

Influence of Huisache Canopy Cover on Herbaceous Production

Grass production under various canopy covers of huisache was calculated from seasonal harvests on a Blackland range site on the Rob and Bessie Welder Wildlife Refuge during 1978 and 1979 (Scifres et al., 1982). The site is nearly level upland typified by Victoria clay (fine, montmorillonitic, hyperthermic family of Udic Pellusterts). The experiment was located on an area which had been rootplowed during the summer of 1963 (Mutz et al., 1978). The rootplowing converted the "Chaparral-bristlegrass" community (Drawe et al., 1978) to huisache-dominated woody stands. The pasture was grazed with cows and calves at 1 animal unit (AU)/4.9 ha.

Grass production did not decrease in 1978, compared to that on huisache-free areas, until huisache canopy cover exceeded 30 percent[3] based on the relationship:

Grass production (kg/ha) = 2,346 + 20 (percent canopy cover) − 0.62 (percent canopy cover)^2

Annual rainfall in 1978 (77.4 cm) was 12.4 cm less than the 25-year average on the study site (Table 2.1). The forage production curve indicated the importance of Texas wintergrass, relative to that of warm-season grasses, in herbaceous stands during years when rainfall (April-June) was less than average. Production of Texas wintergrass increased as huisache canopy cover increased to 25 percent. Texas wintergrass growth during winter partly compensated for losses of warm-season species to weathering and decomposition. As noted by Drawe et al. (1978), "As the huisache overstory increases, the understory herbaceous vegetation has shifted to more shade-tolerant and/or cool-season species such as Texas wintergrass, canarygrass, ozarkgrass, and common six-weeksgrass." The relationship of Texas wintergrass and honey mesquite on the Rolling Plains (Brock, 1978) is similar to that with huisache described by Drawe et al. (1978).

Texas wintergrass has been viewed as one of the "less desirable grasses" for grazing on Coastal Prairie (Powell, 1966). The "desirable grasses" such as big cenchrus, bunch cutgrass, hairyseed paspalum, little bluestem, lovegrass tridens, mourning lovegrass, sideoats grama, silver bluestem, and sourgrass are warm-season species. Considering reduced availability and quality of warm-season species during winter on the Coastal Prairie, the importance of Texas wintergrass as a forage species may be underestimated. If so, the interrelationship of huisache control with Texas wintergrass as it contributes to the forage base must be considered for most efficient management of certain sites on the Coastal Prairie.

The contribution of Texas wintergrass to total forage production may be masked by greater production of warm-season species during wet growing seasons. For example, annual rainfall in 1979 on the Blackland range site exceeded the long-term average by 10.7 cm, and a greater amount occurred during April-June than in 1978. Grass production in 1979 decreased with increasing huisache canopy cover according to the relationship:

Grass production (kg/ha) = 2,047 − 14.9 (percent canopy cover) − 0.29 (percent canopy cover)^2

However, this reduction in proportion of annual forage production contributed by Texas wintergrass does not diminish its importance during the cool season.

Influence of Huisache on Livestock Carrying Capacities

The influence of huisache canopy cover on livestock carrying capacities varies with rainfall conditions, range site, and (on Blackland range sites) relative importance given to Texas wintergrass. Mutz et al. (1978) estimated carrying capacities of cows in 1977 on Blackland range sites treated with mechanical methods in 1963. Half of the experimental areas had also been oiled in 1971 to remove the huisache. Estimates of carrying capacities were based on "herbage scores," similar to range site condition classifications, for the various treatments. The system allowed for no more than 10 percent of the forage to be furnished by Texas wintergrass in developing the herbage score. Data were collected in August of a year which received 83 percent of the average annual precipitation based on rainfall during 1956-1980 (Table 2.1).

Compared to the proportion of huisache in the mixed-brush stands in 1963, huisache had increased by 15 percent by 1977 on sites rootplowed and oiled, and by 76 percent on sites rootplowed only (Mutz et al., 1978). Carrying capacity in 1977 on areas rootplowed and raked in 1963 followed by oiling of huisache in 1971 was 1 AU/5 ha. This compared to an estimated carrying capacity of 1 AU/7.3 ha on areas rootplowed and raked but not oiled. Carrying capacity averaged 1 AU/9.5 ha on plots which did not receive mechanical treatment, but the huisache was removed from the Chaparral-bristlegrass communities by oiling.

The technique of Whitson et al. (1979), applied to data of Scifres et al. (1981), allows evaluation of the influence of

[3]Canopy covers in this research were based on the line-intercept method and do not directly correspond to values established by the Soil Conservation Service (Smith and Rechenthin, 1964) for categorizing brush covers. Cover values in this text may be viewed as "light" = ≤20 percent, "moderate" = 20-40 percent, and "heavy" as >40 percent for comparative purposes.

huisache on carrying capacities of Blackland range sites. This approach does not adjust for "grazing value" among grass species (i.e., the total production of Texas wintergrass is used) and does not include forb production. These data also illustrate potential variation in livestock carrying capacities with variations in huisache canopy covers as influenced by annual rainfall.

Carrying capacities on huisache-free Blackland range sites during 1978 when rainfall was 86 percent of the long-term average (Table 2.1), was 57 percent of that in 1979 when rainfall was 112 percent of the average (Table 3.1). Moreover, carrying capacities for cattle were greater in 1979 than in 1978, regardless of huisache canopy cover within the range, 0 to 70 percent. However, carrying capacities in 1978 were not decreased by 30 percent canopy cover of huisache. In comparison, 21 percent more land area was required to support an animal unit where huisache canopy cover was 30 percent in 1979 than on huisache-free areas.

Botanical Composition of Herbaceous Stands as Influenced by Huisache Removal

Since carrying capacity comparisons are influenced by relative proportion of Texas wintergrass to warm-season species, and since Texas wintergrass occurs on Blackland range sites most abundantly in the proximity of huisache plants, research was conducted to quantify the influence of huisache removal on botanical composition of grass stands on Blackland range sites (Mutz et al., 1982).

The research site is Blackland typified by Victoria clay on the Rob and Bessie Welder Wildlife Foundation's Refuge (Mutz et al., 1982). Primary warm-season grasses on the site are meadow dropseed, silver bluestem, plains bristlegrass, buffalograss, vine mesquite, common curlymesquite, and filly panicum. The primary cool-season grass is Texas wintergrass. Common forbs include prairie coneflower, crown coreopsis, spotted beebalm, bundleflower, Texas snoutbean, and annual sumpweed.

Research was conducted in two pastures, one moderately-stocked, and continuously grazed (1 AU/5.7 ha), and the other moderately-stocked but grazed as a four-pasture three-herd system (Mutz et al., 1982). Huisache manipulation treatments applied to each pasture were (a) no treatment, (b) oiling (application of kerosene or fuel oil to the lower 50 cm of the tree base, see Chapter IV), (c) low-energy grubbing June 27-30, 1978, (d) prescribed burning in winter, 1979, (e) burning following oiling, and (f) burning following grubbing.

Prescribed burns were applied to the continuously-grazed pasture on January 12, and to plots in the four-pasture, three-herd system on February 6, 1979. Burns were applied as headfires when the wind speed was 12 to 19 kilometers (km)/hr, air temperature was 10°C, and relative humidity was 39 to 59 percent. Fine fuel loads were 3200 kg/ha on the continuously grazed and 2000 kg/ha on the deferred-rotationally grazed pastures. Fine fuel water content averaged 13 percent during burning of the continuously-grazed pasture, and 20 percent on the pasture grazed in the four-pasture, three-herd system.

The influence of huisache removal on botanical composition of grass stands was also evaluated on plots grubbed in 1975 by Bontrager et al. (1979). Two untreated plots and two grubbed plots on Odem fine sandy loam were burned in January 1979. Standing crop of herbaceous vegetation and botanical composition of grass stands were evaluated, as described for the 1978 experiment, in April 1980.

Honey mesquite served as a codominant with huisache on the study area (Table 3.2). The continuously-grazed pasture supported an average of 179 huisache plants/ha, 1 to 2 m tall, and canopy cover averaged 8 percent. In contrast, the four-pasture, three-herd system contained an average of 466 plants/ha and canopy cover averaged 19.8 percent. Thus, effects of huisache density are confounded with the influence of grazing management in this experiment. However, huisache canopy covers are in the range reported by Scifres et al. (1982) as complimentary to the presence of Texas wintergrass.

