McGinty

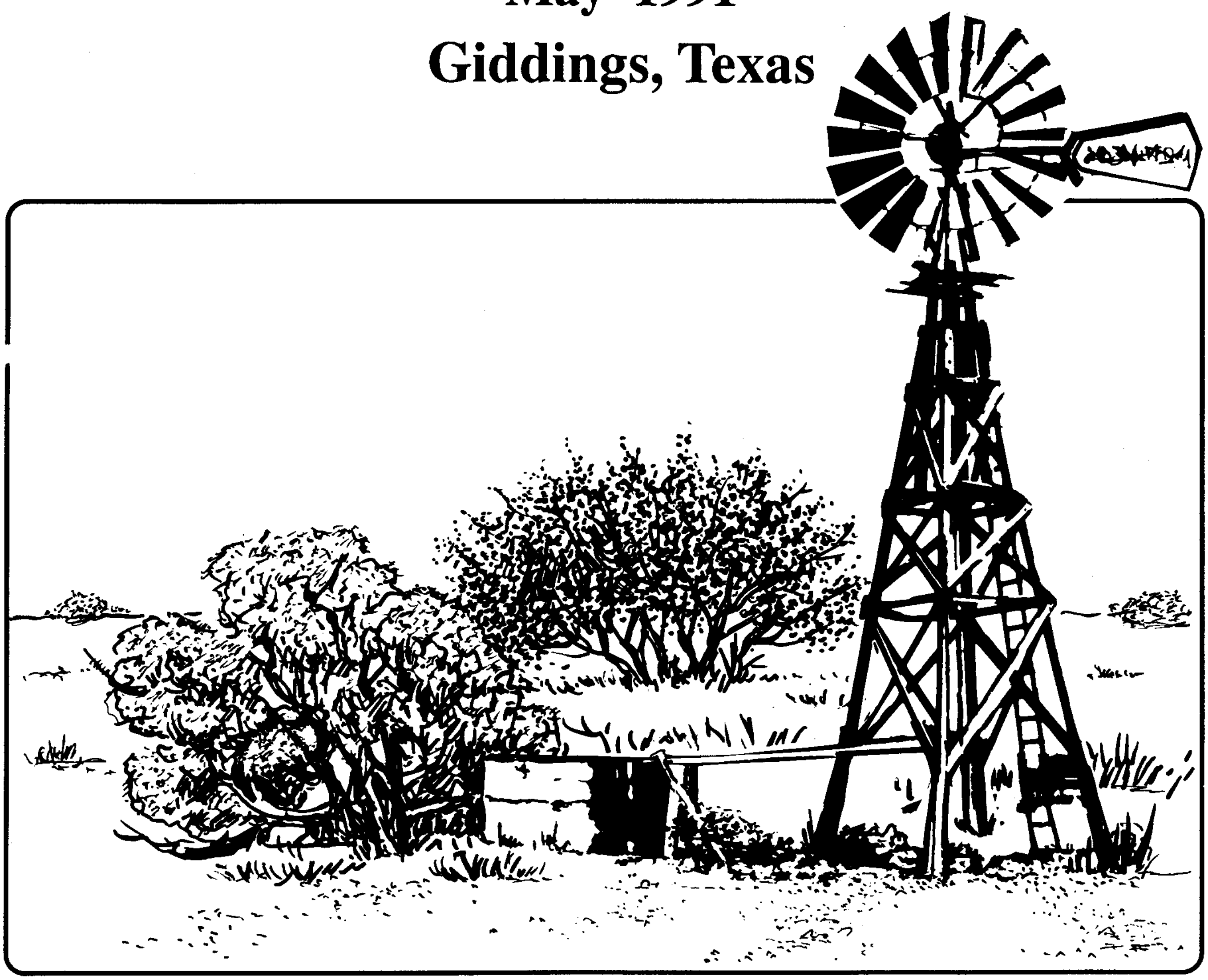
Texas Agricultural Extension Service

Proceedings

Brush Management Symposium

May 1991

Giddings, Texas



Texas Agricultural Extension Service • Zerle L. Carpenter, Director • The Texas A&M University System • College Station, Texas

Proceedings of the

BRUSH MANAGEMENT SYMPOSIUM

Do You Have A Brush Problem?

held on

May 10-11, 1991

in

Giddings, Texas

edited by

Tommy G. Welch
Associate Department Head and
Extension Program Leader for
Rangeland Ecology and Management

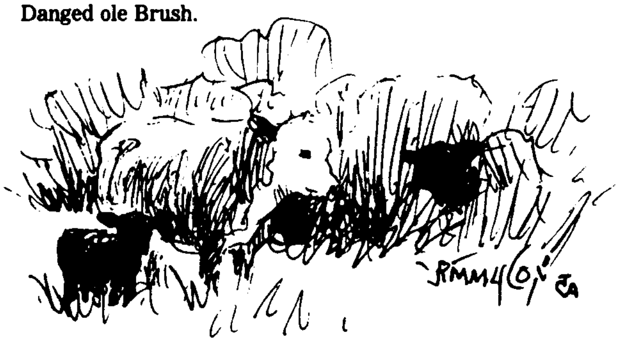
Texas A&M University
Department of Rangeland Ecology and Management
Room 225 Animal Industries Building
College Station, Texas 77843-2126

That Danged Ole Brush!

By Jake Landers
Extension Range Specialist, San Angelo, Texas

Illustrations by Jimmy Cox

When you sell all your goats 'cause of coyote kill,
Then the good price of mohair is a bitter pill,
And oak bud poisoning has made your cows ill,
Danged ole Brush.



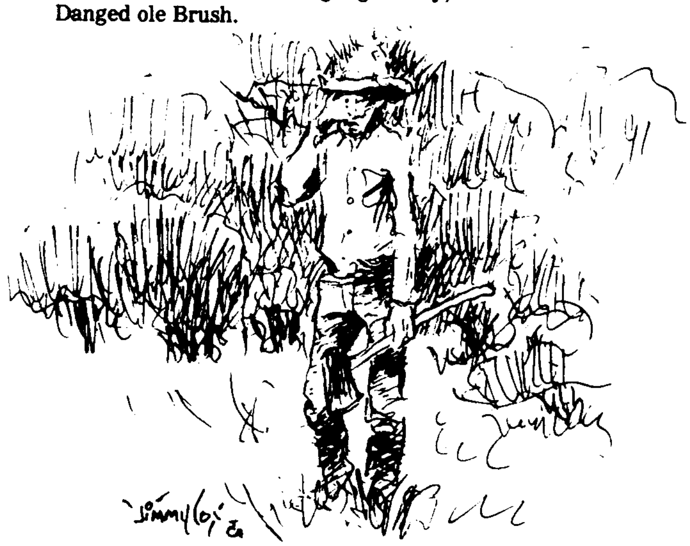
When your horn's all muffled by young growth of cedar,
And you can't find a sick cow in order to feed her,
And your wife says she'll help look if you need her,
Danged ole Brush.

A brushy wall holds up your fences,
And your neighbors think you've lost your senses,
And you balance your books except for expenses,
Danged ole Brush.

Your grazing plan's not working-out right.
Thickets a plenty put the ewes out of sight,
And sick baby lambs keep you up all the night,
Danged ole Brush.

When your neighbor's bull gets your heifers bred,
And he's black as coal and you like 'em red,
And all you see through the mesquite is his head,
Danged ole Brush.

At first you doze and then you spray
And then you grub the wetback way.
You want to burn but it might get away,
Danged ole Brush.



You go to the bank and add to your loan
And fix up the fences and stand by the phone
And sign up the hunters with an encouraging tone,
Danged ole Brush?

You bring in the hunters a thousand a gun
Who don't get much meat but have lots of fun.
Income beats expenses hundred to one,
Danged ole Brush!

Charcoal flavors, mesquite and oak,
Wood chips and firewood, it's no joke
What people'll pay to make the smoke.
Danged ole Brush!

There may be a need for changing my ways,
It's hard to admit brush management pays,
I guess I'll hate it the rest of my days,
Danged ole Brush.□

From Ranch Magazine - December 1986

EQUIVALENT MEASURES

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

TABLE OF CONTENTS

IS BRUSH A PROBLEM?

Tommy G. Welch
Associate Department Head and
Extension Program Leader for
Rangeland Ecology and Management
Texas Agricultural Extension Service
College Station, Texas

The answer to the question "Is Brush a Problem?" would seem to be a simple, straightforward, yes. However, the answer is not simple. The answer depends on a variety of considerations. The answer may differ if it is asked in terms of a statewide perspective or a ranch perspective; a societal view or a rancher view and for ranches with different enterprises. Determination of the answer has become more complex during the past fifteen years. Prior to the mid-seventies all brush on rangeland was generally considered bad. Along with the recognition that brush plants must be managed rather than eradicated came the recognition that most brush plants had some value. The value may be as browse for domestic or wild animals or cover for animals. Also, brush may be an enterprise through the harvest of wood or it may have value from an aesthetic standpoint. On the other hand, brush competes with grass and other forage plants for moisture and nutrients. Often this competition results in an increase in brush plants with a reduction in forage plants. The loss of forage plants not only results in lost livestock production but usually results in deterioration of the resource through erosion of the fertile surface soil. Brush has both positive and negative characteristics. The answer to the question "Is Brush a Problem?" must be determined with the above mentioned factors in mind.

Statewide Perspective

Data compiled from brush inventory surveys conducted by the Soil Conservation Service indicate brush species are currently present on more acres of Texas rangeland than in 1963 (Smith and Rechenthin 1964; Soil Conservation Service 1985). However, the number of acres supporting a dense stand of brush (canopy cover greater than 30%) has decreased. The greatest increase in acreage has been in low density stands (canopy cover less than 10%). This implies brush management activities in the 60's and early 70's effectively reduced dense stands of brush. The increase in low density stands may be a reinvasion of previously treated acreages and invasion into previously brush-free areas. Data on acres of brush treated per year indicate that large-scale, broadcast control of brush has declined in recent years with an increase in individual plant treatments on smaller acreages (Welch 1989). Also, brush species such as ashe juniper (blueberry cedar) and redberry juniper (redberry cedar) have increased in acreage infested partially because of limited control methods available.

The brush inventory conducted by the Soil Conservation Service in 1982 showed 30% of Texas rangeland supported a dense infestation of brush (Soil Conservation Service 1985). Forage production for livestock and wildlife are significantly reduced on these acres. Forage production on rangeland supporting a moderate stand of brush (34.7% of Texas rangeland) is probably reduced for livestock production but may be adequate for wildlife. Lost forage production can be translated into lost revenues from livestock and possibly from wildlife enterprises. These losses have a significant economic impact on the State.

In addition to the direct economic losses, heavy brush infestations indirectly impact the State through effects on watersheds and conservation of the rangeland resource. Although the impact has not been fully quantified, heavy infestations of brush may significantly reduce the amount of water available from rangeland watersheds for use in urban areas. The degree of impact will vary with each watershed. Usually a heavy infestation of brush is accompanied by a loss in grass cover. This often results in more soil erosion which reduces the quality of surface runoff water. Thus, citizens of the State can be concerned about brush infestations on rangeland because of the potential impact on water quantity and quality.

Rangeland that currently supports a dense stand of brush is generally being deteriorated through losses of surface soil. To prevent further deterioration of the resource, a grass cover needs to be established on many of these acres. Managing these areas to increase the grass cover will conserve the resource for further generations and will sustain productivity of these areas.

From a statewide perspective, citizens of the state should consider brush a problem on many acres of rangeland. Brush may not currently be a problem on other acres. Actually, brush on some rangeland areas has societal benefits because of the role it plays in providing positive recreational experiences. Hiking and camping generally take place in areas with some brush cover. Also, many hunting experiences occur in areas with brush cover. The presence of certain brush species has been considered desirable for maintaining the real estate value of land in the Hill Country and in other areas of Texas. However, brush will need to be managed or it may become a problem on these acres in the future.

Individual Ranch Perspective

The answer to the question "Is Brush a Problem?" on an individual ranch must also consider many factors. Brush density has increased on many ranches; but, it has been reduced on others. To determine if brush is a problem on a given ranch, the long-term or strategic goals of the ranch must be known as well as the appropriate enterprise mix that will be used to achieve these goals. The following discussions are intended to illustrate the necessity to consider enterprise requirements when determining if brush is a problem.

One of the most common enterprises on Texas ranches is cattle. The primary forage source for cattle is grass. When a dense stand of brush is present, grass production is almost always reduced. Thus, with a cattle enterprise, brush can be a problem. The presence of some brush may be beneficial from the standpoint of desirable browse and shade.

Brush is generally considered desirable for many wildlife species. However, too much brush may also be detrimental for wildlife. Good white-tailed deer habitat contains brush, forbs and grasses. Brush is needed for cover and food although deer prefer forbs for food. Beasom and Scifres (1977) reported that as much as 80% of a given management unit could be treated with herbicide if applied in an appropriate pattern without lasting negative effects on white-tailed deer population. However, Richardson (1989) states that most successful deer management programs maintain 40-60% of the ranch in brush. For optimum benefit of wildlife, brush must be managed to maintain a stand adequate to satisfy the needs of the wildlife species.

Other livestock enterprises such as goats and sheep may benefit from the presence of brush species. Goats generally prefer a higher proportion of browse in their diets than other livestock enterprises. To support a goal enterprise, brush should be a component of the vegetation. Some brush species such as mesquite and huisache are considered poor browse. Thus, brush stands that are predominantly mesquite and/or huisache may be poor habitat for goats.

Vegetation on a ranch needs to be diverse to obtain optimum production from multiple enterprises. The vegetation should include brush, grass and forbs and must be managed to maintain this diversity.

One of the benefits of brush control that is often cited by ranchers is reduction of the brush stand to improve ability to gather and work livestock. Dense brush is considered a problem for livestock husbandry.

Another aspect of determining if brush is a problem deals with the maintenance of the resource for sustained production and/or use of the resource by future generations. Vegetation is continually changing. Although the change may be slow, it is often toward an increase in brush density when poor management is practiced. Brush species usually increase soon after periods of drought and/or extended periods of overgrazing that reduce grass cover. The presence of young brush plants is an indication of increasing density and future problems with brush. Once brush plants become established, they have the ability to survive even if grass cover improves. However, a good grass cover will generally prevent or retard establishment of more brush plants. Invasion of brush can be considered a real problem when maintenance of the resource for sustained production and for use by future generations is considered.

A long-term management plan that clearly defines the strategic goals of the ranch and the enterprise mix to be used to achieve these goals is needed to help determine if brush is a problem. The appropriate enterprise mix is determined by the goals of the ranch and the vegetation and other ranch resources available. The vegetation resource must be managed to maintain it for benefit of the ranch enterprises. Brush species are part of the range resource. They must be managed just as grass is managed. The management may include control measures to maintain a brush population at a desired level to benefit the ranch enterprises. The ultimate purpose of the management is to achieve ranch goals. Without management, brush will become a problem.

Conclusion

The answer to the question "Is Brush a Problem?" is not easy or simple. In many cases brush is a problem. In others it must be considered a potential problem if not properly managed. Brush is a component of the resource that requires management to manipulate it for desired results. This symposium will provide information and training to aid in the development and implementation of a brush management plan.

LITERATURE CITED

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

Smith, H.N. and C.A. Rechenthin. 1964. Grassland restoration: The Texas brush problem. Soil Conservation Service, U.S.D.A. Temple, Texas 17p.

Soil Conservation Service. 1985. Texas brush inventory. Soil Conservation Service, U.S.D.A. Temple, Texas.

Richardson, C.L. 1989. Brush management effects on deer habitat. Tex. Agr. Exten. Ser. L-2347. 6p.

Welch, T.G. 1989. Acres of Texas rangeland treated for brush and weed control. Tex. Agr. Exten. Ser. Mimeo.

WHY DOES BRUSH INCREASE?