TABLE 3.1. INFLUENCE OF HUISACHE CANOPY COVER (%) ON ESTIMATES OF CARRYING CAPACITIES BASED ON DATA OF SCIFRES ET AL. (1982) COLLECTED IN 1978 AND 1979 FROM BLACKLAND RANGE SITES, WELDER WILDLIFE FOUNDATION REFUGE NEAR SINTON, TEXAS

Huisache canopy cover (%)	Estimated carrying capacity (ha/AU) 1978	1979
0	7.3	4.2
10	6.9	4.4
20	6.8	4.7
30	7.1	5.1
40	7.9	5.7
50	9.4	6.6
60	12.9	8.1
70	24.0	10.7

TABLE 3.2. HUISACHE DENSITY (PLANTS/ha) AND CANOPY COVERS (%) OF HUISACHE, HONEY MESQUITE, AND OTHER WOODY SPECIES IN JUNE 1978, IMMEDIATELY PRIOR TO HUISACHE REMOVAL BY GRUBBING AND OILING ON PASTURES SUBJECTED TO TWO GRAZING MANAGEMENT REGIMES ON THE ROB AND BESSIE WELDER WILDLIFE REFUGE NEAR SINTON

Assigned treatment	Huisache density	Canopy cover: Huisache	Honey mesquite	Others	Total
	Continuous grazing				
None	186	8.5	16.0	0.7	25.2
Oil huisache	132	5.5	13.7	0.6	19.8
Grub huisache	189	5.5	9.7	0.1	15.3
Prescribed burn	183	7.9	9.2	0.2	17.3
Oil/burn	198	10.5	15.8	0.2	26.5
Grub/burn	188	10.3	12.0	0.6	22.9
	4-pasture, 3-herd				
None	438	12.7	32.9	1.1	46.7
Oil huisache	455	6.8	23.2	1.0	31.0
Grub huisache	536	8.1	33.9	1.4	43.4
Prescribed burn	482	13.3	30.8	0.2	44.3
Oil/burn	482	11.7	21.4	0.7	33.8
Grub/burn	400	12.0	22.6	0.4	35.0

Based on evaluations of moderately-stocked (1 AU/5.7 ha), continuously-grazed plots in spring 1979, 11 months after huisache removal by oiling or low-energy grubbing and 4 months after prescribed burning, the proportion of the stands composed of warm-season perennial grasses had increased on treated plots, compared to that of stands on untreated plots (Table 3.3). These relative reductions were accompanied by increases in Texas wintergrass and forbs. The reason for the increase in relative presence of warm-season perennials, primarily meadow dropseed, and the decrease in cool-season grasses on untreated plots in 1980 are not clear. More rainfall was received in 1979 than in 1980, and data were collected in May before seasonal decreases in presence of green Texas wintergrass normally occurs.

Treatment-induced changes in the composition of herbaceous stands on plots grazed as a part of a four-pasture, three-herd system followed the same pattern in both years. The proportion of warm-season perennials in stands on burned plots was greater than that on untreated plots (Table 3.3). In all cases, relative increases in warm-season perennials, primarily meadow dropseed, were accompanied by decreases in Texas wintergrass.

Bontrager et al. (1979) reported that the proportion of cool-season grasses was increased within two growing seasons after removal of huisache by low-energy grubbing on Sinton sandy clay loam and Odem sandy loam. The proportion of Canada wildrye, based on foliar cover, increased from 0 to 4 percent, and Texas wintergrass increased from 2 to 21 percent of the botanical composition on Sinton sandy clay loam after grubbing. Grubbing on Odem sandy loam increased Canada wildrye from 0 to 2 percent and Texas wintergrass from 2 to 19 percent of the herbaceous composition. However, little bluestem also increased significantly on both soils as a result of removing the huisache by grubbing. These increases appeared to occur at the expense of other warm-season grasses such as hairyseed paspalum and knotroot bristlegrass. Also, the initial increase in cool-season species occurred in pits left by grubbing rather than uniformly over treated plots.

Prescribed burning in January 1979 of otherwise untreated Sinton sandy clay loam in the experiment of Bontrager et al. (1979) did not alter grass standing crop in April 1980 (Table 3.4). Removal of huisache by low-energy grubbing in August 1975 significantly increased grass standing crop, but greatest grass yields were harvested from those plots which were grubbed and burned. Forb standing crops on grubbed/prescribed burned plots exceeded those on untreated plots and those treated only with prescribed burning.

In contrast to the composition of herbaceous stands shortly after huisache removal by Bontrager et al. (1979), stands on plots on Sinton sandy clay loam which were grubbed in 1975, whether burned in 1979 or not, tended to contain greater proportions of warm-season perennials, primarily Pan American balsamscale, than those on untreated plots (Table 3.5). As on the Blackland site, the shift toward increased proportions of warm-season grasses was concomitant with a decrease in cool-season grasses, primarily Texas wintergrass, and forbs. This shift is supportive of the deduction by Scifres et al. (1982) that huisache removal could favor warm-season grasses at the expense of Texas wintergrass on some sites.

TABLE 3.3. COMPOSITION OF HERBACEOUS STANDS (%) BASED ON FOLIAR COVER IN MAY 1979 AND 1980 ON PASTURES SUBJECTED TO TWO GRAZING MANAGEMENT REGIMES AFTER OILING OR GRUBBING HUISACHE IN JUNE 1978 AND/OR PRESCRIBED BURNING ON JANUARY 31, 1979 ON THE WELDER WILDLIFE REFUGE NEAR SINTON, TEXAS

	Grazing regime							
	Continuous				4-pasture, 3-herd			
Treatment	WSP[a]	CSA	CSP	Forbs	WSP	CSA	CSP	Forbs
	May 1979							
None	28	20	26	26	44	4	26	26
Oil huisache	37	18	25	20	40	10*	18	32
Grub huisache	42*	19	20	19	50	11*	22	17
Prescribed burn	43*	10*	28	19	77*	1	1*	21
Oil/burn	46*	11*	27	16	79*	6	<1*	14*
Grub/burn	53*	6*	23	18	71*	3	7*	19
	May 1980							
None	52	4	12	32	43	2	36	20
Oil huisache	55	3	7	35	72*	1	10*	17
Grub huisache	45	3	15	37	56	<1	25	18
Prescribed burn	50	2	6	46*	59*	4	11*	26
Oil/burn	29*	1	21*	49*	60*	1	23*	16
Grub/burn	30*	1	20*	49*	48	6*	22*	24

[a]WSP = warm-season perennial grasses; CSA = cool-season annual grasses; CSP = cool-season perennial grasses.

*Significantly different (P≤.05) from mean of untreated plot.

Summary and Conclusions

The interaction of huisache with grass production is not as straightforward as is generally perceived, i.e., grass production does not necessarily decrease as brush cover increases. While huisache canopy increased from 0 to 30 percent on Blackland range sites, cool-season grass production, especially Texas wintergrass, also increased. This relationship may be masked during years with wet growing seasons which stimulate increased production of warm-season grasses and/or when forage production is based solely on end-of-season (late summer to early fall) harvests of standing crops.

Removal of huisache generally reduces the proportion of cool-season annuals, Texas wintergrass, and other cool-season perennials (such as Canada wildrye) in the grass stands. On clay soils, warm-season species such as meadow dropseed, silver bluestem, and little bluestem increase following huisache removal. Species such as Pan American balsamscale, seacoast bluestem, and little bluestem increase in abundance as huisache decreases on sandy loam and sandy clay loam soils.

Projected livestock carrying capacities did not decrease, compared to those of brush-free areas, until the huisache canopy cover exceeded 30 percent (based on the line-intercept method) in a year when annual rainfall was 14 percent less than the 25-year average on the Coastal Prairie. Conversely, during a year when annual rainfall was 12 percent above the long-term average, increasing huisache canopy cover progressively decreased carrying capac[ity]. Carrying capacity on brush-free rangeland increased from 1 AU/23 ha to 1 AU/4.2 ha with an increase of 23.1 cm of annual rainfall.