Timothy E. Fulbright
Texas A&I University
Kingsville, Texas

Summary

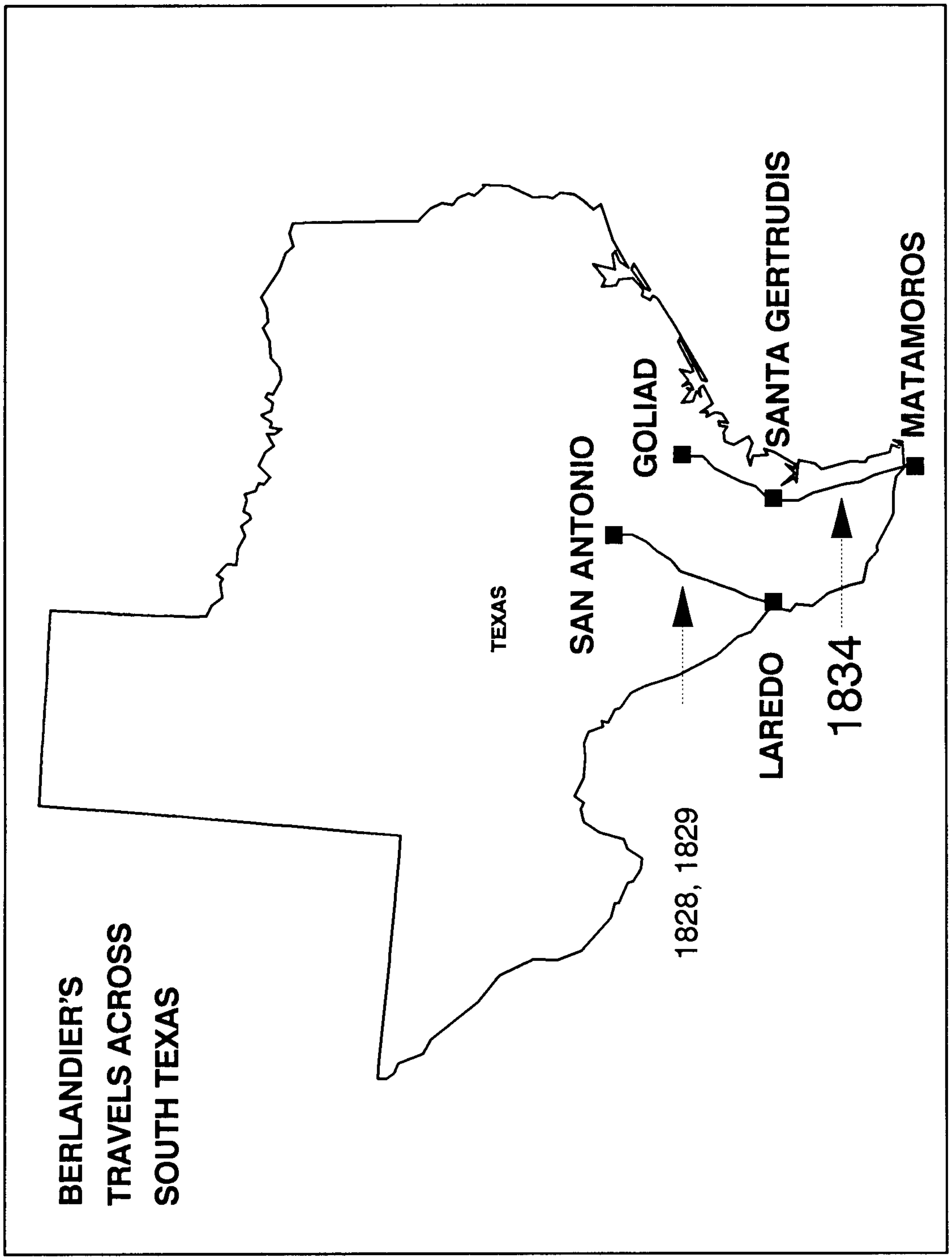
Mesquite and other brush species were present in low densities on Texas rangelands during the 17th and 18th centuries. Brush density greatly increased during the late 19th and early 20th centuries. The increase has been attributed to climatic change, overgrazing, lack of recurrent fires, and increased atmospheric carbon dioxide concentrations coincident with industrialization. Grazing and certain mechanical brush management methods may exacerbate the increase of brush; particularly mesquite. The forces that led to increased brush density on Texas rangeland are unlikely to be halted or reversed in the near future. Brush management to increase grass yield should include periodic maintenance to suppress shrub reestablishment.

The Brush Increase in Historical Perspective

Brush density has increased dramatically on Texas rangelands in the last 150 years. This brush increase has been particularly pronounced in southern Texas. Accounts of Spanish explorers in the 17th and 18th centuries indicate that mesquite was common in the uplands of the western Rio Grande Plain but was generally present in low densities (Inglis 1964). Jean Louis Berlandier, a French botanist employed by the Mexican Boundary Commission to collect plant and animal specimens and study natural history, traveled from Laredo to San Antonio in 1828 (Berlandier 1980). After crossing the Nueces River, he remarked that in some places leguminous shrubs predominated and little grass was present; in other places he said "not one bush grows". Returning to Laredo in 1829 he remarked that a forest was encountered along the Nueces River 1 mile north of its banks. He described the region between the Nueces and Rio Grande rivers as thinly wooded plains. The hills around Laredo were covered with ceniza and woody legumes. In 1834, again travelling from San Antonio to Laredo, he remarked that from the Nueces River 3 miles south to a stream called the El Barrosito mesquite was the predominant vegetation.

Berlandier also traveled from Matamoros to Goliad in 1834. He described the terrain in present-day Willacy and Kenedy Counties as a wilderness of plains with small forests of oaks (Berlandier 1980). He encountered open prairies between Santa Gertrudis Creek near present-day Kingsville and the Nueces River. Woody plants lined the streams in the region.

Brush density in south Texas had increased exponentially by the end of the 19th century (Inglis 1964). Vernon Bailey, in 1900, described the formerly open prairies in present-day Kleberg County as "prairie and mesquite country".


BERLANDIER'S
TRAVELS ACROSS
SOUTH TEXAS
TEXAS
SAN ANTONIO
GOLIAD
SANTA GERTRUDIS
MATAMOROS
LAREDO
1828, 1829
1834

Smith and Rechenthin (1964) stated a 1963 survey showed that 88.5 million acres of Texas' once "luxuriant" grasslands were infested with "low-value" or "worthless" woody plants and that mesquite had increased in range by 1.25 million acres since 1948. Jensen (1988) reported that in 1987 the amount of Texas rangeland infested with brush was 105 million acres. This increase occurred even though Texas landowners mechanically and chemically treated an average of almost 1.5 million acres/year from 1940 to 1981 to suppress brush (Welch 1982).

Theories on Causes of the Brush Increase

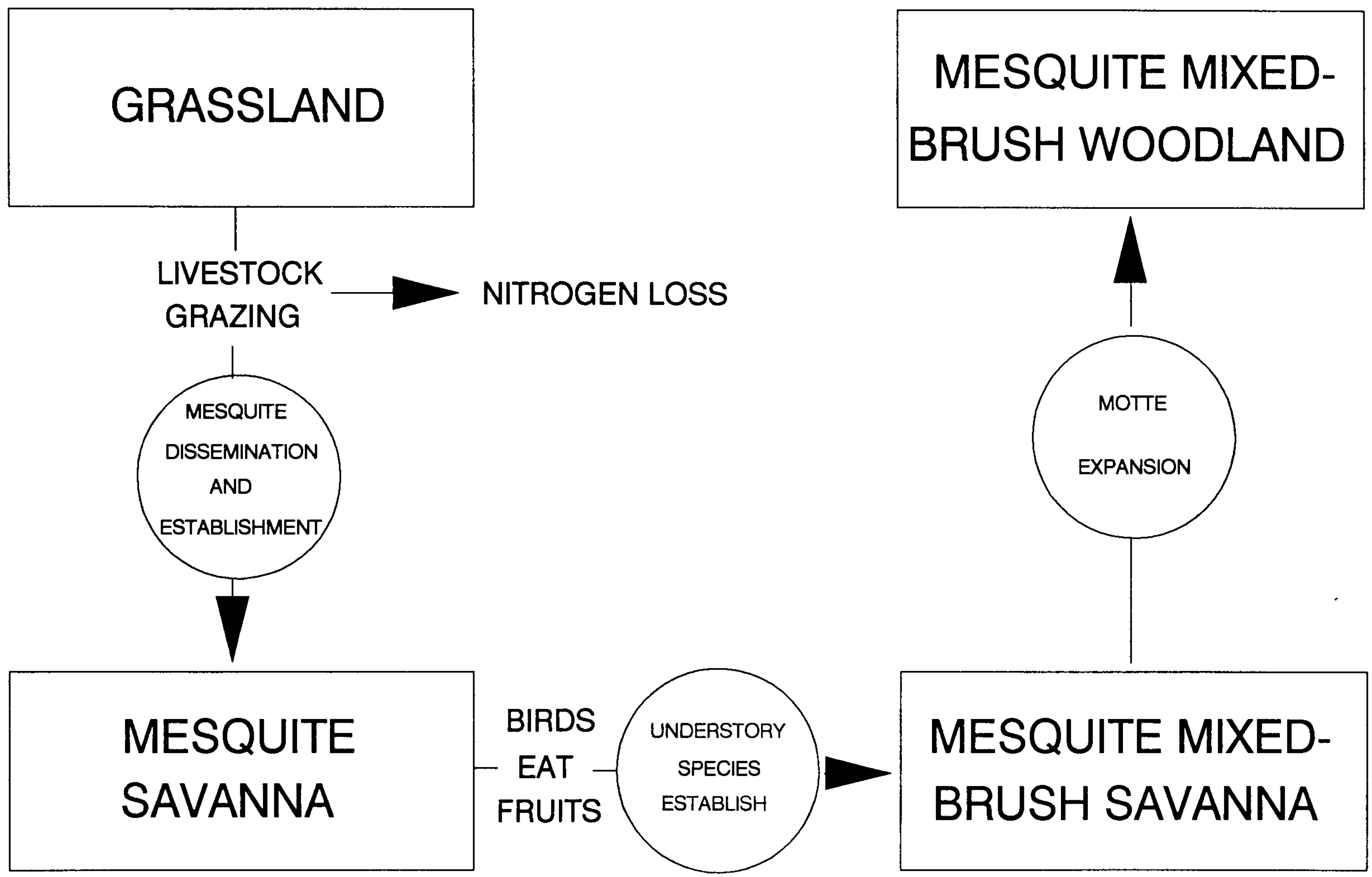
Scientists have yet to develop a comprehensive theory explaining how or why the increase in brush density on Texas rangelands occurred. Climatic change, reduced competition with grasses resulting from overgrazing, and lack of periodically occurring fires to kill brush seedlings have been suggested as factors resulting in increased brush. Another recent theory is that changes in atmospheric concentrations of carbon dioxide (CO_2) led to the increase of woody species, which has occurred not only Texas but in Australia, Africa, and South America. In the last 120 years, global CO_2 concentrations increased from about 270 to 320 ppm. Changes in CO_2 concentration within the historical range may greatly increase growth rates, reproductive yield, and water use efficiency of shrubs but not of warm-season grasses. By giving woody plants a competitive advantage, these changes in CO_2 concentrations may be a cause of the brush increase in addition to cessation of fire, overgrazing, and other factors (Johnson et al. 1990). The driving force in the brush increase was probably a combination of these factors with different ones more important in some localities than in others.

Grazing and the Brush Increase on Texas Rangelands

Grazing is not the sole cause of the brush increase because there are documented cases of brush invading grasslands that were protected from livestock grazing, but it appears to be a driving force in increasing brush density. This is exemplified by Jensen's (1988) observation that the areas most heavily infested with mesquite match the old cattle drive trails that traverse the State.

Livestock grazing may drive increases in mesquite density through (1) seed dissemination, (2) reduced competition between mesquite seedlings and grass because of grass consumption, (3) reduced natural fire resulting from fire suppression by ranchers and consumption of fuel by livestock, and (4) reduced soil nitrogen availability. Cattle relish mesquite beans and eat considerable amounts when they are available. Mesquite seeds are scarified in the digestive tract of cattle. Fisher et al. (1959) found that germination of mesquite seeds was 82 and 69% after passage through the digestive tract of horses and steers, respectively, compared to 26% for seeds not fed to the animals. Brown and Archer (1987) found that cattle dung pats kill grasses that they fall upon,

CONVERSION OF GRASSLAND TO WOODLAND



although the spot is soon colonized by other grasses. Mesquite seedlings emerged from 75% of the dung pats, with an average of 4/pat. Seedling mortality was low. Mesquite seedlings were absent from an adjacent area with no cattle, but were numerous in the area with cattle. In the early days of livestock grazing in south Texas, cattle and horses probably ate pods from mesquites growing along drainages. The animals may have then scattered the seeds in dung in open grassland resulting in seedling establishment.

Pastures containing mesquite are annually sown with mesquite seeds if they are grazed by cattle when the pods are ripe. Seeds deposited in feces may remain viable in the soil and germinate when environmental conditions are favorable. In 1984, after months of drought followed by a 7-inch rain, I counted about 5,000 mesquite seedlings/acre on a ranch in LaSalle County. Many seeds had apparently been deposited in feces and ground into the soil by trampling after the feces dried. The process placed the seeds in an excellent environment for germination.

Overgrazing weakens the ability of grasses to compete with establishing woody plants and thereby may enhance establishment of mesquite seedlings. Bush and Van Auken (1990) found that 40% of the mesquite seedlings that emerged from plots free of herbaceous (grasses and forbs) vegetation survived for 16 weeks whereas no seedlings survived in plots containing herbaceous vegetation. The reduction in grass cover resulting from grazing may result in inadequate fuel loads to carry fires. Once mesquite seedlings are about 3 years old they are virtually impossible to kill with fire.

Grazing may enhance establishment of mesquite indirectly through effects on soil nutrients. On grassland in the Texas Panhandle, annual losses of nitrogen (N) exceed annual gains. Fifty percent of the annual loss comes from volatilization of ammonia from animal waste (Woodmansee 1979). Mesquite forms a symbiotic association with N-fixing bacteria (Johnson and Mayeux 1990). The ability to symbiotically manufacture N may make help mesquite outcompete grasses and may enhance invasion of the plant into grasslands depleted of N. An invasion of mesquite on overgrazed land may be nature's way of restoring fertility to the system.

Mesquite appears to play a pivotal role in conversion of grassland to woodland. After mesquites reach more than 0.5 inch in diameter they may serve as the foci for establishment of other brush species which occur almost exclusively under mesquite canopies (Archer et al. 1988). The first species to establish under mesquites are pricklypear and colima, followed by granjeno, brasil, and Texas persimmon. Later, lotebush, agarita, desert yaupon, and wolfberry establish. Establishment of these species results in formation of mottes of brush, with mesquite as the center. Little establishment of these species occurs in grassy areas between mesquites. Possible explanations for this pattern of distribution are that seed dissemination is localized under mesquites or that the environment under mesquite somehow facilitates establishment of these brush species. All of the brush species mentioned produce fruits eaten by birds. After mesquite invades grassland, birds may carry the seeds of other species from drainages and other locations where they grow and perch in mesquites. Birds perching in the mesquites may defecate and deposit the seeds under the canopy.

Dissemination by birds is not the only explanation for the abundance of granjeno under mesquite canopies. In May 1990, my graduate students planted granjeno seeds under mesquites and in grass-dominated interspaces. In plots cleared of grasses and forbs there were 4 granjeno seedlings/yd^2 under the mesquites in December 1990, compared to 1 seedling/yd^2 in the interspaces. Apparently, environmental conditions under the mesquites are more conducive to granjeno establishment than environmental conditions in interspaces.

Shading, greater availability of soil nutrients, and improved moisture conditions under the mesquites may be more conducive to establishment of the seedlings than sunny, dry, nutrient impoverished conditions in open grassy areas. Mesquite canopies reduce the intensity of sunlight by around 75%, depending on canopy density, during the summer. The shading results in summertime soil surface temperatures that may be more than 36°F lower under mesquites than in open areas. My graduate students and I have recorded temperatures at a 0.4-inch depth in the soil during the hot part of the day exceeding 140°F in the open compared to less than 104°F under mesquites. The high soil temperatures in the interspaces may be lethal to emerging seedlings of granjeno and other understory species.

In southern Texas, Scanlon (1988) reported greater soil nutrient levels under mesquite than in areas dominated by herbaceous vegetation. Organic matter, total N, total sulfur (S), total soluble salts, and total potassium (K) are greater in the upper foot of soil under mesquite canopies than in open areas with no canopy (Tiedemann and Klemmedson 1973). Removal of mesquite causes a decline in available soil N, phosphorus (P), K, and S (Klemmedson and Tiedemann 1986).

Shrubs may improve water holding capacity by improving soil structure through reducing raindrop impact and adding organic matter from litterfall. In addition, the reduction in soil temperature resulting from shading by shrub canopies may reduce rates of evaporation.

Over time, cattle disseminate more seeds and more mesquites establish. More mottes are formed. The mottes continue to expand and the landscape is changed from a mosaic of brush clumps scattered in grassland to brushland with scattered grassy areas. The clumps of brush may continue to expand and ultimately coalesce, forming continuous brushland.

Brush Invasion Following Brush Management

Brush management using mechanical methods, chemical treatments, or fire generally provides only temporary suppression of brush. Roller chopping, shredding, and discing leave the bud zone of shrubs intact and they readily resprout. Root plowing and raking kills most brush plants but, no matter how well a pasture is cleared, a reservoir of brush seeds remains. A short time after treatment brush starts growing back.

In certain cases, the long-term result of brush management is a thicker stand of brush than was present before treatment. In LaSalle County, density of woody plants (excluding seedlings) on rangeland roller chopped 30-32 years earlier was nearly twice that on untreated land (Fulbright and Beasom 1987). Burning on the Aransas National Wildlife Refuge resulted in a 130-240% increase in density of live oak stems (Springer et al. 1987). The number of stems per plant may also be increased by certain treatments. Top growth removal by roller chopping, shredding, and other treatments may convert a stand of large, single-stemmed shrubs to a thicket of multistemmed shrubs.

The composition of brush that reestablishes after brush management often differs from that originally present. In the Coastal Prairie, root plowing of mixed brush stands may result in almost pure stands of huisache in 5-7 years (Mutz et al. 1978). In the Rio Grande Plains, mesquite, which is commonly the primary target of management, may flourish after brush management. In LaSalle County, density of mesquite was 2.7-3.6 times greater on land that had been root plowed 25-30 years earlier than on untreated land (Fulbright and Beasom 1987). This is not surprising since the soil contains a reservoir of mesquite seeds available to germinate and produce seedlings after root plowing. Granjeno, guajillo, brasil, guayacan and other species important in white-tailed deer diets were absent or present in low abundance on root plowed range. Many of these species grow primarily under mesquite canopies and establishment of mesquite may be a precursor to their establishment. Root plowed ranges have low brush diversity because of the predominance of mesquite or huisache. Deer utilize brush stands with high brush diversity more than those with low diversity (Steuter and Wright 1980, Pollock et al. 1989).

Mesquite density also increases after roller chopping (Fulbright and Beasom 1987). In contrast to root plowing, discing does not appear to cause a long-term increase in mesquite or a reduction in high-value browse species or brush diversity (Fulbright et al. 1990). Pricklypear density may be greatly increased by discing, shredding, chaining, and root plowing. In Jim Hogg County, pricklypear density was 600 plants/acre 16 years after discing compared to 155 plants/acre on untreated range (Fulbright et al. 1990). Treatments that break apart large pricklypear plants and spread the pads may greatly increase density because the pads readily root if the soil is moist.