The positive influence of huisache on cool-season grasses on the Coastal Prairie, and the need for green forage during winter, indicate that complete removal of huisache might not be in the best interest of management goals to provide year-round grazing for livestock. However, an adequate test of this hypothesis will require additional research to identify interactions of grazing with huisache control on botanical composition of forage stands.

TABLE 3.4. HERBACEOUS STANDING CROPS (kg/ha) IN APRIL 1980 FOLLOWING LOW-ENERGY GRUBBING OF HUISACHE IN AUGUST 1975 AND PRESCRIBED BURNING ON JANUARY 11, 1979 ON SINTON SANDY CLAY LOAM ON THE WELDER WILDLIFE REFUGE NEAR SINTON, TEXAS

	Standing crop (kg/ha)[1]	
Treatment	Forbs	Grasses
None	162 a	2,320 a
Low-energy grubbing	311 c	3,992 b
Prescribed burning	170 ab	2,412 a
Grubbing/burning	229 b	4,672 c

[1]Means within a column are not significantly different (P≤.05) according to Student-Newman-Keul's test.

TABLE 3.5. GENERALIZED BOTANICAL COMPOSITION (%) OF HERBAGE STANDS BASED ON FOLIAR INTERCEPTS IN APRIL 1980 AFTER LOW-ENERGY GRUBBING OF HUISACHE IN AUGUST 1975 AND GRUBBING FOLLOWING PRESCRIBED BURNING IN JANUARY 1979 ON THE ROB AND BESSIE WELDER WILDLIFE REFUGE NEAR SINTON, TEXAS

	Treatment			
Herbage category	None	Grubbed	Burned	Grubbed-burned
Warm-season perennial grasses	16.2	23.2	14.0	22.0
Cool-season perennial grasses	46.3	28.5*	43.3	15.7*
Cool-season annual grasses	26.0	19.6	21.1	22.1
Grasslikes (sedges, rushes)	0	1.7	2.6	0
Forbs, vines	11.5	27.0*	18.9*	40.3*

*Significantly different (P≤.05) from expected (no treatment) value.

CHAPTER 4

CONTROL METHODS FOR HUISACHE

Mechanical Methods

Huisache rapidly develops new sprouts from residual stem buds remaining after top removal. Therefore, methods such as shredding or roller chopping offer only temporary suppression, usually for no longer than 5 years (Mutz et al., 1978). Since canopy replacement is more rapid in wet than dry years (Rasmussen, 1981), treatment applications of 3-year intervals would probably be a reasonable expectation if the management goal was to suppress the influence of huisache stands on herbaceous vegetation. Such treatments as shredding are inexpensive, they prevent the huisache problem from worsening for a given time period, and there may be advantages to reducing the height of the browse and stimulating new growth for wildlife.

Removal of all stems to the lower-most stem bud (the juncture of the first lateral root) is required to kill huisache plants (Fig. 4.1). Bontrager et al. (1979) evaluated low-energy grubbing (Wiedemann et al., 1977) for removal of huisache on Sinton sandy clay loam and Odem sandy loam on the Rob and Bessie Welder Wildlife Refuge. Low-energy mechanical grubbing of 181 to 689 huisache trees/ha, 1.8 to 2.6 m tall, reduced the canopy cover by 90 to 96 percent and killed 65 to 81 percent of the trees. Grubbing time varied from 0.5 hr/ha for removal of 181 plants/ha to 1.6 hr/ha for removal of 689 plants. Grubbing time was highly correlated ($r = 0.88$) with huisache density.

Figure 4.1. Power grubbing effectively controls huisache if the stems are removed to the first lateral root to ensure that all buds are removed.

The relationship was best described by the equation:

$\hat{Y} = 0.0567 + 0.0024(X)$ where $\hat{Y}$ = grubbing time (hr) and

X = huisache density (plants/ha).

Grubbing relatively dense huisache stands substantially increased the proportion of bare ground immediately after treatment; removal of an average plant left a pit of approximately 36 cm^2. Thus the soil surface, especially where greater huisache densities were removed, became extremely rough.

Efficiency of low-energy grubbing was reduced on clays compared to sandy loams and sandy clay loams. Based on results of Bontrager et al. (1979) and using the same operator and machine, grubbing time increased by 12 to 80 percent on clay, compared to that on sandy loam and sandy clay loam (Table 4.1). The time requirement attributable to differences in soils tended to decrease as huisache stand density increased. Apparently, more time and energy are required to force the blade beneath the lower-most bud on Blackland sites than on sandy loam-sandy clay loam sites. Grubbing efficiency may be increased by removal of herbaceous vegetation, by such means as burning, immediately prior to grubbing. Heavy cover of herbaceous vegetation appears to cause the grubber blade to slip over the surface rather than immediately to cut into the soil. This reduces the blade depth upon contact with the huisache stem, and increases the probability of leaving stem tissues intact, particularly on clay soils as compared to sandy loam or sandy clay loams.

Rootplowing may effectively control huisache. However, some rootplowed sites may be highly susceptible to establishment of almost solid stands of huisache (Mutz et al., 1978). For example, 14 years after Chaparral-bristlegrass communities were rootplowed on the Welder Wildlife Refuge, huisache canopy cover averaged 22.2 percent compared to 4.2 percent on adjacent untreated sites. Huisache accounted for 80.3 percent of the total brush cover on the

TABLE 4.1. COMPARISON OF GRUBBING TIME (hr/ha) ON BLACKLAND RANGE SITE COMPARED TO EXPECTED TIMES BASED ON PREVIOUS EXPERIMENTS ON ODEM SANDY LOAM AND SINTON SANDY CLAY LOAM ON THE WELDER REFUGE

Huisache density (plants/ha)	Grubbing time (hr/ha)		Increase on Blackland site (%)
	Expected[a]	Actual	
186	0.50	0.90	80
188	0.51	0.74	45
391	0.99	1.12	13
397	1.01	1.36	26

[a]Calculated based on results of Bontrager et al. (1979) on Odem sandy loam and Sinton Sandy clay loam where grubbing time = 0.0567+0.0024 (huisache density).

rootplowed site, and 8.6 percent on undisturbed areas. Raking following rootplowing did not influence huisache recovery, compared to rootplowing alone. The huisache stands were apparently fully developed 5 to 7 years after rootplowing. Mutz et al. (1978) believed that greater than normal rainfall, especially the third and fourth growing season following rootplowing (1967, 1969) (Table 2.1), augmented huisache stand development.

Chemical Methods

The most effective chemical control method for huisache is oiling (pouring of 0.25 to 2 liters of diesel oil or kerosene, depending on the basal diameter, around the base of each plant) (Scifres, 1980). Cost of oiling varies with huisache density and amount of oil applied per tree. Oiling of 455 to 482 huisache plants/ha with 0.58 to 0.64 liter of kerosene/tree was estimated to cost $73.89 to $76.93/ha (Table 4.2). Many plants in this stand were less than 1.5 m tall. In contrast, removal of approximately 400 trees/ha by low-energy grubbing cost $34.25/ha. Oiling 198 trees/ha (most $\leq$ 1.5 m tall) cost $75.84/ha, compared to $18.52/ha for low-energy grubbing of similar (188 trees/ha) densities.

Treating the foliage or trunk bases of individual plants with sprays containing 9.6 grams of 2,4,5-T (a.i.) per liter of oil (8 pounds per 100 gallons) effectively controls huisache. Foliar sprays of 2.4 grams (a.i.) of picloram per liter of a 1:3, diesel oil:water emulsion are also effective for huisache control. However, these individual-plant treatments, as with oiling, are generally reserved for relatively thin huisache stands because of labor requirements and treatment costs.

Huisache is not highly susceptible to broadcast 2,4,5-T sprays. At least 2.2 kg/ha of 2,4,5-T is required for a moderate level of control (Scifres, 1980). However, Fisher et al. (1970) reported that aerial applications of 2,4,5-T + picloram (1:1) at 2.2 kg/ha of total herbicide killed about 2[illegible] percent of the plants.