Summary and Conclusions

The philosophy during the 1950's was to irradicate brush and restore the "luxuriant grassland" originally present. Terminology changed from brush eradication to brush control because brush continued to increase despite massive efforts at eradication. Now the term brush management is used. Our perspective on brush management changes as we develop better understanding of the mechanisms underlying the increase of brush.

Much of Texas is brushland and can be converted to grassland only temporarily without periodic maintenance and considerable expense. It is unlikely that the forces that led to conversion of Texas ranges from grass to brush will be halted or reversed in the near future. Brush increases following management partly because of seed dissemination by livestock and seeds remaining in the soil. An important point is to never treat more acreage than you can afford to maintain. Brush control is not a one-shot treatment and periodic maintenance costs should be figured in to the total cost of every project. If follow-up maintenance is not applied after treatments such as root plowing, a thicket of mesquite or huisache may develop that is poor for grazing-- and also poor for wildlife because diversity and the good-quality browse plants are lacking.

Acknowledgements: My research was partially supported by USDA, CSRS, Rangeland Research Grants Program, project number 89-38300-4479; the Caesar Kleberg Foundation for Wildlife Conservation; and the Texas A&I University Faculty Research Enhancement Program.

Literature Cited

Archer, S., C. Scifres, C.R. Bassham, and R. Maggio. 1988. Autogenic succession in a subtropical savanna: conversion of grassland to thorn woodland. Ecol. Monogr. 58:111-127.

Berlandier, J.L. 1980. Journey to Mexico during the years 1826 to 1834 (2 vols.). Translated by S.M. Ohlendorf, J.M. Bigelow, and M.M. Standifer. The Tex. State Hist. Assoc. and Cen. for Studies in Tex. Hist., Univ. Tex., Austin.

Brown, J.R., and S. Archer. 1987. Woody plant seed dispersal and gap formation in a North American subtropical savanna woodland: the role of domestic herbivores. Vegetatio 73:73-80.

Bush, J.K., and O.W. Van Auken. 1990. Growth and survival of Prosopis glandulosa seedlings associated with shade and herbaceous competition. Bot. Gaz. 151:234-239.

Fisher, C.E., C.H. Meadors, R. Behrens, E.D. Robinson, P.T. Marion, and H.T. Morton. 1959. Control of mesquite on grazing lands. Tex. Agr. Exp. Sta. Bull. 935. Coll. Sta., Tex.

Fulbright, T.E., and S.L. Beasom. 1987. Long-term effects of mechanical treatments on white-tailed deer browse. Wildl. Soc. Bull. 15:560-564.

Fulbright, T.E., L. Brothers, E. Montemayor, and B. Schat. 1990. Long-term effects of heavy disking on white-tailed deer browse. In: Abstracts of Papers Presented at the 43rd Annual Meeting of the Society for Range Management, Reno, Nevada, 11-16 February, 1990.

Inglis, J.M. 1964. A history of the vegetation on the Rio Grande Plain. Tex. Parks and Wildl. Dep. Bull. 45.

Jensen, R. 1989. Changing the face of the range-- will brush control boost water yields? Tex. Water Resour. 14, Tex. Water Resour. Inst., Coll. Sta., Tex.

Johnson, H.B., and H.S. Mayeux, Jr. 1990. Prosopis glandulosa and the nitrogen balance of rangelands: extent and occurrence of nodulation. Oecologia (Berl.) 84:176-185.

Johnson, H.B., H.S. Mayeux, Jr., and H.W. Polley. 1990. Increasing atmospheric CO_2 concentrations and vegetation change on rangelands. In: Abstracts of Papers Presented at the 43rd Annual Meeting of the Society for Range Management, Reno, Nevada, 11-16 February, 1990.

Klemmedson, J.O., and A.R. Tiedemann. 1986. Long-term effects of mesquite removal on soil characteristics: II. Nutrient availability. Soil Sci. Soc. Amer. J. 50:476-480.

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. Tex. Agr. Exp. Sta., Coll. Sta., Tex. B-1191.

Pollock, M.T., S. Demarais, and R.E. Zaiglin. 1989. Selection of habitat characteristics by mature white-tailed deer during winter and spring in south Texas, p. 18. In: Abstracts of Papers Presented at the 24th Annual Meeting of the Texas Chapt. of the Wildl. Soc., Coll. Sta., Texas, 30 March -1 April 1990.

Scanlon, J.C. 1988. Spatial and temporal vegetation patterns in a subtropical Prosopis savanna woodland, Texas. Ph. D. Dissertation, Tex. A&M Univ., Coll. Sta.

Smith, H.N., and C.A. Rechenthin. 1964. Grassland restoration--the Texas brush problem. USDA, SCS, Temple, Texas.

Springer, M.D., T.E. Fulbright, and S.L. Beasom. 1987. Long-term response of live oak thickets to prescribed burning. Tex. J. Sci. 39:89-95.

Steuter, A.A. and H.A. Wright. 1980. White-tailed deer densities and brush cover on the Rio Grande Plains. J. Range Manage. 33:328-331.

Tiedemann, A. R., and J. O. Klemmedson. 1973. Effect of mesquite on physical and chemical properties of the soil. Journal of Range Management 26:27-29.

Welch, T.G. 1982. Acres of rangeland treated for brush and weed control. Tex. Agr. Ext. Serv., Coll. Sta., Tex.

Woodmansee, R.G. 1979. Factors influencing input and output of nitrogen in grasslands, p.117-134. In: N. French (ed.), Perspectives in Grassland Ecology. Springer-Verlag, New York.

BRUSH MANAGEMENT DECISIONS : TEN FACTORS TO CONSIDER

C. Wayne Hanselka
Extension Range Specialist
Corpus Christi, Tx. 78410

Summary

Woody vegetation often invades or increases on deteriorated ranges and, because of species or stand characteristics, become a rangeland problem. It has become increasingly necessary to develop and use Integrated Brush Management Systems of solve these problems. Brush management programs require careful planning based upon goals, inventories, economics, etc. Factors unique to each ranch need to be considered in this decision process. These include problem definition, managerial goals, enterprise mix, outside forces, brush characteristics, technologies, economics, environmental concerns, aesthetics, and weather.

Introduction

Brush and weed management philosophies have evolved through several eras. The early era of "eradication" (i.e. complete removal for all time) evolved into the "control" (livable levels) era. This, in turn, evolved into the "management" era including positive aspects of brush and other habitat components.

Management is the administration of any enterprise. It involves the careful planning, organization, motivation, and control in operating all businesses, including the ranch. Sound management decisions depend upon a thorough knowledge of all resources and interrelationships in the business.

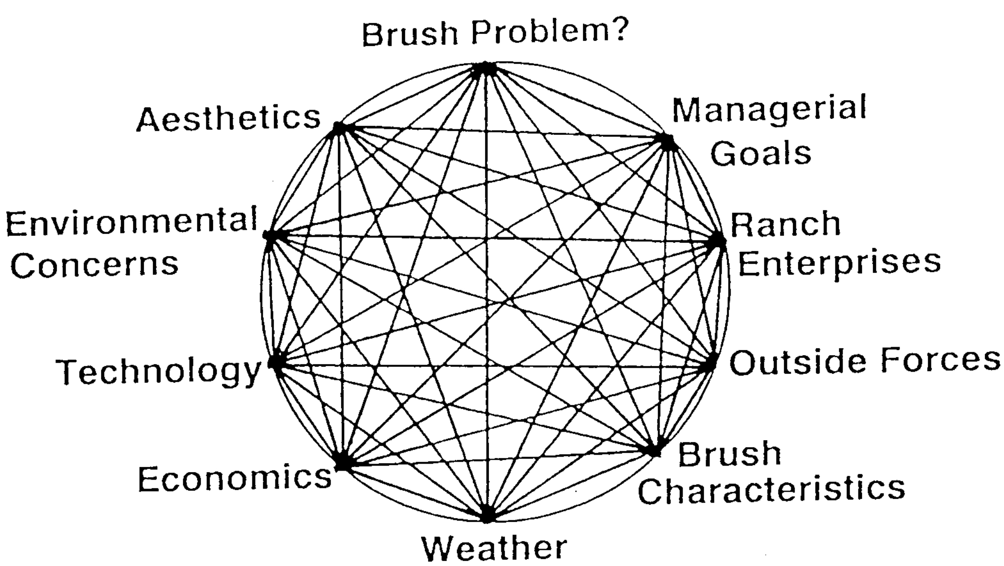
The brush "management" concept also recognizes that several different treatments may be necessary to accomplish objectives. Weaknesses, such as incomplete control of target and associated species, high costs, and potential damage to crops and desirable brush species should be recognized. The choosing of proper technologies, installed in a sequential manner, can overcome many of these weaknesses and extend the life of treatment over a long- term planning horizon. Grazing relationships, wildlife habitat impacts, and economics are important considerations in such a program. This concept and approach has been termed "Integrated Brush Management Systems" (IBMS) and has been successfully tested under a variety of problem situations in Texas.

This concept is presently evolving and tools such as decision-aids, expert systems, models and other computer software are being developed. These tools allow the manager to consider all aspects and ramifications of brush management programs, plan long-term programs, and implement ecologically and economically sound systems to meet objectives.

Brush management programs should be unique to every ranching operation. Choosing whether to invest in a brush management practice requires careful, systematic consideration of several factors. These pertinent factors interact and provide an indication of which decisions are appropriate. Basically, the same decision process that is appropriate for any other major management decision is used (i.e. set goals, inventory resources, select alternatives, analyze economics, etc.).

"Wheel of Fortune" is a TV game show currently popular in which contestants spell out phrases for cash by spinning a wheel. Many times they go bankrupt! Are brush management decisions made in the same fashion? What are the critical factors to consider in the decision-making process? The whys, whens, wheres, whos, and hows of management decisions can be categorized into essentially ten sets of factors. These are all interconnecting and related (Fig. 1). Changes in any one set of factors will probably result in changes in other categories. The first of these is "Do I have a problem?".

Figure 1. The interrelationships of factors affecting brush management are complex.



Is Brush A Problem?

Various species of woody plants, half-shrubs, and herbaceous forbs are, or can be, major vegetation components of nearly all terrestrial ecosystems. These plant growth forms are adapted to a wide range of ecological conditions. This adaptability, resilience, and ability to persist, or even increase in the face of adversity, make them "problems" in places where man perceives them to be too numerous or to have undesirable characteristics. A "problem" usually occurs when plants exist in places and amounts beyond beneficial limits. Dense stands of brush increase the cost of handling livestock and usually reduce desirable forage production. Conversely, brush is used as shade and forage by livestock and is a major habitat component of many species of wildlife. It promotes biodiversity in general and fills specific ecological niches.

The desirability of the existing vegetation species mix depends upon who has control of the land and his/her management objectives. Private ownership or agency stewardship as required by law may manage rangelands for a single enterprise (i.e. livestock, wildlife, etc.) or a suitable combination of enterprises for multiple uses. Therefore, the existing species composition has to be examined in light of these objectives and several questions answered. Does the existing species composition meet the desires of the individual, agency or other controlling party? If a change is required then some program is necessary for species manipulation.

Other Factors to Consider

Steps can be taken to correct the problem once it is decided that a problem exists. The following is a discussion of the major factors to consider in brush management decisions.

Managerial Goals

The ranch is a business conducting multiple enterprises and management decisions should be based upon the long and short-term goals and objectives of the business. These goals should reflect the kind and mix of enterprises on the ranch and the enterprise objectives should match the capabilities of the range. The selection of brush management practices should be based upon matching technically feasible alternatives with estimates of the "best mix" of vegetation in a socially and ecologically accepted program to meet long-range goals. Psychological and emotional needs of the manager should also be considered. Family relationships, needs, and desires are an integral part of planning.

Ranch Enterprises

This is closely related to ranch goals since various enterprises are the means that goals are met. Consequently, the needs and requirements of each enterprise, and their interactions, are factors to consider. The desirability and characteristics of brush stands are determined by the requirements of the enterprise mix. For example, grazing management and wildlife management decisions should be coordinated with brush management decisions. Long term responses need to be considered. A mix of beef cattle, Spanish goats, white-tailed deer, and bobwhite quail will take considerable planning since each enterprise requires varying amounts of brush for optimal production.

Outside Forces

Forces beyond the manager's control may often be a consideration in management decisions. Brush manipulation may be required in the lease agreement and certain acreages have to be treated annually. The decision as whether to treat brush on leased land as opposed to deeded land may be a problem. Financing of brush management programs usually is provided by lending institutions and/or agencies. These funding sources may have restrictions or stipulations that need to be considered in the decision process. The possibility of cost-share funding is another factor to consider. Endangered species protection is currently required by the EPA.

Brush Characteristics

Certain characteristics of the brush complex will determine manipulation needs such as why, how, when, etc. Species composition, density, size, height, resilience, sprouting, etc. will determine the extent of the problem and the options available for management. The size of the unit to be treated may be determined by the extent of the stand. Density will determine if broadcast methods or individual plant treatments are the best options. Height may determine if ground or aerial spraying is appropriate or maybe if root-plowing, discing, chaining, etc. are choices. Sprouting species necessitate the use of root killing methods and not simple top removal methods.

Available Technologies

Technology selection must be based upon all the other factors discussed in this paper. Options can be categorized into mechanical, chemical, biological, and fire. Each category has advantages and disadvantages and supporters and detractors. Technologies have changed through time with research and education activities, public attitudes, environmental concerns, and changing economic scenarios.

Mechanical brush manipulation using dozing, root plowing, chaining, discing, chopping, etc., usually followed by seeding, was the predominate brush management methods for many years. Problems with incomplete control of target species, destruction of soil, and increasing costs has caused a shift away from mechanical methods in recent years although they are still widely used. Mechanical methods are excellent means of wildlife habitat manipulation. These methods can be used for broadcast or individual plant treatments.

Rangeland herbicides include contact oils for basal treatment, translocated chemicals for foliar application, and dry herbicides for soil sterilization and/or root uptake. Varying degrees of efficacy are realized depending upon several variables such as timing, soils, weather, and plant growth and physiology. No herbicide is usually 100% effective. The dead standing stems provide cover for deer but herbicides will remove forbs and cactus from a pasture. These are important wildlife food items.

Prescribed fire has long been used as a pasture renovation and brush suppression tool. During the past 20 years there has been a resurgence of interest in the use of fire. Fire is an economical tool to use and is safe when done under proper conditions. However, it is only a maintenance method in that sprouting brush species are not killed and retreatment is necessary.

The most common biological brush management method in Texas is the use of goats. Approximately 76% of the diets of Spanish goats may be brush. Several studies have shown that spraying or mechanically treating a brush stand and then goating the area will result in excellent maintenance of the reclamation treatment. A goat enterprise will utilize the brush and return a profit on the brush management if certain constraints are overcome.

Economics

Economics should be, and usually are, a major factor in brush management decisions. Several studies have shown that economic returns (measured either as internal rate of return or net present value) depends upon four aspects of the brush management program. These are: (1) range site - deeper, more fertile, range sites respond to brush management efforts and provide greater forage responses and return on investment; (2) initial cost of treatment; (3) length of treatment life; and (4) the use of a combination of options - i.e. spray, fire or mechanical, spray, fire, etc. Economic aspects such as financing, cash flow, debt repayment, benefits/costs ratios, etc. will determine many of the hows and whys of decisions. Management goals need to consider optimum enterprise production at least cost. A major consideration should current and projected livestock prices and the relative costs of supplemental feed.

Environmental Concerns

There are growing societal concerns about the need for ecosystem biodiversity . This includes a balanced mixture of shrubs, forbs, and grasses on our rangelands. Such concerns often translate into brush management decisions. The use of herbicides in proximity to susceptible crops, gardens, housing, etc. is restricted. Regulations are currently being formulated to protect endangered species wherever they occur. This is limited, thus far in Texas, to the use of herbicides.

Another critical issue today is the quality and quantity of water. Rangelands are the watersheds for Texas and as urban water needs grow, there will be more pressure upon rangeland managers to provide the water. Brush management may increase the amount of water, but herbicides may be forbidden on certain recharge zones. Agricultural chemicals as a non-point source of pollution will continue to be a concern.

Aesthetics

Many persons are concerned about the appearance of the range. Many managers will shred brush to manicure the landscape and make it more aesthetically pleasing. High rangeland values for non-agriculture purposes may dictate some do's and don'ts in regard to brush programs. Real estate values are generally higher on ranges that have some large oak trees, mesquites, yuccas, etc. so programs should consider the value of these plants. In many cases, brushy land and/or land treated in patterns for wildlife habitat have higher resale and lease values than completely cleared land.

Weather

Weather plays a major role in the effectiveness of brush management practices. Plant physiology, growth, vigor, etc. is highly dependent upon air and soil temperatures, soil moisture, relative humidities, etc. The choices of what method to use, when to use it, and expected results rest upon weather variables. Species composition in relation to weather determine methods to be used. For example, mechanical treatment of mixed brush stands with good soil moisture will allow greater brush kills but also will tend to spread prickly pear. Foliar sprays are not as effective without adequate rainfall prior to spraying. Also, soil temperatures of 75 degrees at 12-18 inches are necessary for optimum performance of foliar herbicides.