Huisache is susceptible to broadcast applications of picloram sprays in late spring (May-June) or in fall (October) in south Texas. Bovey et al. (1970) reported that 1.1 kg/ha of picloram aerially applied in October near Campbellton, Texas reduced huisache canopies by 95 percent after 2 years. Although broadcast sprays of picloram at 1.1 kg/ha applied in April had reduced huisache canopies near Refugio by only 15 percent after 3 years, the same treatment applied in May reduced the canopies by 45 percent; and applied in October reduced canopies by 68 percent after 2 years (Bovey et al., 1968). Picloram applied to the soil is also effective for huisache control (Bovey et al., 1967). Bovey et al. (1969) reported that picloram granules at 2.2 kg/ha or greater rates applied in spring or fall effectively controlled huisache near Refugio. Huisache rapidly absorbs picloram from the soil solution; exposure to 1 part per million (ppm) for 24 hours killed approximately 60 percent of the plants in greenhouse experiments (Baur and Bovey, 1969). Picloram granules at 2.2 kg/ha reduced huisache canopies by 85 percent 2 years after application in October, and by 95 percent after application in April (Bovey et al., 1970).

Management by Prescribed Burning

Interest of range livestock producers in prescribed burning as a brush management tool has intensified during the past 5 years. This interest was precipitated largely by the rising costs of herbicides, energy and heavy equipment. However, Box and White (1969) reported that burns of brush stands not pretreated with mechanical methods on the Welder Wildlife Refuge were uneven because of discontinuous fuel loads. Successive fires did not improve the

TABLE 4.2. HUISACHE DENSITY AND CANOPY COVERS; AMOUNT OF OIL, LABOR, AND COST OF OILING; TREES REMOVED; AND GRUBBING TIME AND COSTS OF LOW-ENERGY GRUBBING IN MAY 1978 IN THE EXPERIMENT TO EVALUATE METHODS OF HUISACHE REMOVAL ON THE WELDER FOUNDATION

		Original huisache stand		Oiling			Low-energy grubbing		
Grazing system	Treatment	Density plants/ha	Canopy cover (%)	Amount (Liters/tree)	Time (Man hr/ha)	Cost[a] ($/ha)	Trees removed/ha	Time (ha/hr)	Cost[b] ($/ha)
Four pasture, 3 herd	None	438	12.7	--	--	--	--	--	--
	Prescribed burn	482	13.7	--	--	--	--	--	--
	Grub	536	8.1	--	--	--	391	0.89	28.09
	Oil	455	6.8	0.64	1.76	76.93	--	--	--
	Grub/prescribed burn	400	12.0	--	--	--	397	0.73	34.25
	Oil/prescribed burn	482	11.7	0.58	1.70	73.89	--	--	--
Continuous	None	186	8.5	--	--	--	--	--	--
	Prescribed burn	183	7.9	--	--	--	--	--	--
	Grub	189	5.5	--	--	--	186	1.11	22.52
	Oil	132	5.5	1.43	1.27	50.38	--	--	--
	Grub/prescribed burning	188	10.3	--	--	--	188	1.35	18.52
	Oil/prescribed burning	198	10.5	1.50	1.14	75.84	--	--	--

[a]Calculated as labor, $4.00/man hr and kerosene at $0.24/liter.
[b]Calculated as $25.00 per operating hour.

pattern of burning, and the proportion of huisache in the woody stand increased following burning. Pretreatment by mechanical top removal methods apparently improved the degree of fire-induced damage to huisache (Box et al., 1967; Box and White, 1969).

Impact of Huisache on Variables Critical to Prescribed Burning

Results of previous research on burning of huisache were accrued from mixed-brush stands (Box et al., 1967; Box and White, 1969). Considering the influence of huisache stands on botanical composition of herbaceous communities (Scifres, 1982), and hence on fine fuel characteristics, research was designed to evaluate fire behavior in huisache stands compared to that in areas from which huisache had been removed.

Research (Scifres et al., 1982) was superimposed on the experiment of Bontrager et al. (1979) on the Welder Wildlife Refuge. Soils of the experimental area are Cumulic Haplustalls of the Odem series (sandy loam). Detailed site descriptions are given by Bontrager et al. (1979).

A low-energy grubber (Wiedemann et al., 1977) was used to remove huisache from 14, 1 to 2-ha plots on August 26, 1975. Two grubbed plots and two untreated plots were randomly selected to be burned on January 11, 1979.

Response of huisache to prescribed burning can largely be clarified by differences in fire behavior induced by mechanical pretreatment (Scifres et al., 1982). Fine fuel loads on plots with undisturbed huisache averaged 2126 kg/ha, of which 68 percent was green material (Table 4.3). In contrast, fine fuel loads on grubbed plots averaged 3455 kg/ha, of which 20 percent was green material. Moreover, fine fuel water contents averaged 27 percent on untreated plots, and 13 percent on those which had been grubbed. Plots previously grubbed burned five times faster and averaged 234°C greater maximum temperatures than untreated plots. These differences were attributed to the greater fine fuel load, lower proportion of green material in the standing fuel, and lower fine fuel water contents, although there were differences in wind speeds and relative humidities during the burns. Uniformity of fine fuel consumption on grubbed plots indicated improved distribution of fine fuel, compared to untreated plots (Table 4.3).

Based on this study and previous research (Box et al., 1967; Box and White, 1969), prescribed burning for huisache management holds most promise when applied subsequent to reduction of the brush stand by an initial treatment, or when applied to prevent light stands from increasing in cover. Moderate-to-heavy huisache stands prevent development of an adequate load of continuous fine fuel for effective burning, especially in late fall or winter.

TABLE 4.3. FUEL AND ENVIRONMENTAL VARIABLES AND OBSERVED CHARACTERISTICS OF FIRE BEHAVIOR ON JANUARY 11, 1979 ON AREAS WHICH WERE GRUBBED TO REMOVE HUISACHE IN AUGUST 1975 COMPARED TO UNTREATED AREAS ON THE ROB AND BESSIE WELDER WILDLIFE REFUGE NEAR SINTON

Variable	Previous treatment: None	Grubbed
Fine fuel load (kg/ha)		
Standing green	1,436	696
Standing dead	690	2,759
Fuel water content (%)	27	13
Wind speed (km/hr)[a]	10-13	13-16
Air temperature (°C)	11	11
Relative humidity (%)	47	39
Burn time (minutes/plot)	20	4
Maximum fire temperature (°C)	371	616
Fine fuel consumed (%)	60	95

[a]Wind was from the northeast for all burns.

TABLE 4.4. DENSITY (plants/ha), CANOPY COVER (%) HEIGHT (m), AND NUMBERS OF STEMS PER HUISACHE PLANT PRETREATMENT (JANUARY 1979), ON JULY 9, 1979 AND ON APRIL 9, 1980 AFTER LOW-ENERGY GRUBBING OF HUISACHE IN AUGUST 1975 AND PRESCRIBED BURNING ON JANUARY 11, 1979 ON THE WELDER WILDLIFE REFUGE NEAR SINTON, TEXAS[1]

Treatment	Density (plants/ha)	Canopy cover (%)	Average height (m)	Numbers of stems (stems/plant)
		January 1979		
None	371 a	27.0 a	2.46 a	1.0 a
Low-energy grubbing	42 b	0.8 b	1.86 b	1.3 a
		July 1979		
None	371 a	30.0 a	3.52 a	1.0 a
Low-energy grubbing	42 b	0.9 b	1.97 b	1.3 ab
Prescribed burning	371 a	20.3 a	2.86 a	1.8 b
Grubbing/burning	36 b	0.2 b	0.74 c	7.6 c
		April 1980		
None	371 a	33.0 a	3.71 a	1.0 a
Low-energy grubbing	42 b	0.9 b	2.03 b	2.1 b
Prescribed burning	371 a	20.3 a	2.86 a	1.8 b
Grubbing/burning	36 b	0.3 b	1.07 c	6.7 c

[1]Means with a column and within a date followed by the same letter are not significantly different ($P \leq .05$) according to Student-Newman-Keul's test.

Ground cover beneath the huisache cover is composed, in large part, of cool-season herbs which remain green through most of the winter.

Huisache Response to Burning Following Oiling or Grubbing

Bontrager et al. (1979) reported that huisache canopy cover averaged 15.1 percent on an Odem sandy loam site on the Welder Refuge in 1975. Huisache canopy cover on untreated plots averaged 27 percent in January 1979, and had increased to 33 percent by April 1980 (Table 4.4). Huisache canopy cover was less than 1 percent in January 1979 on plots grubbed in August 1975, but plant height averaged 1.86 m. Prescribed burning of grubbed plots initially reduced huisache top growth by 95 percent. Canopy cover of huisache on grubbed (1975) and burned (1979) plots was only 0.3 percent in April 1980. In contrast, fire had little effect on canopies of huisache plants on plots which had not been grubbed. Canopy cover was reduced about 20 percent the summer following the fires.