Conclusions

Brush stands may be so large, dense, or objectionable that they are considered competitive and undesirable and, thus, a "problem". Brush or weed management programs utilizing chemicals, mechanical means, fire, or biological treatments involve a planning process considering certain basic sets of factors. Increasing public environmental concerns, changed perspectives on brush species, improved technologies, and economics have forced a re-evaluation of attitudes. Indiscriminate removal of brush for the sole purpose of increasing herbaceous forage for livestock is incompatible with the definition of range management and is of dubious economic justification.

Long term goals of brush management should be to stabilize the soil and increase water retention. This may be accomplished by manipulating vegetation for quantity, quality, and stability. The range site potential is used and secondary succession is evaluated to meet these goals. Plants and plant communities are modified to increase production, species composition, and value. Decision-making thus involves achieving a balance of range potential, the herbaceous and woody plants, and the grazing animals.

CAN BRUSH MANAGEMENT BENEFIT WATER QUANTITY AND QUALITY?

Robert W. Knight and Thomas L. Thurow
Department of Rangeland Ecology and Management
Texas A&M University
College Station, Texas

Summary

Water quantity and quality may be improved by proper brush management techniques and follow-up management. If proper management does not follow brush management treatments water quality and ultimately water yield will be reduced because of the lack of herbaceous cover increased brush densities. Proper brush management techniques currently provide the best opportunity for increasing water yield and maintaining high quality water in Texas.

As the municipal, industrial and agricultural activities of Texas continue to increase there is an accompanying increase in water demand. The expansion of these sectors has reached the point where demand is starting to exceed supply. This situation places public officials in a difficult position because further growth cannot take place unless: a) more water is made available or b) the existing supply of water is reapportioned among the users. Solution (b) is such a politically divisive topic that it makes sense to first carefully consider all options that can increase the amount of water available. The options for increasing water availability are essentially limited to two basic strategies.

Reduce Use

Improved techniques for water reuse can increase water availability by enabling the existing high quality water to be used more efficiently while using low quality water for other uses. If conservation and reuse technology is to be implemented it is important that the user expect that the cost associated with the change be offset by benefits. If the cost of a more efficient irrigation system is to be borne by the farmer and the saved water goes primarily to the city, the farmer will have little incentive to change unless he is compensated for the difference between the costs and benefits of implementing the new technology. Current law may in some cases actually discourage conservation. For example, retention of water right under Appropriation Doctrine is dependent on use; this sometimes results in continued use of inefficient irrigation systems for the purpose of maintaining the full appropriation claim. Texas ground water law currently allows landowners to remove as much ground water as they want.

Development of crops, lawn grasses and equipment that need less water can reduce demand. There is, of course, a cost associated with the research needed for these innovations and the time for development of useable products is uncertain. Another way to encourage conservation is to increase cost of the resource, a politically unpopular solution, particularly among constituents that have a low profit margin combined with a need to use large amounts of water. Reuse of "gray" water would further expand available water supplies. "Gray" water is water from sinks, showers and washing machines which requires little treatment before use. Gray water may be used on lawns and golf courses which use large amounts of water.

Increase Existing Supplies

Increasing the amount of water by transferring it from another region has become unpractical because of environmental and cost constraints. High cost of large-scale conversion of salt water to fresh water restricts it as a viable supply method. Increasing the amount of precipitation through cloud-seeding shows promise in specific circumstances but the variability of results and the potential for litigation constrains wide-spread application. Another restriction to this method is that suitable clouds must be present if they are to be seeded. The Edwards Underground Water District appropriated money during a recent drought for cloud-seeding, but never spent any because of the lack of clouds.

Reduction of evapotranspiration loss of water from the plants on watersheds is a method that could theoretically result in increased water yield. Hibbert (1983) estimated that the surface water supply in the Colorado River Basin of the western U.S. could be increased by one-third current yield (an extra 7.5 million cubic meters annually) if vegetation on 16% (65,000 hectares) of the basin were managed solely to increase water yield. Much of this increase would theoretically be obtained by conversion of vegetation types to species that use less water (ie. changing the species composition on watersheds from trees and shrubs to grass).

Approximately 250,000 hectares of Texas rangeland are dominated by shrubs and trees, prompting speculation that conversion of shrublands to grasslands could result in a substantial increase in the supply of water available for off-site use (Griffin and McCarl 1989). Griffin and McCarl (1989) report that studies in Texas have not yielded as great an increase as the work done by Hibbert (1983) in Arizona (Figure 1). Unquantified examples of how shrub-clearing can increase water yield are common (eg. re-initiated flow from long-dormant springs of Rocky Creek near San Angelo, TX (Kelton 1975)). Indeed, several ranchers in the Fredricksburg/Kerrville, TX region have been successfully clearing small areas (0.5 -4 hectares) of shrubs over the past 20 years for the primary purpose of spring development. Conversely, ranchers in other regions of Texas have experienced no increase in spring flow associated with shrub removal. A consequence of these mixed results is widespread confusion regarding the potential and cost-effectiveness of shrub removal for the purpose of increasing water yield.

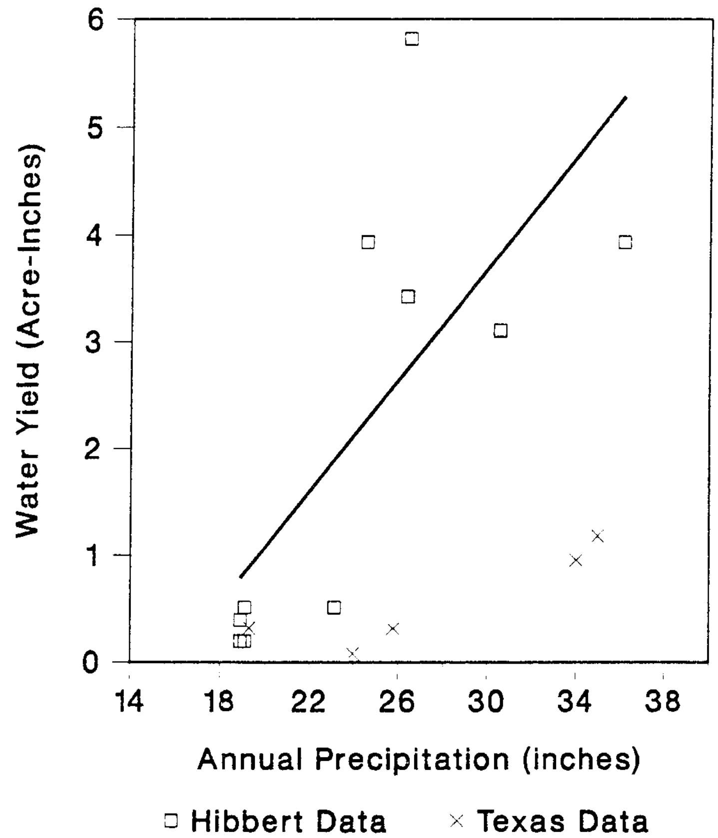


Figure 1. Comparison of water yields between Arizona and Texas study sites (from Griffin and McCarl 1989).

Shrub Management As A Means Of Increasing Available Water

The fate of precipitation falling on a watershed can be expressed by the equation:

$$\text{Precipitation} = \text{Runoff} + \text{Deep Drainage} + \text{Evapotranspiration}.$$

Runoff is defined as the portion of annual precipitation that leaves the site through surface flow or lateral flow through the soil. **Deep drainage** is the portion of precipitation that percolates through the soil profile beyond the reach of roots. **Evapotranspiration** is composed of both water lost by **evaporation** of water from the soil or from surface water and **transpiration** of water released to the atmosphere by passing through permeable membranes or pores of living organisms. Management action affects water yield to the extent that it changes how precipitation is partitioned between the runoff, deep drainage and evapotranspiration components of the water balance equation. There is a need for research to better understand the relationship between vegetation cover type and water yield before supply forecasts and economic analysis of shrub management can be assessed (Griffin and McCarl 1989).

Evapotranspiration is by far the greatest route of water loss in Texas shrubland, accounting for 90-95% of water loss (Weltz 1987, Carlson et al. 1990). The percentage of water lost to evapotranspiration could theoretically be reduced through conversion from shrub cover to grass cover. This reduction in evapotranspiration would be expected for several reasons:

1) Precipitation that strikes and adheres to vegetation may return to the atmosphere through evaporation without ever reaching the soil (ie. **interception loss**). Interception loss is governed primarily by the vegetation water holding capacity, which is a function of the plant surface area, morphological characteristics and storm intensity. The extent of differences in rainfall interception among plant communities was documented for rangeland on the Edward's Plateau of Texas. The estimated annual interception loss for a site dominated by curlymesquite (Hilaria belangeri) was 10.8% of annual precipitation. A site dominated by sideoats grama (Bouteloua curtipendula) had an estimated annual interception loss of 18.1%. Live oak trees (Quercus virginiana) and the litter beneath the trees intercepted about 46% of annual precipitation (Thurow et al. 1987). These data indicate that shifts in the kind or amount of vegetation associated with grazing and brush management affects interception, which in turn affects the amount of precipitation actually reaching the soil.

2) Water yield should increase if shrub removal reduces the amount of leaf tissue through which water can transpire. A reduction should also take place if the period during which the leaves are actively transpiring is reduced. Grass leaf tissue often begins senescence earlier than tree leaves because as the topsoil dries the shallow-rooted grasses run out of water while the deep-rooted shrubs can continue to tap water deeper in the soil profile (Davis and Pace 1977).

Another reason that water yield would be expected to increase as shrubs are removed is because the change in cover type will affect how much water will infiltrate the soil surface. If the infiltration rate is reduced the potential for runoff is increased. In general the amount of cover, and hence the rate of infiltration, is usually greatest under trees and shrubs, followed in decreasing order by sites dominated by bunchgrasses, shortgrasses and bare ground (Thurow et al. 1986). Sediment loss is closely correlated with runoff; both increase rapidly as cover is reduced. Water quality is an important consideration in water supply, therefore the herbaceous community must be managed to allow an increase in quantity without a significant decrease in quality. The effects of vegetation on the hydrologic and erosion characteristics of the site are shown in Figure 2. A study of Knight et al. has shown that brush may be managed to increase forage production while maintaining high quality runoff (Knight et al. 1983).

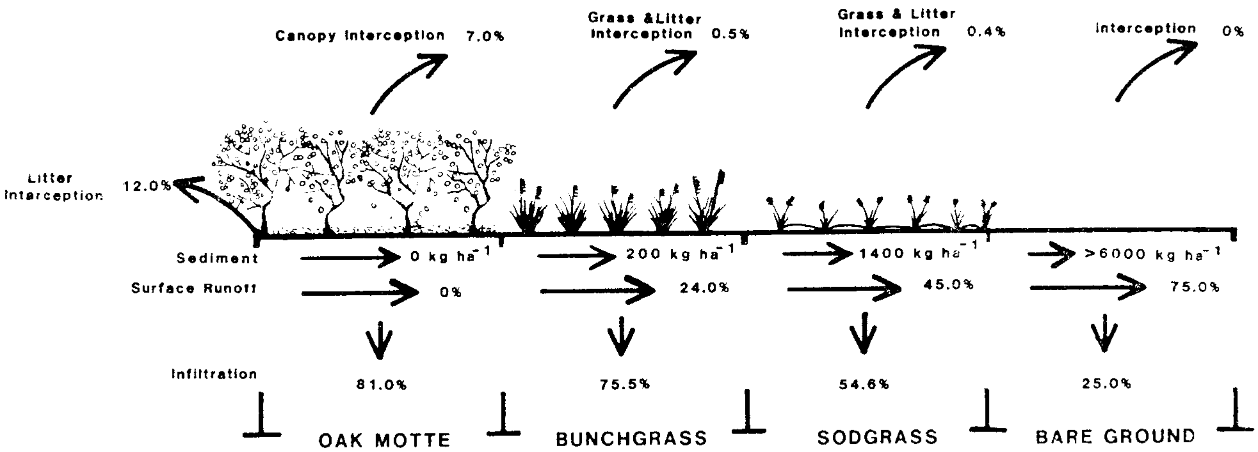


Figure 2. Water budgets and erosion associated with different vegetation types on the Edwards Plateau, Texas based on 10 cm of rainfall in 30 minutes (Blackburn et al. 1986).

Water yield improvement is based on the premise that runoff or deep drainage will increase by an amount equal to the net reduction in evapotranspiration. Little opportunity for evapotranspiration reduction exists in warm regions that receive less than 46 cm of precipitation per year. This is because these warm, arid regions lose a greater proportion of precipitation to evaporation from the surface soil since there is not enough rain for large amounts to percolate deep into the soil. Also, in these dry locations one vegetation type is about as efficient as any other in using the small amount of available water.

In regions that receive over 46 cm per year the amount of water that can be expected from shrub removal is dependent upon the soils, storm characteristics and response of the herbaceous vegetation. The great diversity inherent in each of these factors complicates predictions of water fate and thereby confounds speculation on the potential for increased water yield as a result of vegetation manipulation. Hibbert (1983) estimated that about 0.25 inch of additional water yield could be expected in Arizona for each 1 inch of annual precipitation above 18 inches following elimination of woody species (Figure 1). He expected that most of the increase in water yield would occur as increased subsurface flow and ground water recharge.

Preliminary research in Texas (Richardson et al. 1979, Weltz 1987, Carlson et al. 1990) suggest that expected water yields would generally fall below those predicted by Hibbert's hypothesis (Figure 1). The reasons for smaller than predicted yields in these studies are diverse. For example, if the soils are deep and the percolation rate through the soil profile is slow (possibly caused by clay soils or a restrictive layer in the soil) the water may move so slowly that it cannot escape beyond the reach of roots before it is all used by the plants. Conversely, if the soil has a high percolation rate (possibly caused by sandy soils) or if the soil is shallow and overlying a fractured rock substrate then water will quickly pass beyond the root zone. This relationship explains why the major aquifer recharge zones of the state are characterized by either sandy soils (Carrizo-Wilcox Aquifer) or shallow soils overlying fractured rock (Edwards Aquifer). It also explains why areas with deep, fine textured soils, like for example the Rolling Plains and Blackland Prairies, are not associated with major aquifer recharge.

When shrubs are cleared there is an increase in light and water availability that often prompts an increase in the herbaceous vegetation. The magnitude of the herbaceous vegetation increase will determine the amount of evapotranspiration that will occur from the site. If the herbaceous leaf tissue increases to match the decrease in shrub leaf tissue it will be unlikely that there will be a significant difference in transpiration unless the shrubs were evergreen types. The degree of herbaceous response will also be determined by the intensity of livestock use on the pasture. Data collected by Weltz (1987) near Alice, TX and Carlson et al. (1990) near Throckmorton, TX were on sites that were ungrazed and were in regions where substantial herbaceous response can be expected when shrubs are removed. Neither site showed substantial change in the water balance when shrubs were removed. In drier regions farther west, such as from Fredricksburg to San Angelo, the herbaceous response to shrub removal on grazed pastures was less. Consequently, ranchers in these regions have demonstrated success at increasing spring flow when shrubs are removed. In the forests of East Texas the potential for water yield increase would also be high because the large amount of precipitation in this region would ensure that water would runoff or percolate beyond the herbaceous root zone. Also the transpiring tissue of the large tree canopies could not be matched by tissue response in the herbaceous layer.

Storm characteristics also affect the amount of runoff and deep drainage. Since an initial amount of storm rainfall will be intercepted by vegetation or stored in the topsoil it would be expected that runoff and deep drainage would be a minor portion of small storms but an increasingly greater proportion of large storms. Indeed, Hibbert (1979) found that 80% of the water yield increase from shrub removal in Arizona was associated with large storms that occurred in wetter than average years. Brown and Fogel (1987) also found in Arizona that increased surface runoff from shrub removal occurred during high flow periods when reservoirs were nearly or totally full. This resulted in about 50% of the increased water supply going uncaptured. These results imply that additional facilities may be needed that can capture the supply when it is available if the benefits of runoff induced by shrub removal are to be maximized.

Public acceptance of shrub clearing to increase water yield not only depends on the amount of water yielded, but also environmental considerations. Public administrators must weigh these concerns along with the economics of shrub removal. To determine the cost/benefit ratio of a shrub clearing operation the resource manager must be able to predict how much increase in water yield and herbaceous production is likely to result. The Rangeland Ecology and Management Department at Texas A&M University is conducting research in diverse areas of Texas (Sonora, Uvalde, Throckmorton, Alice, Broaddus, and College Station) to determine how rangeland management will influence water quality and quantity. The results of these research projects are being used to develop decision-aid tools that will enable resource managers to make informed management decisions.

Literature Cited

Blackburn, W.H., T.L. Thurow and C.A. Taylor, Jr. 1986. Soil erosion on rangeland. pp. 31-39. In: Use of Cover, Soils and Weather Data in Rangeland Monitoring Symposium Proceedings. Society for Range Management, Denver, CO.

Brown, T.C. and M.M. Fogel. 1987. Use of streamflow increases from vegetation management in the Verde River basin. Water Resources Bulletin 23:1149-1160.

Carlson, D.H., T.L. Thurow, R.W. Knight and R.K. Heitschmidt. 1990. Effect of honey mesquite on the water balance of Texas Rolling Plains rangeland. J. Range Manage. 43:491-496.

Davis, E.A. and C.P. Pase. 1977. Root systems of shrub live oak: implications for water yield in Arizona chaparral. J. Soil & Water Cons. 32:174-180.

Griffin, R.C., and B.A. McCarl. 1989. Brushland management for increased water yield in Texas. Water Resources Bulletin 25:175-186.

Hibbert, A.R. 1979. Managing vegetation to increase flow in the Colorado River Basin. USDA Forest Service General Technical Report, Rocky Mountain Forest and Range Experiment Station, RM-66, Fort Collins, CO.

Hibbert, A.R. 1983. Water yield improvement potential by vegetation management on western rangelands. Water Resources Bulletin 19:375-381.