Prescribed burning of untreated huisache stands on Odem sandy loam did not significantly change average plant height (Table 4.2). Conversely, huisache plants on plots grubbed and then burned were significantly shorter than those on plots grubbed only, burned only, or untreated in April 1980. The burning of grubbed plots increased the number of sprouts by damaging aerial portions of the huisache plants, which breaks apical dominance.

Summary and Conclusions

Top removal, such as by shredding or roller chopping, only temporarily reduces the influence of huisache on rangeland. Huisache may replace its top growth within two or three growing seasons after removal.

Low-energy grubbing, especially of light to moderately dense stands, appears to be a practical method of huisache removal. Removal of huisache stems to beneath the lowermost stem bud is necessary to prevent sprout development. Grubbing takes more time and energy on clay than on sandy loam-sandy clay loam sites. Rootplowing effectively removes huisache, but soil disturbance appears to stimulate development of new stands, especially on Blackland sites.

Prescribed burning effectively top-kills huisache, but the canopies are rapidly replaced. Moderately dense to dense stands are often difficult to burn effectively with winter fires because of the affinity of cool-season herbs for huisache stands. Presence of cool-season plants causes fine fuel loads to contain relatively high amounts of water, and reduces maximum fire temperatures, compared to fine fuel loads where huisache stands are thin enough to allow warm-season species to compose the fine fuel.

Prescribed burning appears to be most effective for huisache management when it follows other practices such as grubbing or oiling. The initial practice reduces huisache stand density and increases the fuel load and the proportion of the fuel load which is warm-season species.

CHAPTER 5

VALUES OF HUISACHE FOR WILDLIFE HABITAT

The habitat of wildlife such as white-tailed deer, javelina, and wild turkey is affected by woody plants which provide cover screen, sites for loafing and bedding, and a source of food (browse and mast). Cover is a structural habitat requirement, and wildlife generally demonstrates little preference among woody species which meet this need (McMahan and Inglis, 1974). Coastal prairie deer can adapt to habitats that are more open than is characteristic of other deer ranges. This is probably a function of the fact that tall and midgrasses, tall forbs, and low brush (such as creeping mesquite) provide a cover screen at deer height much of the time. The adequate screen allows deer to escape by means of a few seconds run. The year long presence of some huisache makes the screening cover on a site less variable through time, and so contributes to habitat quality. Shade is important in these semitropical climes, so tall huisache, whether in mottes or widely spaced, is a positive attribute.

Distinct food preferences are exhibited by white-tailed deer. Factors affecting diet selection can be broadly categorized as (1) relative availability of the food item, and (2) relative preference for that food item as affected by qualities such as palatability. Availability is a function of height of brush, site, season, and weather conditions, and is relatively easily measured. However, preference is more difficult to assess, and can be established quantitatively only by using the animals as indicators. Few studies have evaluated the importance of huisache to white-tailed deer and other wildlife, and interpretation of huisache values must be couched in comparative terms considering the presence of other species.

Nutritive Values of Huisache Browse

Rasmussen (1981) evaluated crude protein, phosphorus, and digestible organic matter contents of huisache browse at monthly intervals from July to November 1979 and from April until September 1980 on the Welder Wildlife Refuge. Only twig tips were analyzed for the nutrients, with size of a "browsable twig" being determined as that part distal to the first thorn which was hard to the touch. Crude protein content of huisache twig tips varied from 15 to 23 percent during 1979, and from 12 to 23 percent during 1980. Crude protein contents did not appear to vary with season of collection but were related to antecedent rainfall for that sampling period. Crude protein contents of huisache twigs were greater when rainfall prior to sampling was adequate to stimulate new growth than when preceded by dry periods.

Phosphorus contents of huisache twigs followed the same trends as did crude protein; the contents were influenced less by season of sampling than by degree of twig maturity as influenced by rainfall (Rasmussen, 1981). Phosphorus varied from 0.21 to 0.29 percent during the growing season, and varied from 0.16 to 0.29 percent during 1980.

Rasmussen (1981) reported that water contents of huisache twigs during the 1979 growing season varied from 60 to 80 percent, and from 55 to 76 percent in 1980. Digestible organic matter varied from 37 to 51 percent and from 42 to 58 percent for the 2 years.

Contribution of Huisache to White-tailed Deer Diets

Everitt and Drawe (1974) reported that rumens of white-tailed deer during the spring of 1970-1971 on the south Texas Plains contained, by volume, 37.1% forbs, 33.1% browse, 17.5% cacti, and 2.5% grasses. Analyses of deer rumens on the Welder Wildlife Refuge in 1966 indicated that diets on clay sites were composed of 70% forbs, 22% browse, and 8% grasses (Drawe, 1968). Relative proportions of forage classes selected from sandy sites in the same year were 53% forbs, 45% browse, and 2% grasses. Rainfall for 1966 was 81.3 cm, 92% of the long-term average (Table 2.1), so it may be deduced that availability of the various forage classes was not constrained by lack of precipitation. Thus, browse normally accounts for less than 50 percent of deer diets on the Coastal Prairie. Moreover, range site, as it influences kinds of forages available, regulates deer diets.

Drawe (1968) developed deer preference ratings for various species in the summer of 1966 on the Welder Wildlife Refuge by recording frequency of occurrence and volume in the rumen as related to availability in the habitat. Preference ratings were developed for those species which made up at least 50 percent of deer diets, and contributed at least 1 percent to diet volume. Huisache was not highly preferred by deer on clay sites. For example, the preference rating for huisache was 43 compared to 863 for pricklypear mast, the most preferred diet item on the site. Conversely, the preference rating for huisache (browse + mast) on sandy sites was 806, and 558 for mast only. The next highest rating was 219 for lime pricklyash.

According to Drawe (1968), use of huisache by white-tailed deer was largely regulated by rainfall. For example, more huisache was used following dry periods when forb availability was severely reduced. As the mast crop of huisache was reduced, and rainfall stimulated the vegetative growth of forbs, deer shifted back to selecting for forbs in their diets.

Although huisache was an important component of deer diets on sandy sites in Drawe's (1968) study, he emphasized the diversity of species selected. For example, deer diets on the Welder Wildlife Refuge during summer 1966 contained 58 plant species including nine browse species, 42 species of forbs, and eight grasses. Scifres (1980) suggested that this diet diversity supports the high degree of versatility of deer in responding to vegetation changes induced by brush management.

Chamrad and Box (1968), like other researchers, reported that white-tailed deer were grazers (if not primarily so) as well as browsers, and that they used a wide variety of species (a minimum of 160 plant taxa were observed in the deer rumens). Huisache was not considered a "high priority" forage plant for deer, regardless of range site.

Based on available research results, huisache appears to be a "highly preferred" diet item during dry periods when forb availability is restricted, especially on sandy sites. However, the species is not generally highly preferred by deer.

Value of Huisache for other Wildlife Species

Very little is known about the value of huisache to wildlife species other than white-tailed deer. Cover or screen value of huisache on the Coastal Prairie may be assumed to be comparable to that of other chaparral species for most species of wildlife.

Turkeys prefer some screening cover for feeding and/or nesting activities (Baker, 1979). The relatively open areas of huisache-grassland communities (Drawe et al., 1978) of the Welder Wildlife Refuge are used for these activities. Even though huisache develops into a relatively large tree, there is no mention of its use as a roost tree. The form and height of huisache does not allow it to be strongly favored as woody cover for quail.

Huisache is apparently of low forage value to other wildlife. Low (1970) examined stomach contents of 73 javelina from south Texas, none of which contained huisache. Everitt et al. (1981) found only minor amounts of huisache in 117 stomachs of south Texas javelina.