Kelton, E. 1975. The story of Rocky Creek. The Practicing Nutritionist. 9:1-5.

Knight, R.W., W.H. Blackburn and C.J. Scifres. 1983. Infiltration rates and sediment production following herbicide/fire brush treatments. J. Range Manage. 36:154-157.

Richardson, C.W., E. Burnett and R.W. Bovey. 1979. Hydrologic effects of brush control on Texas rangelands. Trans. ASAE 22:315-319.

Thurow, T.L., W.H. Blackburn and C.A. Taylor, Jr. 1986. Hydrologic characteristics of vegetation types as affected by livestock grazing systems, Edwards Plateau, Texas. J. Range Manage. 39:505-509.

Thurow, T.L., W.H. Blackburn, S.D. Warren and C.A. Taylor, Jr. 1987. Rainfall interception by midgrass, shortgrass and live oak mottes. J. Range Manage. 40:455-460.

Weltz, M.A. 1987. Observed and estimated (Erhym-II Model) water budgets for south Texas rangelands. PhD. Thesis. Texas A&M University, College Station, TX. 173p.

RANGELAND WEED AND BRUSH MANAGEMENT TECHNOLOGIES

PAST AND PRESENT

Allan McGinty
Extension Range Specialist
Texas Agricultural Extension Service
Fort Stockton, Texas

During the past decade, significant technological changes in rangeland weed and brush control have occurred. The past ten years have seen both the loss and addition of herbicides to our brush and weed control inventories. New application equipment and techniques have been developed to improve herbicide efficacy and lower costs. Fire has become commonly used as a range improvement tool, often integrated with other brush control practices such as herbicides or mechanical control. The advent of personal computers has resulted in the development of software that allows the timely, economic analysis of proposed treatments.

Unfortunately the 1980's did not reduce the complexity of integrating weed and brush control technology into the total ranch business. A rancher now more than ever before, needs to evaluate the impact of each piece of technology on the non-livestock resources of his ranch. Wildlife considerations are becoming more important when developing a brush or weed control plan. When brush is treated, the real estate value of a ranch can be drastically altered. Today's rancher must also consider the effects herbicide applications may have on endangered species and ground water.

The purpose of this paper is to examine the technological changes that have occurred in rangeland weed and brush control over the past decade, to discuss some of the forces that may have fostered these changes, and to predict future developments in rangeland weed and brush control during the 1990's.

Where We Have Been (The 1980's)

When we look at rangeland weed and brush control in the 1980's it becomes apparent that significant changes have occurred. These changes include a depleted herbicide inventory, development of new herbicide application equipment and techniques, new mechanical brush control equipment, the increased use of fire and development of computer based, decision support systems.

Herbicides

The single most significant change in relation to rangeland herbicides during the 1980's was the loss of 2,4,5-T. This herbicide had been used for over 30 years and was considered the brush control product. It was sprayed by aircraft, by ground rigs and by hand as a basal treatment. It was considered relatively cheap and effective. The loss of this herbicide was also the first experience the ranching industry had with vocal and extremely powerful "anti-herbicide" interest groups and the media.

Fortunately, the loss of 2,4,5-T in the early 1980's coincided with the registration of several new herbicides that have helped fill the void. **Triclopyr**, sold under the brand name Grazon ET by Dow Chemical Company, quickly replaced almost all uses of 2,4,5-T. This herbicide was previously labeled for right-of-way brush control and hardwood control in forests. When used for rangeland brush control in Texas, it's selectivity, rate and efficacy are almost identical to 2,4,5-T. Unfortunately, cost is also greater.

Also in the early 1980's, **tebuthiuron**, a soil applied herbicide, was registered for rangeland use by Elanco Products Company. This herbicide provides effective control for brush species treatable in the past only by mechanical means. Tebuthiuron, marketed initially as Graslan and currently as Spike had prior use for total vegetation control on right-of-ways or in the oil field. Fortunately, researchers found that the herbicide became selective for woody plants and forbs when applied at lower rates. This herbicide is formulated as a pellet and provides excellent control of creosotebush, tarbush, catclaw, winged elm, whitebrush and many oak species. Tebuthiuron is very sensitive to pellet distribution. As such, new equipment was developed to insure consistent results following commercial aerial applications.

Hexazinone, sold under the trade names Velpar L and Velpar RP, is a soil applied herbicide first registered for rangeland woody plant control by Dupont Chemical Company in the early 1980's. This herbicide also had prior use as a soil sterilent for total vegetation control. Unfortunately, hexazinone did not become beneficially selective when rates were lowered. As such, new application techniques were developed to allow it's use on rangeland.

Hexazinone was first formulated as a large pellet (gridball) to be aerially applied to rangeland. Unfortunately, the rates required were so high, both grass damage and costs were excessive. Next, an attempt was made to hand place the gridballs under the dripline of individual woody plants. It was hoped this technique would restrict grass damage to the canopy area. To everyone's disappointment the gridballs would not dissolve with normal rainfall. They were also well liked and accumulated by pack rats.

Following the failure of the gridballs, hexazinone was re-formulated as a liquid, to be applied undiluted, to the soil surface under target plants using a spotgun. With this method of application and formulation, hexazinone became the first range herbicide targeted exclusively for individual plant treatment.

Clopyralid was the last major rangeland herbicide receiving registration during the 1980's. Originally a field crop herbicide, it is marketed for rangeland under the trade name Reclaim. Registration was first received in 1987. Few other range herbicides have received as much publicity as this product. This herbicides is targeted almost exclusively for mesquite control. Aerial applications have produced much higher root kills as compared to 2,4,5-T, triclopyr, dicamba, picloram or mixtures of these. Unfortunately, this increase in control came with a higher price tag.

Upon review of rangeland herbicide development during the past ten years, two facts become apparent. First, most of the new herbicides were registered during the first half of the decade, and second, all of the herbicides were initially developed for other markets. Rangeland does not represent a lucrative market for most chemical companies. Rangeland's ability to pay is much lower as compared to cropland, and retreatment intervals are extended. This situation, coupled with high development and registration costs ($40 + million/herbicide), equate to restricted development of new herbicides for rangeland. Most certainly the almost absence of new rangeland herbicides during the latter half of the decade foretell of events to come.

Herbicide Application Equipment

There was considerable activity during the 1980's in the development of new and innovative delivery systems for herbicides. One of the first advances was triggered by the registration of tebuthiuron (Spike). This soil applied herbicide is very sensitive to pellet distribution. The standard gravity fed, dry material spreaders then available for aerial application did not accurately and uniformly deliver this herbicide. Consequently, a device called **Meterate** was developed. This piece of equipment is fitted to the bottom of the aircraft's hopper and positively meters the pelleted tebuthiuron from the airplane into the slipstream. Rates delivered are precise and can be changed in flight by simple adjustment of rotor speed. Bridging is no longer a problem as with older, gravity fed spreaders. This piece of equipment is largely responsible for the commercial success of tebuthiuron on rangeland.

One other piece of equipment developed or adapted for tebuthiuron application was the **Solo backpack airblast sprayer**. In the early 1980's tebuthiuron was generally restricted to aerial applications. Ground applications were possible with whirlybird type spreaders, but were restricted because of narrow swath widths and inability to handle rough terrain. In the mid-80's the Solo became available. Previously used as a backpack unit capable of applying liquid pesticides as a fine mist, the unit was modified to deliver dry pellets. This backpack unit uses a small gasoline engine to generate a strong stream of wind through a hand held wand. Tebuthiuron pellets are metered by gravity into this windstream. The wand is moved slowly from one side to the other to deliver a 60 to 75 foot swath. This unit can handle rough terrain and cover significant acreages. Ranchers have been very innovative, mounting the applicator on jeeps, 4-wheel motorcycles, trucks and even using it horseback.

The **spotgun** was first developed during the early 1980's, again due to the unique problems associated with using a particular herbicide. In this case the herbicide was hexazinone (Velpar L). To avoid excessive grass injury it was necessary to place hexazinone, undiluted, in precisely measured doses, beneath each target plant. The spot gun, which is a slightly modified drench gun was the result. The spotgun can be connected directly to the herbicide container and adjusted to deliver predetermined amounts. As with the Meterate device, this one piece of equipment is largely responsible for the commercial success of hexazinone.

During the 1980's, equipment was developed that more accurately targeted foliar applied herbicide sprays as compared to broadcast applications. One such piece of equipment is the **Brush Robot**, manufactured by Continental Belton. The Brush Robot consists of a heavy duty tool bar (8 to 16 ft. long) upon which special omnivalves are placed every 6 inches. These valves are similar to the valves used on the water hose at service stations. A nozzle is connected to each valve, as well as a short arm to activate the valve. A fiberglass tank and PTO-driven pump complete the Brush Robot. When mounted on a three-point hitch behind a tractor, the tool bar can be pulled across regrowth brush. As a brush plant passes under the tool bar, the nozzle arm is pulled back activating the omnivalve overhead. Each plant receives a targeted foliar spray of herbicide. This piece of equipment is best suited for control of scattered brush of small stature.

The **carpeted roller** was developed during the early 1980's, in an attempt to reduce the quantity of herbicide needed to control mid-to-small stature brush as compared to broadcast methods. The carpeted roller attaches to a front-end loader on a rubber tired tractor. Basically, the application device is a piece of floor carpet wrapped around a rotating 10-inch PVC pipe. Herbicide is periodically sprayed or dribbled onto the carpet as the tractor pushes the roller over the brush, applying the herbicide. The roller can be raised or lowered hydraulically to adjust for height of the brush. As with the Brush Robot, this piece of equipment is best suited for preventative or maintenance control of brush (brush less than 6 feet tall). The carpeted roller is not commercially marketed at this time. Plans detailing custom construction are available from the Texas Agricultural Extension Service.

The **mistblower** is a piece of application equipment that has seen extensive use in pest control around orchards and in urban areas. In the early-to-mid 1980's there was considerable interest in New Mexico in the mist blower as a means of reducing herbicide application costs for perennial broomweed control. The mistblower is best described as a gasoline engine or PTO driven wind machine. The wind generated is directed through a volute while herbicide is injected into the windstream. Swath widths of 50 to 100 feet are obtained. Unfortunately the fine mist generated is very susceptible to drift, so much so, that use of a mistblower is now prohibited on the labels of some range herbicides. Concern over off-site damage from herbicide sprays has essentially eliminated this device as an option for rangeland herbicide application during the 1990's.

The use of **3 and 4 wheeled motorcycles, dunebuggies and other innovative vehicles** increased during the 1980's to facilitate ground applications of herbicides. The introduction of hexazinone (Velpar L), coupled with increased interest in individual plant treatment techniques, had much to do with this phenomenon. Commercially produced spray equipment consisting of booms, handguns, multiple tanks and 12 volt pumps became available for attachment to these types of vehicles. Commercial applicators began to utilize motorcycles and spotguns for contract, maintenance control of brush. The 1980's saw a time when no longer were aircraft considered the only option for application of rangeland herbicides.

Herbicide Application Techniques

Not all changes that occurred in the 1980's were restricted to herbicides or equipment. One of the most significant technological changes was the **shift to fall spraying** for many subshrubs such as perennial broomweed and rayless goldenrod. This change in timing is due in large part to research documenting carbohydrate flow in perennial broomweed. As a result of this research, plants such as perennial broomweed that were generally resistant to spring applications of herbicides, can now be controlled with relatively low rates of herbicides in the fall. Spraying in the late fall or winter also reduces complications associated with potential crop damage from spray drift.

For many years ranchers have controlled mesquite by the basal application of diesel alone or with the addition of 2% herbicide. This technique saw less use as mesquite became more multi-stemmed, and as costs of diesel and labor increased. Two new methods of basal application, introduced only a couple of years ago, have stimulated renewed interest in individual plant control. One of the techniques is called **low-volume basal application**. With this method, a solution is mixed containing 25% herbicide (usually triclopyr) and 75% diesel. The solution is then applied to the basal stems of a brush plant until those stems are uniformly wet. The mixture is <u>not</u> applied in such a volume that the mixture runs off and puddles around the base.

Streamline basal applications are similar. The concentration of herbicide in the mixture is maintained at 25%, diesel is reduced to 65%, and a penetrant such as Cide Kick II is added at a rate of 10%. Instead of uniformly wetting the basal stems, as with the low-volume method, only a narrow stream is applied to the base. Both methods have proven to provide excellent control of mesquite and other woody plant species. The low-volume basal method has provided the most consistent control, averaging almost 90% rootkill of multi-stemmed mesquite.

Mechanical Brush Control

Technological changes in rangeland weed and brush control have also occurred in the mechanical control arena. In the early 1980's research reports first appeared concerning **low-energy grubbing**. Power grubbing for brush control with a bulldozer was first introduced into Texas in 1938 by a north Texas rancher. Over the years both ranchers and researchers worked to improve the grubbing blade and to reduce power requirements for grubbing. By the early 1980's both front and rear mounted, hydraulically assisted grubbers were being attached to low horsepower, rubber wheeled tractors. These grubbing units are ideally suited for maintenance control of small to mid-sized woody plants with densities less than 100 plants/acre.

Chaining, a relatively low-cost brush control method, has been used extensively for range improvement since it was first developed in the 1940's. Since that first anchor chain was used, work has never stopped to modify the chain to improve brush control efficiency and to prepare seedbeds for reseeding debris littered rangeland. Two significant modifications were made during the 1980's.

The **disk-chain** is a large anchor chain with disk blades welded to alternate links. When swivels are attached and the unit is pulled diagonally, a disking action is achieved as it rotates. Such chains operate at about 1/2 the cost and energy use of large offset disks.

The **chain diker** also uses a large anchor chain with blades welded to each link. As the chain diker is pulled, the chain rotates and the blades create a broadcast pattern of diamond-shaped basins. The basins hold rain where it falls, allowing the water to soak evenly across the treated area. Initial tests on row crops with furrow diking have shown yields increases of 30% or more as compared to conventional tillage. Hopefully the chain diker will perform as well on rangeland.

Fire

The 1980's will be remembered as the decade **prescribed burning** came into widespread used for rangeland improvement in Texas. Stimulated by increasing costs of chemical brush control and stagnant livestock markets, ranchers became more dependent on fire for brush suppression. In 1980 prescribed fire was used on an estimated 200,000 acres of Texas rangeland. Eight years later, this figure had more than doubled to 500,00 acres.

Fire was a natural ecological factor on most Texas rangeland before European settlement. Intense, summer wildfires were responsible for the creation and maintenance of most of our grasslands. Fire was also used by Indians to drive or concentrate game. Fire is <u>not</u> a new technology, but the widespread use of fire by Texas ranchers in the 1980's was new.

The greatest technological advance in the use of fire during the 1980's was the development of custom prescriptions for vegetative manipulation. As both researchers and producers began to apply fire to a variety of problems and situations, critical knowledge was gained concerning fire's impact on plant communities.

The 1980's also resulted in the first use of the **Heli-torch** on Texas rangelands. The Heli-torch is suspended beneath a helicopter and dispenses ignited, jelly gas. The unit is used when uniform ignition of large acreages is desired.

Integrated Brush Control Practices

Hand in hand with the increased use of fire in Texas came the development of **integrated brush management practices**. Both researchers and ranchers began to see the fallacy of the quest for one shot, one time, treatments for brush control. It became apparent that treatment life was a critical factor for obtaining positive economic responses from range improvement practices.

It also became clear that every single brush management practice has it's unique strengths and weaknesses, and that long-term economically successful brush management was rarely achieved with single treatments. The application of two or more practices, applied in the proper sequence in long-term planning horizons, with equal considerations for all range resources, emerged for the management of several major rangeland brush species.

One example of an integrated system is the fire/picloram system developed during the 1980's for control of pricklypear cactus. In the Edwards Plateau and adjacent regions of Texas, pricklypear causes severe economic losses to sheep and goat producers. Injury occurs from the spines when sheep or goats consume the pricklypear fruit or pads and from impaction of the rumen by seed following ingestion of pear apples (fruits). Prior to 1980 the recommended practice for pricklypear control was aerial spraying with a 1:1 mixture of 2,4,5-T and picloram or picloram alone at a rate of 0.5 lb/ac in late spring or early summer. This practice did not produce consistent, satisfactory results. Prescribed fire applied as a single practice reduced pricklypear on mixed grass range by only 50 to 60%. Fortunately, researchers found that burning pricklypear infested range in late winter, followed by the aerial application in April to May of only 1/8 lb to 1/4 lb/ac of picloram resulted in excellent control of pricklypear. This is a prime example of synergism between two practices. Neither treatment alone provided acceptable long-term control, but when combined they provided excellent results, with total costs only about 1/2 that of the current standard practice (aerial application of 1/2 lb/ac of picloram).

Other examples of integrated systems developed during the 1980's are the use of fire and mechanical treatments for control of juniper and the combination of mechanical treatments, fire and herbicides for control of Macartney rose.

Decision Making Systems

Probably the most important overall technological advance during the 1980's was the **home computer.** This is true not only for rangeland weed and brush control but for agriculture in general. Many of us remember the tedious task of evaluating long term capitol investments by hand. Errors were frequent and the array of options evaluated were few. As a consequence, decisions concerning thousands to hundreds of thousands of dollars were often based on little more than gut feelings.

Times have changed. Computers and software are now available that allow the quick, relatively easy and error free manipulation of vast amounts of data. Among other things, software now available will compare range improvement options, make an economic analysis of separate ranch enterprises and perform ranch record keeping duties. Consultants, extension and other advisory personnel have always preached the importance of record keeping. Nobody disagreed with their importance. The problem was always how to manage and manipulate the information so that it could be used to make management decisions. This problem is in large part solved with currently available computer technology.

Closely tied to the development of the personal computer has been the development of **expert systems.** Sometimes referred to as knowledge systems, these terms describe formal decision trees that interact with the user much as a consultant interacts with a client. Some general working properties of expert systems are first that they are highly interactive with the user. The system often holds an apparent intelligent conversation with the user by asking questions. Secondly, most expert systems are formed around straightforward "if-then" rule bases.

One example of an expert system is the decision tree developed for Macartney rose control. When using this system, the user is prompted concerning specific characteristics of the Macartney rose he wishes to control. At each question prompt the user is generally given a yes or no option. As each question is answered he is led to the most appropriate treatment option.

The 1980's also saw for the first time the **total systems approach** to rangeland weed and brush control. In the past most research and ranch decision making related to range improvement practices never considered the impact of those practices on the total ranch business. Also there were no formal decision aids to assist with the evaluation of range improvement practices as related to economic feasibility and compatibility with other ranch practices and goals. IBMS (Integrated Brush Management Systems) changed this situation. IBMS represented the first step toward creating comprehensive decision-making models for total resource management.

Where Are We Going? (1990's)

One of the best ways to predict the future is to examine the past. Obviously many new and powerful forces now affect rangeland weed and brush control. No longer does a rancher have the luxury of applying a herbicide without considering a multitude of impacts that practice might have. Wildlife, once taken for granted, are now a vital part of many ranch businesses. Most range improvement practices directly impact this valuable resource. The aesthetic value of brush is now recognized. Excessive fence-to-fence brush control may significantly lower the real estate value of rangeland. Endangered species and ground water contamination are terms commonly heard as related to rangeland herbicide use. These factors have already severely restricted herbicide use in some areas.

Most will agree that the 1990's will see fewer new herbicides labeled for rangeland as compared to the 1980's. Also, greater restraints will be imposed on use of the herbicides we have. These restraints will take the form of higher costs for the herbicides, protection of endangered species and ground water, and more stringent labeling and licensing requirements by the Environmental Protection Agency and the Texas Department of Agriculture.

Assuming these predictions are correct, where do we go from here? The 1990's will most likely see renewed interest in herbicide adjuvants. Since there will be few new herbicide products for researchers to work with, they will channel their energies into improving the efficacy of the products already at hand. Prototype work by TAES in the Edwards Plateau has produced encouraging data concerning the addition of a penetrant to foliar applications of picloram for control of redberry juniper. The addition of the penetrant increased rootkill from 65 to 97%. Of coarse with the justifiable concern of spray drift during herbicide applications, adjuvants that reduce off site movement will become more important.

Closely linked to potential improvement in herbicide adjuvants, will be improvements in herbicide delivery systems. As costs and legal restrictions increase it will become more important to apply the least amount of herbicide per unit of land area with the absolute minimum amount of drift from the target site. The principle of the brush robot will most likely be improved upon. Electronic sensors are already being evaluated for activating nozzles for highly accurate spot treatment of brush.

Because of costs of broadcast weed and brush control, the 1990's will likely see continued interest in individual plant treatment techniques. With these techniques, herbicide applications can be targeted to those plants and areas most in need. These techniques will be especially important as maintenance treatments to extend treatment life and thus the economic return from broadcast applications.

New and more powerful expert systems will undoubtedly be developed during the 90's. By the end of the decade it may be possible for a rancher to obtain a computer program from the Extension Service that will council him concerning all of his weed and brush management decisions. This program will not only evaluate the economics of a decision, but also make treatment recommendations based on his specific goals and problems.

The 1990's will also see increased research and use of biological control organisms. Work is in progress by the Agricultural Research Service to find an effective biological control organism for perennial broomweed.

The future of prescribed burning is not certain in the 90's. The first half of the decade will almost certainly see a continued increase in the use of fire. How long prescribed burning can escape from restrictions due to air quality concerns, is anyone's guess. Many small towns that used incinerators for garbage disposal have already had to face this problem.

Some individuals predict restrictions on herbicides will result in a resurgence in the use of mechanical brush control practices. This may be true, but unfortunately the cost of fossil fuels can be expected to simultaneously increase. It seems doubtful, that the use of mechanical brush control practices will increase unless engineering develops entirely new energy systems.

One final projection is that there will be fewer overall resources expended for rangeland weed and brush control in the 1990's as compared to the 1980's. This will not be because of a lack of available technology, but possibly because of the costs associated with that technology (time, money and environmental impacts).

SHORTCUT METHODS FOR DETERMINING COST EFFECTIVENESS OF BRUSH TREATMENTS

Larry D. White
Extension Range Specialist

Introduction

Success, cost effectiveness, profitability, etc. are all in the "eyes of the beholder". Different people have different reasons, goals, objectives, resources and constraints that determine the "best" alternative selected and implemented. A rancher should always examine the current situation and determine what responses for each ranch resource must be accomplished to survive and provide some benefits to satisfy wants. Brush control decisions are no different than most ranch decisions in that planning needs to be done, alternatives evaluated and the selected alternatives considered in relation to the entire ranch business. However, unlike decisions such as purchase of livestock or equipment, once brush control is applied it can't be sold as a capitol asset unless the land is sold or the responses achieved are marketed through an enterprise.

A cost effective practice usually refers to an equitable financial return on the investment of ranch resources. Most often ranchers only consider the financial investment with little consideration of impact on labor, management expertise and environmental aspects and constraints on future resources and decisions.

All methods of estimating potential cost effectiveness of brush control treatments have the same weakness, ie. risk of predicting future responses from treatments, enterprise performance, markets, "hidden" costs, other benefits, followup treatments, and management required. A rancher should plan and evaluate using the simplest to the more intensive methods available before implementing a program. Being action oriented, most ranchers do not do a thorough enough evaluation before making a decision. In general, if a practice is not cost effective using shortcut methods, you cannot make them effective with more intensive planning and analysis. This is true because more intense planning usually results in more realistic production and cost evaluations resulting in a lower financial return. All levels of evaluation should indicate the advantages of implementing a practice out-weigh the disadvantages before adoption. The risk of responses different than expected is probably higher the simpler the evaluation method used. Each individual must consider the amount of risk they are willing to accept when determining a practice to be cost effective.

Evaluating Alternatives

Many ranchers commonly use shortcut methods or "gut feeling" or experience of others to make brush management decisions. The questions asked of one-self or others must provide adequate information on likely responses to be achieved versus all costs of implementation. These must be considered in relation to the needs of the ranch now and over the longterm.

Welch (1986) emphasized several important steps to be followed to obtain profitable brush and weed control: conduct an adequate resource inventory, know your ranch objectives, identify applicable control alternatives, use economic analysis to select the most economically feasible alternatives, install the practice properly and use proper followup management. Following these steps is important but how will you economically analyze between feasible alternatives? Most ranchers seeking recommendations on brush and weed control ask questions in the following order:

1) What is the best method to kill a certain plant such as mesquite? Answer given, usually following several questions.

2) What does it cost? That's too expensive!

3) What would you recommend?

The answer, it depends! All practices currently available are cost effective for some situations. More important, the rancher seldom asks for information on responses and risks, but is most affected by the cost of treatment. The best practice is not necessarily the cheapest or most expensive. Analysis is the only way to determine the best alternative.

Shortcut Analysis of Economic Criteria

"Economic analysis of technically feasible brush management alternatives requires assessment of the amount of benefits and costs in monetary terms (Conner 1985). However, "some benefits and costs are non- monetary in nature" and should be considered in making the final choice.

A brush management study reported by Conners (1985) will be used to illustrate each of the shortcut methods a rancher can use. The methods described will not exhaust the approaches that different people use but will illustrate several possibilities for consideration.

Each situation analysis will describe information needed, calculation of results, and considerations if making a decision without further analysis.

The range situation being considered for treatment occurs on a 1,000 acre pasture in South Texas mixed brush on a sandy loam range site with a canopy cover of approximately 50 percent (Conner 1985). Aerial application of herbicide will be considered the "recommended" treatment. The pasture is currently stocked with 34 cows (a cow unit, includes necessary bulls and replacement heifers).

Each situation will build on information from previous situations.

Situation 1

The cost of aerial spraying is $23.50 per acre for a total cost of $23,500.

Cash-on-hand analysis indicates the rancher can afford to treat the pasture and "he" wants to kill the brush to improve grass production and roundup of livestock? Treat if you can afford it, otherwise you will be out of the cattle business due to brush" is often heard. This is a true statement in many respects but treating brush may not keep you in business if it is not cost effective. Is this practice cost effective? Let's see, with an average weaning weight of 470 pounds and a calf crop of 81 percent, the average production per cow is 381 pounds of weaned calf. At a sale price of $70 per hundred weight, we can make $266.70 per cow. Gross income minus variable costs of $125.00 per cow equals $141.70 gross margin.

How many cows would be needed to pay the cost of treatment?

$23,500 ÷ $141.70 = 165.8 cows needed. Can this be done? Will it pay?

Several short comings should be evident:

1. First, an additional stocking of 165.8 cows plus the original 34 equals 200 cows or a stocking rate of 5.0 ac/cow. Forage response will likely be inadequate for a first year break even. In fact, this stocking rate after forage production increases would be too heavy.

2. The treatment should last several years and forage production will not immediately appear (several years may be required to achieve maximum production). Need to pay for treatment over several years (longevity of treatment).

3. The time value of money (interest) has not been considered a cost.

4. The cost of additional cows has not been considered.

5. Livestock performance is assumed to remain the same.

More information is needed to analyze this situation.

Situation 2

The treatment is expected to reach maximum production in years 2-3 and be maintained for a couple of years before brush regrowth affects forage production. Stocking rate could not be increased until one year after treatment.

How many additional cows would need to be grazed if the treatment lasted 5 years?

$23,500 ÷ 5 = $4,700 per year

$4,700 ÷ $141.70 = 33.2 additional cows per year are required to break even. Resulting in 34 + 33 = 67 cows or a stocking rate of 14.9 ac/cow. This is probably not feasible (increasing from 29.4 ac/cow to the 14.9 ac/cow) the first year.

Shortcoming of accepting this practice without further analysis would be:

1. Time value of money on the brush treatment cost has not be considered.

2. Cows were stocked immediately. If cows are stocked one year after treatment, returns will only be obtained for 4 years. First year payment must be made from current operation. The second through the fifth year would require the $23,500 be recovered in four years or $5875 per year. Additional cows required would be $5875 ÷ $141.70 = 41.5 or a total of 75.5 cows in the pasture (13.2 ac/cow) years 2 through 5. This may be feasible.

Situation 3

Another way to analyze this situation might be the use of an amortization table. If the rancher borrowed the $23,500 for 5 years, what would the annual payment be at 12% interest (a.p.r.)? Using a financial calculator, the payment would be $6519.12 per year. At $141.70 per cow return, an addition 46.0 cows would be required to break even over 5 years (including interest).

Thirteen (12.8) additional cows must be grazed just to pay interest. In fact, more cows are required because stocking rate cannot be increased until the beginning of the second year. With four years to break even, the $6519.12 for the first year needs to be recovered resulting in an annual payment years two through five of $8228.90. At the same return, an additional 58.0 cows (total of 92 cows) are required (10.9 ac/cow). The amount of forage that must be produced each year grazed is 3483 pounds per acre (assuming each cow unit equals an animal unit eating 26 pound per day and a 25 percent harvest efficiency, White and Richardson 1989). Even with the use of the break even amortization approach, you only paid principal and interest without any return for your management or risk. Using your own money, this return might be feasible; however, using borrowed money you increased risk and need a higher return.

Several points have not been considered:

1. Still have not considered cost of additional cows.

2. Cows purchased must have a calf for sale the first year which increases purchase price. Did not consider salvage value of cows purchased.

3. Forage response will not be the same for years two through five if treated areas return to pre-treatment condition in the sixth year. In fact, a longer planning period is more realistic, forage response may be similar for years two through five, but decline slowly over the next five years to pre-treatment conditions (year 10).

4. Assumed cow production and cost would remain the same.

In each of the previous situations, the end result identified needed increases to break even. A better method to evaluate investments utilizes partial budgeting.

A partial budget only considers changes in income and costs that would occur following treatment. There are four major factors in a cow/calf operation that can change: number of production units grazed, production per unit, value per unit sold, and variable (direct) cost of production. Changes in stocking rate (number of production units grazed) following treatment is commonly considered but impact on the other three factors is often ignored. Calculations and projection of responses become very complicated when more factors change. A complete analysis involving each factor (and components within each factor) requires detail best analyzed by use of appropriate software (such as Econ described by Conner et al., 1990) on a computer.

A financial calculator can effectively be used to compute an internal rate of return, net present value, etc. for partial budgets. For Situation 3, a partial budget approach would identify changes over time in income and expenses. This is often diagramed as a cash flow schedule by years.

Assuming cow production and variable cost remain the same, i.e. gross margin equals $141.70 per cow (unit), the only change to be considered is stocking rate (Table 1).

The internal rate of return including the cow salvage value in year 7 equals 1.2%. The internal rate of return is the periodic interest rate that causes the net present value of a cash flow schedule to be zero. The net present value for this situation is $2431.10 above the investment. The treatment broke even if the responses are correct. Other amenities such as easier handling of livestock, etc. may convince you to implement the brush control. However, note that in year 6 the pasture still supports 33 cows more than before treatment. In effect, the forage response is

Table 1. Change in stocking rate (ac/cow unit) and cash flow schedule for treated and untreated pasture for six years.

Projected Change in Stocking Rate

Planning Horizon (Years)

Pasture	0	1	2	3	4	5	6
Treated	29.4	23.3	17.9	14.9	13.0	13.0	15.0
Not Treated	29.4	29.4	29.4	29.4	29.4	29.4	29.4

Number of Cow Units Grazed On 1000 Acres

Treated	34	43	56	67	77	77	67
Not Treated	34	34	34	34	34	34	34
Cows Added/Yr.	0	9	13	11	10	0	0
Total Cows Added	0	9	22	33	43	43	33
Cows Reduced	0	0	0	0	0	0	10

Projected Cash Flow Schedule (Difference in Dollars)

Cash-Flow	0	1	2	3	4	5	6
New Returns							
Cow G.M	0	1275.30	3117.40	4676.10	6093.10	6093.10	4676.10
Cow Sold*	0	0	0	0	0	0	6000.00
Salvage value of remaining cows = $19,800.							
Expenditures							
Treatment	23500.00						
Cow Unit Purchase	0	5400.00	7800.00	6600.00	6000.00	0	0
Net Change	-23,500	-4124.70	-4682.60	-1923.90	93.10	6093.10	1067.10

Salvage value = $19,800

* Assume cows sold, purchased and salvage value equals $600 per unit.

longer than 6 years. Also, note that stocking rate was progressively increased when forage production increased. If a rancher does not increase stocking rate following treatment, the treatment costs must be paid from increased returns due to increased production per unit, increased value per unit, or decreased variable cost per unit.

Situation 4

A more complete partial budget analysis showing each response change is needed to be as accurate as possible. Conner (1985) considered a ranch goal of sustaining the pasture productivity following treatment. A prescribed burn to maintain control of brush regrowth was installed in years 3, 6 and 10. This combination of practices is less costly than repeated aerial spraying at 7 to 10 year intervals. Also, to be more realistic, the cash flow schedule was projected for a 12 year period.

Assuming stocking rate is the only factor that changes, ie. gross margin equals $141.70 per cow unit, the stocking rate and cash flow schedule is shown in Table 2.

The internal rate of return including the cow salvage value in year 13 equals 5.29%. The net present value equals $23,655.00. The brush treatment would probably be accepted if you use your own money. However, if money had to be borrowed, interest rates at the bank would negate any profits to the rancher. Several points assumed in this example could be improved with more detailed analysis: 1) many pastures continue to decline in productivity if brush control is not practiced, 2) production costs for supplemental feed and labor could increase on untreated pasture, 3) if drought occurs stocking rates would probably be affected sooner and more drastically on the untreated pasture, 4) labor savings and reduced stress on livestock during roundup on treated pasture would be a benefit, and 5) if planned properly wildlife enterprises could be benefitted. Including these details could increase monetary benefits from implementing the brush management program. In addition, research indicates that improved forage conditions, especially following a prescribed burn, usually improve forage intake and quality of livestock diets resulting in increased weaning percentages and weaning weights.

In fact, Conner (1985) considered an increase in animal performance as well as the above. His final detailed analysis resulted in an internal rate of return of 7.47%.

Table 2. Stocking rate changes and cash flow schedule for projected brush control treatment using partial budgeting.

	Planning Horizon (Years)												
Pasture	0	1	2	3	4	5	6	7	8	9	10	11	12
Treated	29.4	23.3	17.9	14.9	13.0	13.0	15.0	13.0	13.0	15.0	15.0	13.0	13.0
Not Treated	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
	Number of Cow Units Grazed on 1000 Acres												
Treated	34	43	56	67	77	77	67	77	67	67	67	77	77
Not Treated	34	34	34	34	34	34	34	34	34	34	34	34	34
Cows Added/Yr	0	9	13	11	10	0	0	10	0	0	0	10	0
Total Cows Added	0	9	22	33	43	43	33	43	43	33	33	43	43
Cows Reduced	0	0	0	0	0	0	10	0	0	10	0	0	0

	Projected Cash-Flow Schedule (Difference in Dollars) (Years)												
Cash Flow	0	1	2	3	4	5	6	7	8	9	10	11	12
Net Returns													
Cow G.M.	0	1275.30	3117.40	4676.10	6093.10	6093.10	4676.10	6093.10	6093.10	4676.10	4676.10	6093.10	6093.10
Cows Sold	0	0	0	0	0	0	6000.00	0	0	6000.00	0	0	0
Expenditures													
Treatment	23,500.00	0	0	6000.00*	0	0	3250.00*	0	0	0	3250.00*	0	0
Cow Unit Purchased	0	5400.00	7800.00	6600.00	6000.00	0	0	6000.00	0	0	0	6000.00	0
Cow Salvage value year 13 = $25,800.00													
Net Change	-23,500.00	-4124.70	-4682.60	-7923.90	93.10	6093.10	7426.10	93.10	6093.10	10676.10	1426.10	93.10	6093.10

* Prescribed burns require construction of firelanes, etc. The first burn is more expensive than subsequent burns.