The feeding behavior of most wildlife species other than white-tailed deer would preclude the consumption of the vegetative parts of huisache. The seeds are not common in quail crops (W. H. Kiel, Jr., personal comm.), and it apparently is not utilized by game birds such as turkeys. The opportunistic feeding behavior of such species as javelina and feral hogs make the food value of huisache low. However, during years of heavy mast production, huisache may be a supplement to the diet of these two ground-feeding animals, both of which have jaws and teeth strong enough to break the hard seed coats.

Everitt and Alaniz (1981) analyzed the nutrient contents of fruits of several brush species in south Texas and related their findings to published nutrient requirements of several species of wildlife. They considered the average crude protein content of huisache (17.55%) adequate for meeting the requirements of white-tailed deer and bobwhite quail. However, the levels of phosphorus (0.24%), calcium (1.19%), and sodium (0.08%) contents were inadequate to meet the dietary needs of most wildlife.

Management Techniques for Improving Huisache Browse for White-tailed Deer

Since only those huisache twigs which are not highly lignified and without hard thorns are browsed, actual availability of browse is often much less than "apparent availability" based on casual observation of huisache abundance. Moreover, only those twigs within reach of the deer are actually "browsable." Huisache plants about 2 m tall each produced about 18 browsable twigs (0.72 g of usable browse per plant) from August 1979 to August 1980 on the Welder Wildlife Refuge (Rasmussen, 1981).

Browse may be improved for white-tailed deer by increasing amount available, improving accessibility, and increasing nutritional status by stimulating new growth (Scifres, 1980). Thus, any method which replaces decadent trees with vigorous new growth should improve browse quality for deer. For example, Powell and Box (1966) reported that preference values for huisache (by deer and cattle) were higher on mowed than on undisturbed areas. The influence of such treatments was transient, however, since "current growth of south Texas woody plants becomes less available to all animals with increasing age, size, and 'thorniness'." For example, preference values were 1700 for mowed huisache, 2300 for mowed huisache the year of treatment, and 1995 for mowed huisache at 2 years after treatment.

Powell and Box (1966) reported that crude protein contents of browse from undisturbed huisache in spring was 18.37 percent, compared to 20.35 percent in browse from mowed plants. Huisache browse contained significantly greater amounts of crude protein and phosphorus the growing season after burning in winter when rainfall was not limiting (Rasmussen, 1981). Increases in crude protein content attributable to burning were 1 to 8 percent during the growing season following winter burning, with greatest differences following periods of significant rainfall. The difference in crude protein contents between unburned and regrowth plants diminished the year after burning, varying from 1 to 4 percent, depending on rainfall. Trends induced in phosphorus contents by burning were the same as with crude protein contents. Increases varied from 0.25 percent more (86 percent increase) in burned than in unburned browse in July after burning in January, to 0.06 percent less (25 percent decrease) phosphorus in burned browse in November. Burning did not alter digestible organic matter content of huisache browse.

Summary and Conclusions

Special values relative to the cover needs of white-tailed deer are difficult to assess for any woody species. Apparently, species of woody plant is not so important as existence of at least minimal amounts of cover required to meet deer needs; cover structure and topographical qualities of the site must be matched to meet deer loafing and bedding needs. Huisache can provide screening cover for deer but probably should not be considered a key component of deer habitat, unless it is one of only a few woody species present.

Nutritive values of huisache do not appear superior to many other species which commonly occur within the distribution range of white-tailed deer. An average plant about 2 m tall may produce less than 1 g of usable browse annually. Huisache appears to be preferred browse for white-tailed deer only on certain sites (sandy loams) during times (midsummer) when forbs are not abundant.

The value of huisache to other wildlife species appears to be low. The primary value of huisache to species such as turkey, javelina, and feral hogs is to provide screening cover. Yet huisache has little or no value as a food item for these wildlife species.

Management techniques, such as shredding or burning, can be applied to increase huisache browse availability, accessibility, and nutritional values. However, these positive effects are transient, lasting only one or two growing seasons, and the increased values may be masked by reduced rainfall.

CHAPTER 6

INTEGRATED BRUSH MANAGEMENT SYSTEMS (IBMS) FOR HUISACHE

Integrated Brush Management Systems (IBMS) are two or more brush control methods used together with grazing management and other techniques to achieve specific resource management goals economically. Since resource management objectives vary, no two IBMS would necessarily be the same.

There is no specific control method without limitations to its effectiveness for improving huisache-dominated rangeland (see discussion, Chapter 4). Therefore, long-term improvement of rangeland supporting excessive huisache cover requires application of two or more of these methods over several years. Such an improvement program can be effectively developed only when land use objectives are clearly stated, alternatives are selected for application in a sequence which will capitalize on the strengths of each, and an adequate planning horizon is selected (Scifres, 1978, 1980, 1981). This approach has resulted in effective improvement of Coastal Prairie where potential productivity was not being achieved because of the presence of Macartney rose (Scifres, 1975). Brush management must be coordinated with grazing management and with cognizance of wildlife habitat needs (Scifres et al., 1979) for development of IBMS.

Critical Considerations

The specific IBMS for huisache management will depend on:

1. resource management objectives of "targeted areas" for improvement relative to overall ranch firm objectives.
2. huisache stand density, since individual-plant treatment costs vary with stand density. One basis for selecting a treatment alternative might be cost comparisons for a given stand density. For example, if aerial herbicide application costs \$60.54/ha, then theoretically, a stand of 985 trees/ha could be removed by low-energy grubbing from clay loam/sandy clay loam for the same cost (based on operations cost of \$25/hour). Less data are available for oiling costs, but it appears from our research that oiling of about 400 trees/ha would approximate the cost of aerial herbicide application. However, consideration of cost alone does not constitute a logical economic basis for treatment selection. Economic criteria such as pay-back period and net present value analysis should be considered (Scifres, 1980). Moreover, producer preference and/or constraints to treatment may override economic superiority. For example, grubbing may leave the surface so rough as to limit management effectiveness. Proximity of susceptible crops may limit use of aerial sprays.
3. associated woody plants. If the huisache occurs in interspaces between "chaparral" mottes, then the control method selected might differ from that used on single-species stands (for example, broadcast treatments may, in some cases, be restricted to pure stands of huisache).

System Components

The components discussed here for the brush management segment of an IBMS for huisache are restricted to our research experiences (Fig. 6.1). Managers are encouraged to vary use of methods described here to meet specific management objectives. Our experience indicates that treatments may be applied in concert with any one of various grazing management systems.

Based on recent research, densities of ≤400 trees/ha may be effectively removed by low-energy grubbing or oiling. Grubbing should be accomplished when the soil is damp enough to allow quick penetration of the grubber blade, but not so wet as to cause excessive surface damage by the tractor. This consideration is more critical for clay sites than for clay loams/sandy clay loams.

Dense covers of herbaceous vegetation may retard effectiveness of either grubbing or oiling. Heavy herbaceous cover may cause the grubber blade to slip over the surface rather than to immediately penetrate the soil, resulting in decreased grubbing depth (H. T. Wiedemann, personal communication). Interception of oil by herbaceous vegetation may prevent complete coverage of the lower huisache stem and reduces effectiveness. Therefore reducing herbaceous vegetation by "heavier than normal grazing" or by burning immediately prior to these treatments should be considered.

Research reported here was conducted on low-energy grubbing with a crawler tractor (Wiedemann et al., 1975). However, recent research on rear-mounted grubber blades on rubber-tired tractors appears promising (Ueckert et al., 1981), especially for seedlings and small plants.

Although aerial herbicide application is not usually as effective as individual plant methods, relative to the percentage of huisache plants killed, it may be the only feasible alternative for large areas of moderate to dense (>400 trees/ha) stands of large trees, especially on clay soils. Ground broadcast application may be feasible for moderate to dense stands of small plants, especially on small areas. The most effective treatment is 2,4,5-T + picloram with at least 1.1 kg/ha (a.i.) applied in spring or fall. Fall treatments may often be preferred to minimize the potential for damage to adjacent susceptible crops. The herbicide may be aerially applied in a diesel oil:water (1:3, 1:4) emulsion. Application should be delayed if huisache plants are stressed by low soil water, if canopies have been damaged significantly (e.g., by insects), and/or if air temperatures have been less than 24°C for several days.