Conclusions

Short cut methods of evaluating cost effectiveness of range improvements have shortcomings just as any method. However, the simpler the analysis the more serious the risk of making an improper decision. Treatment life is one of the most important aspects of financial analysis. Except for very low cost treatments, it is nearly impossible to expect immediate forage responses translated through animal enterprises to break even. Using an amortization table to identify minimum annual payments for several years can help evaluate if a practice is likely to be practical. Partial budgeting and use of a financial calculator to analyze a cash flow schedule is practical and can be performed by most ranchers. This level of detailed evaluation is often adequate to determine financial feasibility. A more accurate and detailed evaluation may be required where changes in many factors are considered. This detailed analysis is best performed using a computer and software such as Econ (Conner et al 1990).

A rancher who constructs a cash flow schedule has specific questions to be answered before a practice is judged financially feasible. The simple truth is that responses achieved are more important than the tools used. Information on these responses, ie. longevity of treatment and annual response of number of production units, production per unit, value per unit sold, and variable cost of production, can be obtained from experience, the literature and from your Texas Agricultural Extension County agent or specialist. Once these responses have been estimated and the practice is implemented, they serve as criteria to be monitored for feedback and improvement of future range improvement analyses.

References

Conner, J.R. 1985. Technology selection based on economic criteria. pp. 47-54. In Integrated Brush Management Systems for South Texas: Development and Implementation. Texas Agricultural Experiment Station, B-1493, College Station.

Conner, J.R., W.T. Hamilton, J.W. Stuth and D.A. Riegel. 1990. Computerized Economic Analysis of Brush Management Alternatives. 12 p. In L.D. White (Ed.) 1990. Proceedings of Brush Management Symposium, Pleasanton, Texas, May 2-3. Texas Agricultural Extension Service, Uvalde.

Welch, T.B. 1986. Profitable brush and weed control. pp 207-218. In Guynn, D.E. and T.R. Troxel (Eds.). Proceedings of the 1986 International Ranchers Roundup, Kerrville, Texas. Texas Agricultural Extension Service, College Station.

White, L.D. and C. Richardson. How Much Forage Do You Have? Texas Agricultural Extension Service Bulletin B-1646, College Station, 8 pp.

Grazing Management Following Brush Control

David Bade, Extension Forage Specialist
Texas Agricultural Extension Service
Bryan, Texas

Summary

Brush management efforts can be economically feasible as they result in increased quality forage utilized to enhance livestock production. Reduced brush canopy through control or suppression efforts will release forage growth in native and improved pastures. Increased forage growth comes from germination of desirable forage plant seeds from the soil profile and/or increased vigor and growth of existing desirable plants. Forage management to increase desired forage growth instead of undesirable plants consists of grazing management and other management practices. Grazing management plans must be carefully designed in native ranges in years following brush control to increase and sustain the composition of desirable plants. Rotational grazing is a must to control the degree, frequency of utilization and the length of rest periods for these plants. Grazing management plans of improved pastures must consider the forage type (sod or bunch) and the animal and land production objectives. Grazing management in improved pastures following brush control is only one tool in pasture renovation. Seeding and/or reseeding of improved grasses following brush control will require additional seedbed preparation and specialized grazing management during the establishment year.

Introduction

Grazing after brush control or suppression must be carefully planned to sustain achieved brush control improvements while economically utilizing forage responses for sustained livestock production. Grazing and other forage management practices following any brush management practice will vary depending on the type of pasture (native, improved sod grass, improved bunch grass) and the overall goals and objectives of the rancher.

NATIVE RANGES AND PASTURES

Brush control or brush suppression efforts will be economically successful only if they translate into increased and sustained livestock production from our land resource. Increased long term stocking rates and improved animal production from treated lands will result if desirable grass and forb species are allowed to increase in the plant community. The main management objective of the treated land in the first few years subsequent to control is to increase and sustain the composition of desirable grass and forb species for livestock and wildlife production goals.

Brush management will result in reduced brush canopies. Canopy reductions from 20 to 95% have been reported in subsequent years after chemical brush treatments, depending on the type of brush and the effectiveness of the chemical treatment (Flinn et al 1989). Acceptable criteria of canopy reduction from herbicide treatment approaches 80% (Scifres 1989). Close to 100% reduction of brush canopy is achieved with mechanical control. This opening of the brush canopy will eliminate or greatly reduce competition of brush - especially the competition for light for grass growth. Increased light reaching the soil surface, and reduced brush competition for moisture and nutrients will allow germination of dormant seeds in bare spaces, and increased tillering and vigor of existing, weakened grass and forb species. A 80% reduction in prickly pear canopy resulted in doubling the yield of forage in South Texas in the 3 subsequent years to treatment (Hanselka 1991). Mechanical disturbance by root plowing or deep discing enhanced buffelgrass plant densities and greatly increased forage production over undisturbed spots through increased germination of seeds in the sites (Hanselka 1990).

Unfortunately a wide variety of seeds are present in the soil profile, with only a few being seeds of the desired forage species. It is very common to see a large flush of weeds germinating and becoming the predominate part of the pasture climax following brush control.

Weed control measures to reduce weed competition and allow grass increases for grazing will be an important management tool in restoring native pastures. Table 1 illustrates the importance of herbicides for native bermudagrass pastures (Bade 1988).

Table 1. The average effects of herbicide and fertilizer treatments on forage growth in a native pasture.

Treatment	Pounds of dry matter/acre Total	Weeds	Grass
Control	2030	1980	50
Herbicide no fertilizer	3886	0	3886
Fertilizer no herbicide	4853	4384	469
Herbicide and fertilizer	6738	0	6738

Herbicide is the average of 2,4 D, Weedmaster and Grazon P+D.

The use of herbicides on native pasture will release more desirable grasses. In Table 1 approximately 2 pounds of grass were produced for each pound of weeds controlled. Grass production was increased from 50 pounds per acre to 3886 pounds per acre with a herbicide application. That is an increase from 1.9 animal unit grazing days to 149.5 animal unit grazing days. Since the grass was common bermudagrass, fertilization was effective in further increasing forage production. Fertilization without herbicide, however, only fertilized the weeds without greatly increasing grass growth for grazing.

Result demonstrations on other native pasture sites have resulted in from 1 to 2 pounds of grass yields per pound of weeds controlled. Growth of native pastures in Gonzales County increased from 1093 pounds to 3329 pounds by controlling 1260 pounds of weeds by herbicides in 1983 (Wright 1983) and from 360 pounds to 743 pounds in the dry year of 1989 (Wright 1989). This expansion in grass growth extends potential animal unit grazing days and the opportunity for increased animal production.

Although forage production is increased, the goal of increasing desirable species dictates that grazing management be such that desirable species be protected from overgrazing and allowed to regain vigor and reseed. Cattle will select limited desirable plants and completely defoliate plants frequently after brush management under continuous grazing systems stocked at moderate to high levels. The grazing system after brush management must allow for only proper use and defoliation of desired plants, and adequate rest periods for revitalizing desired plants. A well planned rotation grazing system is a must! Although stocking rates can be increased due to more grass growth, flexibility must be incorporated during the first few years to allow for plant increases. Care must be taken to ensure proper grazing distribution is achieved.

Although seed for desirable native plants are present in the soil profile, occasionally native pastures which have brush control measures will be reseeded with desired native or nationalized grasses (i.e. buffelgrass in South Texas). This is usually done when mechanical brush control is involved, which leaves some soil disturbance for seed germination. Seeding of introduced species (i.e. kleingrass, giant bermudagrass) usually is not done without further and extensive seedbed preparation to ensure seeding success.

Grazing Management under sustained brush management schemes

Usually brush will not be controlled by a one time treatment. Regrowth of brush usually occurs and must be controlled in subsequent years. These control brush management schemes have implications on grazing management in years following brush control efforts.

Where prescribed burning is considered for control of resprouting brush, some fall grass growth must be allowed to accumulate for proper fuel for the late winter or early spring burn. Generally 1500 to 2000 pounds of dry grass per acre are required for an effective broadcast burn (White and Hanselka 1989). Grazing stocking rates and rotation schemes must take this fuel requirement into consideration during the growing season prior to the prescribed burn.

Grazing systems must also consider other ranch goals which alter the amount or composition of desired plants in the pasture. When wildlife (quail or doves) are included in the ranch goals, some weed growth is encouraged. This decreases available forage in the grazing program. The use of multiple species (i.e. cattle with sheep and/or goats) will require a different plant composition than grass alone for cattle. Forbs will be considered valuable for such use. Grazing management plans must be developed to incorporate all ranch and personal goals and be carefully planned on a year by year basis based on management objectives for the native pastures and rangelands.

IMPROVED PASTURES

Often brush control is done as part of the process of renovation of neglected bermudagrass pastures (sod type grass), as a part of reseeding improved bunch grass pastures, or part of changing native brush pastures to improved pastures. All have common goals in the years subsequent to control - the establishment or reestablishment of a solid stand of grass. Grazing management is important in establishment and utilization of improved pastures for sustained production.

Renovation of neglected sod type pastures

Brush management in neglected sod pastures (bermudagrass, bahiagrass) will help reduce brush competition and release grass growth. Brush control in a coastal bermudagrass pasture in Goliad County in 1990 increased forage production from 5315 pounds per acre to 6450 pounds per acre (Hale 1990). Response of course is dependent on the number and density of brush plants in the pasture.

Reduction of the brush canopy will not only allow grass growth, but will also promote weed seed germination. Often these pastures can be renovated by a combination of herbicide and fertilizer. Increases in pounds of coastal bermudagrass produced per pound of weeds controlled ranged from 3 pounds in a wet year to 7 pounds in a dry year in Victoria County (Dorsett 1984). The combination of herbicide and fertilizer changed a neglected bermudagrass pasture from 90% brownseed paspalum to 95% coastal bermudagrass in one growing season (Bauman et al 1990).

Increased bermudagrass or bahiagrass growth due to brush control can be more effectively utilized than can native or bunch grass species. Whereas desirable bunch grasses must be only grazed to 50% defoliation and be allowed extended rest periods for revitalization; sod grasses can be heavily and frequently defoliated without affecting forage vigor. Thus they can withstand close, continuous grazing. Although the growth form of bermudagrass was altered under heavily stocked, continuously grazed pastures, forage growth rate and hence vigor was not affected by the level of grazing pressure (Rouquette 1988). Bermudagrass growth under heavy, frequent defoliation was low growing with short, thick stolons and short leaves.

While rotational grazing schemes will facilitate forage management (i.e. cutting hay from excess growth, using herbicides with grazing restrictions) "regimented cattle rotation schedules have not, to date, been a viable, economic alternative to those continuously grazed bermudagrass pastures in which some variable stocking rate method has been utilized. Bermudagrass pastures do not require periods of rest during the active growing season, or other manipulations for stand maintenance and vigor." (Rouquette 1988). Grazing pressure or stocking rates should be determined by livestock production goals. Light stocking rates will promote large individual animal gains but low gains per acre. Light stocking will also allow for flexibility in times of erratic pasture growth. Heavier stocking rates, conversely results in lower individual animal gains but higher gains per acre (Table 2). Stocking rates of bermudagrass and other sod grasses must be a compromise from these two extremes based on animal and land production objectives.

Table 2. Liveweight performance of weaned calves grazing Coastal Bermudagrass at four levels of available forage.

Stocking Rate	Available Forage lbs/acre	Stocking rate an/acre	Animal Gain lbs/an	lbs/acre
Low	3522	3.9	372	1451
Medium low	2112	5.0	309	1545
Medium high	1618	6.5	254	1651
High	921	9.7	110	1067

Rouquette 1984.

Reseeding or seeding of introduced grasses

Often brush control is followed by seedbed preparation and seeding or sprigging of introduced grasses. Selection of introduced grass species must be based on adaptability to soil, climate and animal grazing management plans. Grazing management during the establishment year of introduced bunch grasses must be regulated to ensure grass establishment and growth. Subsequent grazing management will be based on the base grass (sod vs bunch) and production potential of the pasture. Weed control, fertilization, hay and grazing management schemes of these pastures will ensure fast establishment and sustained forage production for livestock following brush management.

Literature Cited

Bade, David. 1988. Fertilization and Weed Control for Native Pastures in the Upper Texas Gulf Coast. 1988 Angelton Beef Cattle-Pasture Field Day.

Bauman, Paul A., David Bade, and Darrin L. Biediger. 1990. Forage Response to Mechanical and Chemical Weed Control Measures in Pasturelands. ABST. Texas Plant Protection Conference. College Station, Texas.

Dorsett, Donald. 1984. Management of Improved Bermudagrass to Maximize Yield and Nutritive Value of Hay. Proceedings. Bermudagrass Symposium. Hill Farm Research Station, Homer, La.

Flinn, R.C., C.S. Scifres, R.A. Crane, B.H. Koerth, D.N. Ueckert,and W.T. Hamilton. 1989. Ground Broadcast Application of Herbicides. Management of South Texas Mixed Brush with Herbicides. Texas Agri. Experiment Station B-1623.

Hale, Dennis. 1990. Goliad County Result Demonstration Handbook.

Hanselka, C. W. 1990. Natural Reestablishment of Buffelgrass. Jim Hogg, Zapata, and Webb Counties. Personal Communication.

Hanselka, C.W. and Calvin Richardson. 1990. Response of a Pricklypear Community to Management with Picloram. Publishment pending.

Rouquette, F.M. 1988. Intensive Grazing of Warm Season Grasses in Humid Area. AFGC Forage and Grassland Conference Proc. Baton Rouqe, La.

Rouquette, F.M., L.D. Roth, M.J. Florence and W.C. Ellis. 1984. Liveweight Gains of Weaned Calves from Four Levels of Available Forage. Forage Research in Texas.

Scifres, C. J. 1989. Management of South Texas Mixed Brush with Herbicides. B1623.

White, Larry and C. Wayne Hanselka. 1989. Prescribed Range Burning in Texas. Texas Agr. Ext. Service B-1310.

Wright, Orval. 1983. Gonzales County Result Demonstration Handbook.

Wright, Orval. 1989. Gonzales County Result Demonstration Handbook.

PUTTING IT TOGETHER - AN EFFECTIVE BRUSH MANAGEMENT PLAN

Wayne T. Hamilton
Texas Agricultural Experiment Station

Summary

Putting brush management together into a system that optimizes its contribution to ranch objectives requires good planning. Planning is the management process we use to chart a course to reach objectives. It "bridges the gap" between where we are today and where we want to be at the end of some future time period, and it is basically choosing from among alternative courses of action that are available to us. Therefore, planning requires being aware of alternative opportunities, being able to forecast changes that will occur from different management scenarios, and being able to quantify these changes so that they may be analyzed and compared to other alternatives. Once a plan is selected and implemented, the results should be monitored and "fed back" into the planning process to improve accuracy, making planning a more reliable and realistic management tool. Good planning requires following a sequence of steps that will lead to the most efficient plan (Figure 1).

Objective Setting - Develop a Perspective on Brush Management

Brush management planning should begin with setting of objectives. Objectives should be general at the outset of the planning process until a comprehensive inventory of resources has been accomplished. They should also be developed in a "systems context," simultaneously considering grazing management and wildlife management goals, as well as brush management (Scifres et al. 1985).

Deciding on an effective brush management plan to best meet your long-term objectives for range, livestock and wildlife resources usually involves a complex decision-making process. The reasons for this complexity include the diversity of range sites and vegetation, previous treatments, current range condition, past history of use, variation in effectiveness of different treatments from which to choose, and differences in posttreatment wildlife, livestock or aesthetic requirements. The nature of the brush, including size, density, and growth form is also a factor affecting brush management decisions. In short, there is no "one best" brush management practice. The trick is to pick the treatments that will be most effective and economical in changing the vegetation to match your objectives for the range. Keep in mind that many individual brush management practices do not last for the time needed to recover investments in the treatment and associated costs (Whitson and Scifres 1980, Scifres and Hamilton 1989). This means that range managers need to consider brush management programs or systems that incorporate long-term maintenance practices rather than single treatments.