Consideration should be given to herbicide application in strips or suitable pattern to minimize potential effects on wildlife screen, and to reduce damage to associated deer food plants (Beasom and Scifres, 1977). These methods may be followed by prescribed burning to suppress regrowth of plants surviving the treatment and/or invading seedlings. Prescribed burning following broadcast herbicide applications also serves to reinstate forb populations killed by the treatment (Scifres, 1980).

There are several approaches to developing a safe, effective fire plan. Our research has utilized a burning plan in which backfiring on the lee side of the target pasture is first installed to provide a firebreak (Gordon and Scifres, 1977; Scifres, 1980). After the backfire has burned into the pasture a sufficient distance to provide a uniform fire break of 30 to 60 m, headfires are ignited. Environmental conditions (Fig. 6.1) largely regulate the relative safety and effectiveness of the fires. In general, a uniformly-distributed fine fuel load of at least 3,000 kg/ha and a wind speed of 15 to 20 km/hr when relative humidity is ≤60 percent, have resulted in effective burns on the Coastal Prairie. When the fine fuel loads are 4,000 kg/ha or more and relative humidities are ≤20 percent (usually indicating northerly winds) which normally causes water content of standing fine fuel to be 10 percent or less, wind speeds of 8 to 11 km/hr may be most satisfactory.

Summary and Conclusions

Based on recent research, low-energy grubbing in combination with prescribed burning or individual-plant chemical treatments (oiling or herbicide) combined with prescribed burning appear most effective as components of IBMS for huisache stands of ≤400 plants (≤2 m tall)/ha. Stand densities of 400 to 600 plants/ha have been effectively treated by grubbing on clay loam/sandy clay loam sites, but may not be efficiently grubbed on clay sites. Stands of >400 plants/ha, especially where a large proportion of the stand includes plants which are ≥2 m tall, may require aerial application of herbicide as the initial treatment, followed by application of prescribed burning.

Figure 6.1. Potential brush control components in integrated brush management system (IBMS) for improvement of rangeland infested with huisache.

	PHASE I INITIAL REDUCTION OF BRUSH COVER	PHASE II FINE FUEL DEVELOPMENT-BURN PREPARATION	PHASE III INSTALLATION OF PRESCRIBED BURNS	PHASE IV MAINTENANCE OF RANGE IMPROVEMENT
OBJECTIVE	Increase forage production for livestock; maintain/improve habitat quality for white-tailed deer.	Improved botanical composition of herbaceous stands, build adequate, uniform locd of fine fuel.	Improve botanical composition of forage stands, suppress regrowth from treated plants, missed plants, and invading seedlings; improve browse nutritive values.	Maintain huisache canopy cover which will allow best mix of cool/warm season forages; offer improved browse supply to white-tailed deer.
ACTIVITY	If huisache density ≤400 trees/ha, low-energy grub or oil; 400-600 trees/ha of plants ≤2 m tall on clay loam/sandy clay loam site, low-energy grub; ≥600 large (>2 m) trees/ha, aerially apply 2,4,5-T + picloram at 1.1 kg/ha.	Develop fire plan; construct fire lanes; adjust stocking rate to forage production potential, plan deferment of targeted pastures, for 90 to 120 days in the fall prior to installation of winter burn.	Install prescribed burn according to sound fire plan; burn with headfire when wind speed 15 to 20 km/hr, RH ≤60%, fine fuel moisture ≤25%; if RH <20%, fine fuel water ≤10%, wind speed steady at 8 to 11 km/hr will burn.	Schedule prescribed burns as needed, approximately 3-year intervals.
CONSIDERATIONS	Removal to 15%> canopy cover reduces abundance of cool-season grasses; grubbing may be accomplished when soil water content conducive to maximum effectiveness; grubbing slower on clay soil so restricted to <400 trees/ha. Aerial spraying should leave ≥30% of the brush for deer; may apply in fall or spring.	Adjust deferment period to rainfall conditions, under drought conditions utilize accumulated fine fuel as appropriate, and delay burn until next year.	Adjust post burn deferment of grazing to rainfall conditions and spring growth; usually defer burned areas until late April after February burn.	Schedule cool-season burns following wet falls when soil profile contains adequate water to promote spring growth; set burning schedules to match grazing system.
EXPECTED RESULTS	Grubbing or oiling will kill 95% ± of the treated plants; pits left from grubbing will not fill for several growing seasons, especially on clay sites. Aerial spray reduce overall canopy by 90%; kill, >20% of trees	Accumulate at least 3,000 kg/ha of standing fine fuel of uniform distribution	Huisache regrowth ≤2 m tall top killed, stems 1.5 to 2.5 cm diam. consumed to ground line; rapid development of new stems from live stem bases.	Range condition improvement; rough vegetation removed; grazing distribution optimized; huisache suppression but regrowth offering browse of improved nutritional value.

LITERATURE CITED

Baker, W. B. 1979. Habitat use, productivity, and nest predation of Rio Grande turkeys. Ph.D. diss., Texas A&M Univ., College Station. 46 pp.

Baur, J. R., and C. R. Swanson. 1968. Effects of nutrient level and daylength on growth and susceptibility of mesquite and huisache to 2,4,5-T and picloram. Texas Agr. Exp. Sta. Prog. Rep. 2595 *in* Consol. Prog. Rep. 2483-2609: 35-38.

Baur, J. R., and R. W. Bovey. 1969. Distribution of root-absorbed picloram. Weed Sci. 17:524-527.

Bontrager, O. E., C. J. Scifres, and D. L. Drawe. 1979. Huisache control by power grubbing. J. Range Manage. 32: 185-188.

Bovey, R. W., F. S. Davis, and M. G. Merkle. 1967. Distribution of picloram in huisache after foliar and soil applications. Weed Sci. 15:245-249.

Bovey, R. W., S. K. Lehman, H. L. Morton, and J. R. Baur. 1968. Control of running live oak, huisache, and mesquite in Texas. Texas Agr. Exp. Sta. Prog. Rep. 2592, *in* Cons. Prog. Rep. 2583-2609: 27-30.

Bovey, R. W., H. L. Morton, J. R. Baur, J: D. Diaz-Colon, C. C. Dowler, and S. K. Lehman. 1969. Granular herbicides for woody plant control. Weed Sci. 17:538-541.

Bovey, R. W., J. R. Baur, and H. L. Morton. 1970. Control of huisache and associated woody species in south Texas. J. Range. Manage. 34:47-50.

Bovey, R. W., H. L. Morton, J. R. Baur, J. D. Diaz-Colon, and S. K. Lehman. 1970. Granular herbicides for woody plant control. Texas Agr. Exp. Sta. Prog. Rep. 2806 *in* Consol. Prog. Rep. 2801-2828: 23-26.

Bovey, R. W., and R. E. Meyer. 1974. Mortality of honey mesquite and huisache seedlings from herbicides and top removal. Weed Sci. 22:276-279.

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

Box, T. W., J. Powell, and D. L. Drawe. 1967. Influence of fire on South Texas chaparral communities. Ecology 48:955-961.

Brock, J. H. 1978. Influence of honey mesquite and its control on zonal vegetation patterns. Ph.D. Diss., Texas A&M Univ., College Station. 201 pp.

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

Chamrad, A. D., and T. W. Box. 1968. Food habits of white-tailed deer in south Texas. J. Range Manage. 21: 158-164.

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

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

Everitt, J. H., and D. L. Drawe. 1974. Spring food habits of white-tailed deer in the South Texas Plains. J. Range Manage. 27-15-19.

Everitt, J. H., and M. A. Alaniz. 1981. Nutrient content of cactus and woody plant fruits eaten by birds and mammals in south Texas. Southw. Nat. 26:301-305.

Everitt, J. H., C. L. Gonzales, M. A. Alaniz, and G. V. Latigo. 1981. Food habits of collared peccary on south Texas rangelands. J. Range Manage. 34(2): 141-143.

Fisher, C. E., E. D. Robison, G. O. Hoffman, C. H. Meadors, and B. T. Cross. 1970. Aerial application of chemicals for control of brush on rangeland. Texas Agr. Exp. Sta. Prog. Rep. 2801 *in* Consol. Prog. Rep. 2801-2828: 5-11.

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

Gould, F. W. 1975. Texas Plants. A checklist and ecological summary. Texas Agr. Exp. Sta. Misc. Pub. 585 (Rev.). 121 pp.

Jones, F. B. 1975. Flora of the Texas Coastal Bend. Welder Wildlife Found. Contr. B-6, Mission Press, Corpus Christi, TX. 262 pp.

Low, W. A. 1970. The influence of ardity on reproduction of the collared peccary in Texas. Ph.D. Diss., Univ. British Colombia, Vancover. 170 pp.

McHahan, C. A., and J. M. Inglis. Use of Rio Grande Plain brush types by white-tailed deer. J. Range Manage. 27:369-374.

Meyer, R. E., and S. M. Meola. 1978. Morphological characteristics of leaves and stems of selected Texas woody plants. U.S. Dep. Agr. Tech. Bull. 1564: 200 pp.

Mutz, J. L., C. J. Scifres, and D. L. Drawe. 1982. Botanical composition changes of herbaceous stands following reduction of huisache on the Coastal Prairie. PR-4007 *in* Brush Manage. and Range Improvement Res., 1980-1981, Tex. Agr. Exp. Sta. Cons. Prog. Rep. 3968-4014. (In press).

Mutz, J. L., C. J. Scifres, D. L. Drawe, T. W. Box, and R. E. Whitson. 1978. Range vegetation after mechanical brush treatment on the Coastal Prairie. Texas Agr. Exp. Sta. Bull. 1191. 16 pp.

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

Powell, J., and T. W. Box. 1966. Brush management influences preference values of south Texas woody species for deer and cattle. J. Range Manage. 19:212-214.

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: 191-195.

Rasmussen, G. A. 1981. Fire-induced growth responses of huisache. M.S. Thesis, Texas A&M Univ., College Station. 64 pp.

Scifres, C. J., and J. H. Brock. 1969. Moisture-temperature interrelations in germination and early seedling development of mesquite. J. Range Manage. 22:334-337.

Scifres, C. J., and R. R. Hahn. 1971. Response of honey mesquite seedlings to top removal. J. Range Manage. 24:296-298.

Scifres, C. J., and J. H. Brock. 1972. Emergence of honey mesquite seedlings relative to planting depth and soil temperature. J. Range Manage. 25:217-219.

Scifres, C. J. 1975. Salient aspects of huisache seed germination. Southw. Nat. 18:383-392.

Scifres, C. J. 1975. Systems for improving Macartney rose infested Coastal Prairie rangeland. Texas Agr. Exp. Sta. Misc. Pub. 1225: 12 pp.

Scifres, C. J. 1978. Range vegetation management with herbicides and alternative methods: An overview and perspective. U.S. Dep. Agr.-U.S. Environ. Prot. Agency Symp., Use of Herbicides in Forestry. pp. 151-165.

Scifres, C. J., D. L. Drawe, J. L. Mutz, O. E. Bontrager, and J. W. McAtee. 1979. Range improvement practices for the Coastal Prairie: Needs, present applications, and research advances. Proc. Welder Wildlife Symp. 1: 15-24.

Scifres, C. J. 1980. Brush Management. Principles and practices for Texas and the southwest. Texas A&M Univ. Press, College Station. 360 pp.

Scifres, C. J. 1981. Integrated brush management systems (IBMS) for rangeland: Concepts and applications. Internat. Stockmen's School, Beef Cattle Sci. Handbk. 18:74-79.

Scifres, C. J., J. L. Mutz, and D. L. Drawe. 1982. Impact of huisache removal by grubbing on variables critical to prescribed burning on the Coastal Prairie. PR-3989 *in* Brush Manage. and Range Improvement Res. 1980-1981, Tex. Agr. Exp. Sta. Cons. Prog. Rep. 3968-4014 (In press).

Scifres, C. J., J. L. Mutz, D. L. Drawe, and R. E. Whitson. 1982. Interrelationships of huisache canopy cover with range forage on the Coastal Prairie. J. Range Manage. 35: (In press).

Smith, H. N., and C. A. Rechenthin. 1964. Grassland Restoration. The Texas Brush Problem. U.S. Dep. Agr., Soil Cons. Ser. Unnumbered Pub. 32 pp.

Ueckert, D. N. 1973. Effects of leaf-footed bugs on mesquite reproduction. J. Range Manage. 26:227-229.

Ueckert, D. N., K. L. Polk, and C. R. Ward. 1971. Mesquite twig girdler: A possible means of control. J. Range Manage. 24:116-118.

Vines, R. A. 1960. Trees, Shrubs, and Woody Vines of the Southwest. University of Texas Press, Austin. 1104 pp.

Whitson, R. E., W. T. Hamilton, and C. J. Scifres. 1979. Techniques and considerations for economic analysis of brush control alternatives. Texas Agr. Exp. Sta., Dep. Range Sci. Tech. Rep. 79-1:30 pp.

Wiedemann, H. T., B. T. Cross, and C. E. Fisher. 1977. Low-energy grubber for controlling brush. Trans. Amer. Soc. Agr. Engr. 20:210-213.

APPENDIX A
Conversions From Metric to English Units

Metric unit	English equivalent
Centimeter (cm)	0.3937 inch
Cubic centimeter (cm^3)	0.0002642 gallon
Degree Centigrade (°C)	(°C × 1.8) + 32 = °Fahrenheit
Gram (g)	0.03527 ounce, 0.0022 pound
Hectare (ha)	2.471 acres
Kilogram (kg)	0.4535 pound
Kilogram/hectare (kg/ha)	1.12 pounds/acre
Kilometer (km)	0.621 mile
Kilometers/hour (km/hr)	1.61 miles/hour
Liter (L)	0.264 gallon
Liters/hectare (L/ha)	0.107 gallon/acre
Meter (m)	39.4 inches, 3.28 feet
Milligram (mg)	3.527×10^{-3} ounce, 2.2×10^{-4} pound
Millimeter (mm)	0.0495 inch
Square centimeter (cm^2)	0.155 square inch
Square meter (m^2)	1552.36 square inches, 10.76 square feet

APPENDIX B
Scientific Names of Plants and Animals Mentioned in Text

PLANTS

Common name	Scientific name
Annual sumpweed	*Iva annua* L.
Big cenchrus	*Cenchrus myosuroides* H.B.K.
Buffalograss	*Buchloe dactyloides* (Nutt.) Engelm.
Bunch cutgrass	*Leersia monandra* Swartz.
Bundleflower	*Desmanthus illinoensis* (Michx.) MacM.
Canada wildrye	*Elymus canadensis* L. var. *canadensis*
Common curlymesquite	*Hilaria belangeri* (Steud.) Nash.
Crown coreopsis	*Coreopsis nuecensis* Heller
Filly Panicum	*Panicum filipes* Scribn.
Hairyseed paspalum	*Paspalum pubiflorum* Rupr. & Fourn. var. *pubiflorum*
Honey mesquite	*Prosopis glandulosa* Torr. var. *glandulosa*
Little bluestem	*Schizachyrium scoparium* (Michx.) Nash.
Longtom	*Paspalum lividum* Trin.
Lovegrass tridens	*Tridens eragrostoides* Vasey & Scribn.) Nash.
Macartney rose	*Rose bracteata* L.
Meadow dropseed	*Sporobolus asper* (Michx.) Kunth. var. *hookeri* (Trin.) Vasey
Mourning lovegrass	*Eragrostic lugens* Nus.
Plains bristlegrass	*Setaria macrostachya* H.B.K.
Prairie coneflower	*Ratibida columnaris* (Sims) D. Don
Seacoast bluestem	*Schizachyrium scoparium* (Michx.) Nash var. *littoralis* (Nash) Gould
Sideoats grama	*Bouteloua curtipendula* (Michx.) Torr.
Silver Bluestem	*Bothriochloa saccharoides* (Swartz.) Rydb. var. *torreyana* (Steud.) Gould
Spotted beebalm	*Monarda punctata* L.
Sourgrass	*Digitaria insularis* (L.) Mez ex. Ekman
Texas snoutbean	*Rhyncosia texana* Torr. & Gray
Texas wintergrass	*Stipa leucotricha* Trin. & Rupr.
Vine mesquite	*Panicum obtusum* H.B.K.

ANIMALS

White-tailed deer	*Odocoileus virginianus*
Wild turkey	*Meleagris gallopavo*
Javelina	*Dicotyles tajacu*
Bobwhite quail	*Colinus virginianus*

1.2M — 9-82