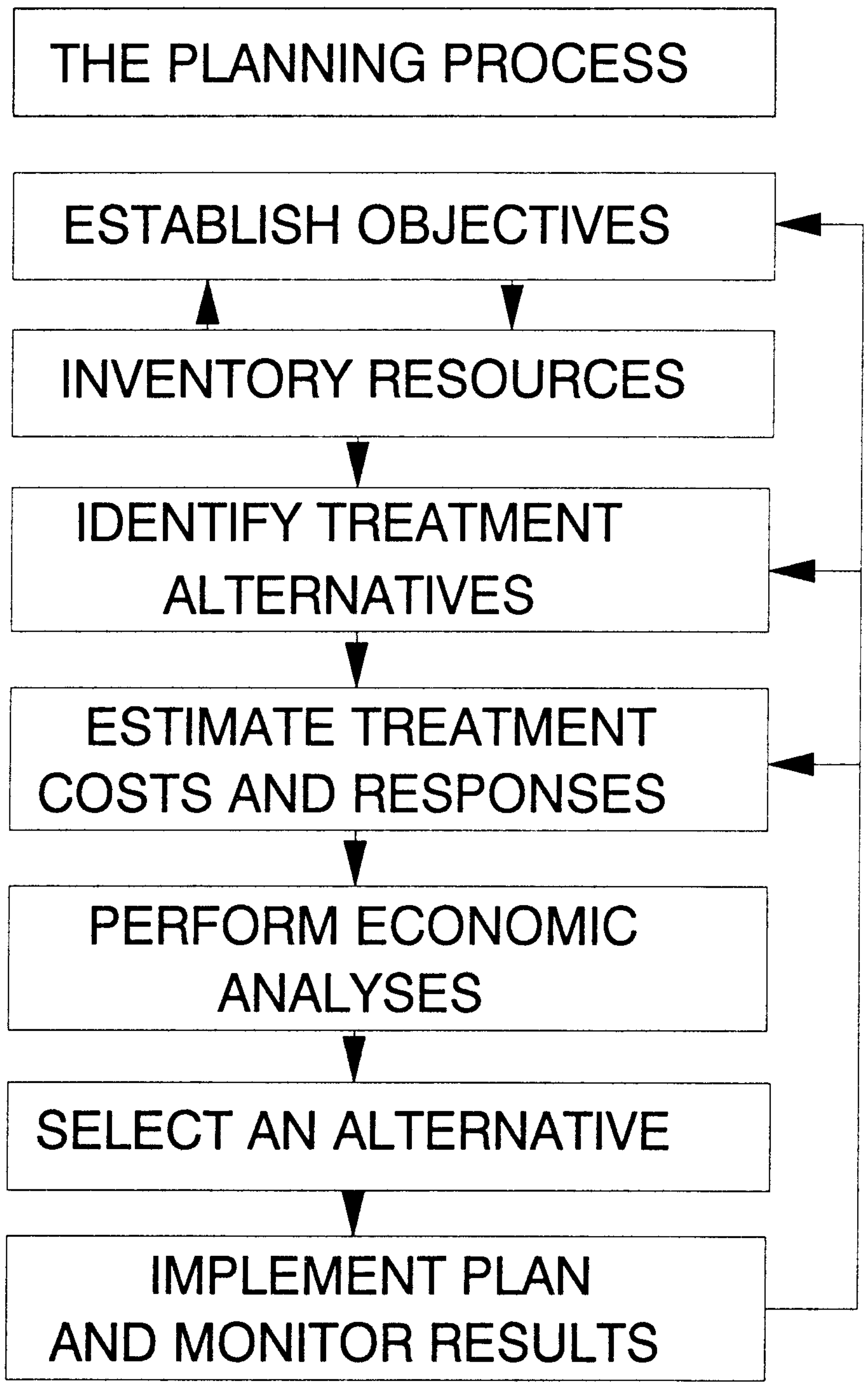


Figure 1. Diagram of the process used in planning brush management.

Resource Inventory

In order to make the best judgments about the merit of any plan for accomplishing objectives, you must first have a good inventory of your resources to show "where you are." It is difficult to know how to plan for change, or even to know if change is feasible, unless we fully understand what resources we currently have and their capabilities and limitations. We need to use current levels of production from the range as a basis for measuring progress toward goals from planned treatments - "you can't tell how far you've gone unless you know where you started."

Characterize the Range

Perhaps the best way to characterize the range for planning purposes is to identify range sites. These range sites provide information on significant differences between rangeland based on soil and topographic features. Moreover, site characterization identifies the potential natural vegetation and total annual yield for each site. By determining current condition of each range site, that is, comparing current to potential vegetation, stocking rate estimates can be combined with projected vegetation changes from brush management to provide a basis for assessing treatment effects. Even if planned changes include the use of artificial seedings instead of natural succession to increase range production, potential yields will vary by range site and can be estimated from range site descriptions. These differences become critical in projecting responses to treatments that will provide the basis for offsetting costs.

Develop Response Units

There is often a need to divide the range even more precisely than range sites in order to accurately inventory current production and to project responses. For example, areas previously treated or those planned for brush management and those left untreated may be on the same range site. However, response of these areas over the planning horizon will likely be totally different. Livestock distribution problems caused by distance from water can also influence responses within the same range site and should be considered in the planning process. We call these different areas "response units," and they can become a part of the inventory process (Hamilton et al. 1989) (Figure 2). A computerized forage inventory system called FORAGE is now available through the Extension Service software catalog. This software will assist users in developing inventories to the response unit level as a "stand alone" package. The computer software our Ranching Systems Group has developed in cooperation with SCS [Grazing Land Applications (GLA)] also accommodates the development of forage and livestock inventories at the response unit level as part of the entire strategic planning process that GLA includes (Stuth et al. 1990).

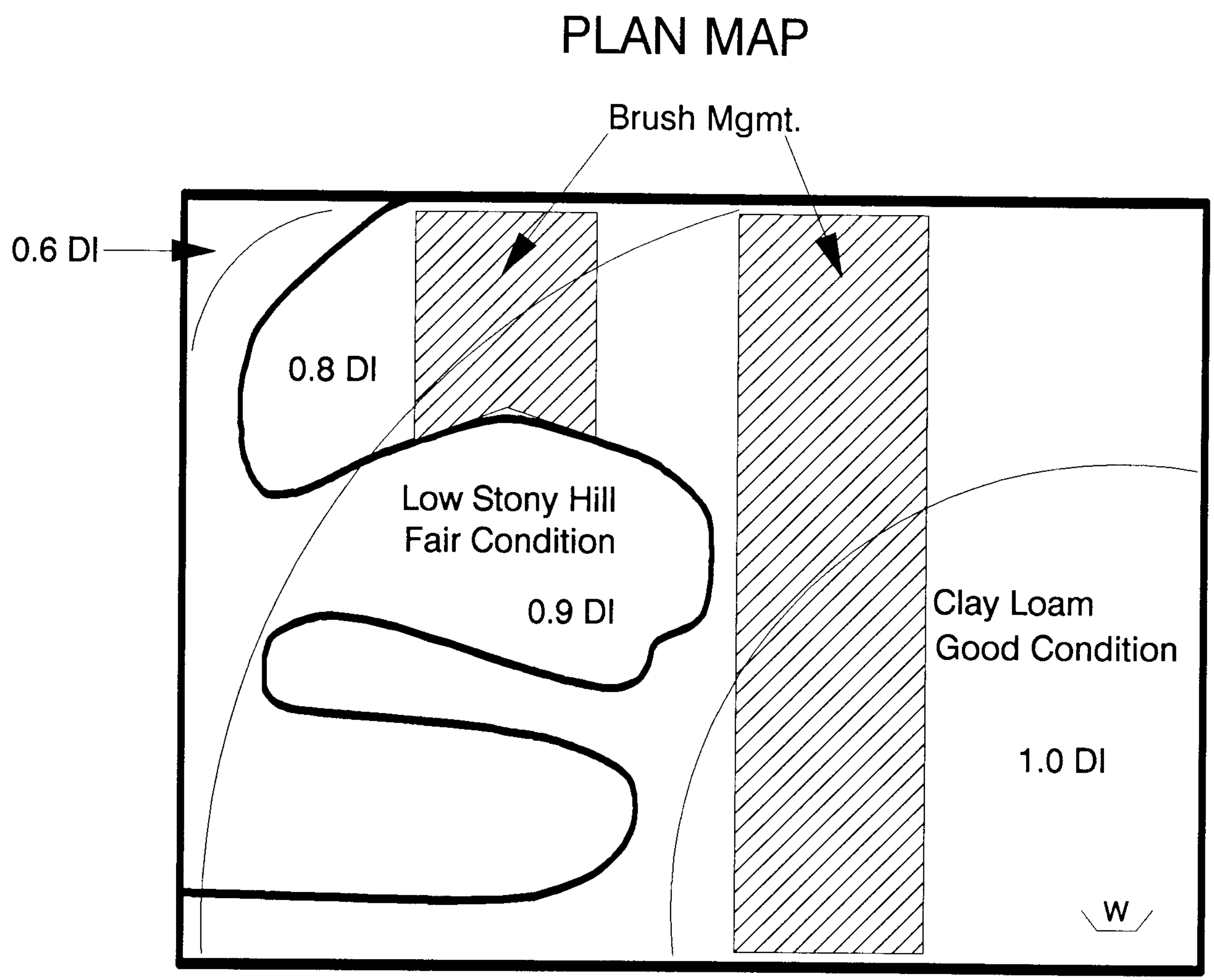


Figure 2. A plan map showing "response units" in a brush management plan.

Identify and Quantify Woody Plants

When you are developing a brush management program, a detailed measure must be made of the current impact of brush on range resources and the relationship of woody plants to management goals. Brush species differ in their value to planned land uses, response to control measures, and relationships to potential production of range sites involved. For example, honey mesquite (*Prosopis glandulosa* var. *glandulosa*) may be a problem species on the same area of range where spiny hackberry (*Celtis pallida*) is considered a desirable plant. These species respond differently to some treatment alternatives, which may also be desirable. Whitebrush (*Aloysia lyciodes*) is quite susceptible to tebuthiuron, while honey mesquite is not susceptible to similar rates of the same herbicide. Guajillo (*Acacia berlandieri*) would have a different relationship to potential forage yield on gravelly ridge sites than would honey mesquite on clay flats.

The specific information you need about your woody plant composition can be determined with line transects on representative parts of each range site and recording the amount of canopy intercept along the line by individual woody plants. The amount of canopy intercept can then be summed by species and divided by total transect length to estimate percent canopy cover for each species and for total of all woody plants. It may also be important to record woody plant height and other parameters, such as average basal diameter, which can affect control technologies. Woody plant densities may also be important and can be determined by counting the number of plants within a known land area.

Identifying and determining the relative percent composition of the woody plants by individual species allows you to determine the brush problem more precisely. It also allows you to more accurately estimate the response from different practices that could be used because of the difference in expected responses by species. For example, you should be able to predict if a secondary species will become a future problem based on responses to the initial treatment selected. The release and spread of pricklypear following some mechanical practices, or the increase in non-susceptible understory species following chemical control of oaks or mesquite are well known examples of such problems.

Once you have accrued adequate information on the woody plant component of your range vegetation, you should be ready for decision-making. You can answer the questions: Is there really a brush problem? Is the brush the most limiting factor to increasing production from the herbaceous plants on the range? Which brush species are desirable or undesirable? What are the technically feasible alternative treatments that you could use? What will the treated area look like one year after treatment, five years, fifteen years? What kind of follow-up treatments and frequency will be needed to maintain the most desirable combination of plants?

Include Wildlife and Grazing Management Objectives

An integral part of resource analysis should always be an assessment of current and projected wildlife populations so that planners are cognizant of the influence of brush management on habitat and subsequent wildlife quantity and quality. Brush manipulation can negatively impact important wildlife species, or it can be used as a positive influence for habitat improvement (Scifres 1980). For example, both foliar and soil applied herbicides can be used in variable rate patterns of application to create mosaics of diverse vegetation types and enhance wildlife habitat (Scifres and Koerth 1986). In South Texas, the economic importance of wildlife usually dictates management objectives for maintenance or improvement of game species habitat.

An additional part of resource analysis should be a review of stocking history of the range and a look at the match between kind and classes of domestic animals being used as opposed to those best suited for current and proposed vegetation. For example, recognition of the role of goats in the maintenance of woody plant competition at acceptable levels may be important. The complimentary aspects in carrying capacity of the range that could be available through combination stocking as opposed to a single kind of animal can be significant. Planners should always be aware that woody plants play a significant role in range animal nutrition during critical periods for both wildlife and livestock, and that accessibility, acceptability and nutritional value can often be improved through brush management (Hamilton 1979).

Match the Brush Problem with Appropriate Technology

Seldom will there be only a single technically feasible alternative to consider in planning a brush management program. There are so many different problem brush and weed species in South Texas and different control technologies from which to select that it is difficult to be sure you have considered all of the right possibilities. Moreover, different treatments that may be equally effective in controlling the target species could well have significant economic differences (e.g., cost of herbicides or how soon benefits can be expected based on posttreatment response of forage plants). There may also be differences in how these same treatments affect secondary woody species and, thus, the expected posttreatment vegetation as it relates to wildlife habitat or brush maintenance requirements (Hamilton et al. 1981).

Recognition of these difficulties in selecting from the array of technologies available for brush management led to the development of EXSEL (expert system for technology selection), a computerized expert system that allows users to interact with databases that match appropriate mechanical, chemical and burning practices with specific brush or weed problems. The user inputs the required information to characterize the brush problem and furnishes important additional information, such as data on soils and geographic region. EXSEL is particularly helpful in assisting users to match herbicides, rates, mixtures and application techniques with brush and weed problems. Additionally, EXSEL provides suggested response recommendations that can be used to project posttreatment changes in the vegetation and in range carrying capacity.

Treatment Costs and Responses

Once appropriate technologies are identified for different brush management scenarios, the question then becomes one of efficiency of plans. We usually think of the most efficient plan as the one that returns the greatest benefits over costs. In order to make this assessment, we need to estimate the resource requirements necessary to carry out each alternative plan (costs), as well as the production changes that will occur over time (benefits). This requires development of production response curves that allow comparison of the benefits of treatment alternatives to the results of no treatment over a planning horizon.

Costs of brush treatments are relative easy to determine. Most contractors will provide cost quotations, or, you can determine your own costs for application of a practice if you intend to do the work yourself. Determining the responses to expect from treatment alternatives is more difficult but certainly not impossible. As mentioned above, EXSEL will provide guidance on expected responses so that a "response curve" may be developed. These curves must show how long after treatment will be required to get maximum response, what maximum response will be, how long it will last, and when the treatment effect is exhausted (Figure 3). Building response curves requires planners to project the total vegetation complex at points in time following treatment and to determine how the optimum mix of plants can be maintained over the planning horizon.

Information for building response curves that are accurate for your particular resources can come from a combination of sources and you should use them all. These sources include: 1) your personal experience with the same or similar treatments, 2) published research results for your area, 3) research from similar areas on the same species, 4) neighboring ranches, 5) Extension result demonstrations, and 6) expert opinion (observation and experience of ranchers, and personnel from SCS, TAEX, TAES, etc. in your area). Responses must be expressed in terms of livestock products, such as increases in range carrying capacity (number of animals), weaning weights, conception rates, individual animal gain, wool or mohair production, or decreases in variable or other costs that are attributable to treatment. Benefits can then be related to treatment costs on a monetary basis. There may also be other costs and/or benefits associated with the improvement program that should be included, such as changes to wildlife income potential.

Proper planning must provide for optimizing the response of the forage base after treatments are applied. Some systematic grazing schemes allow for pre-and posttreatment deferments necessary for effective initial results and recovery of treated areas, while other systems provide less flexibility. One-herd, multiple-pasture grazing systems offer the best opportunities to leave areas out of grazing use during critical periods associated with brush management. Year around grazing will probably

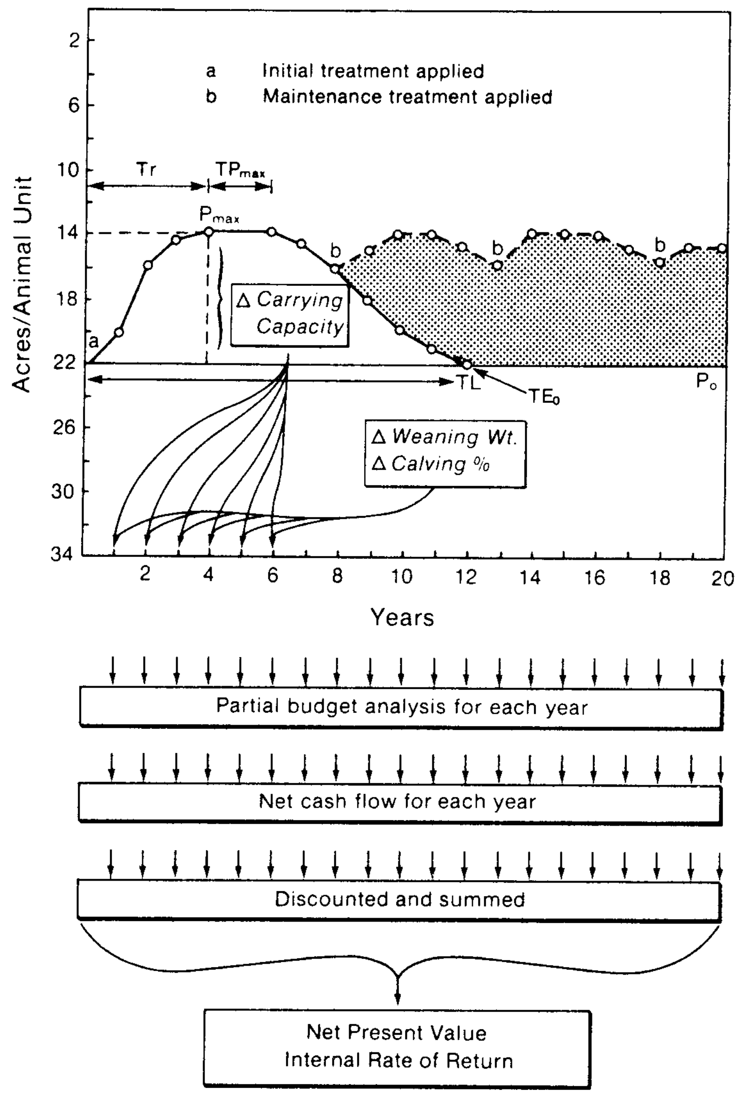


Figure 3. A response curve for an initial brush management practice, a maintenance practice and the procedure for economic analysis.

constrain posttreatment response even at low stocking rates, particularly when only a portion of a pasture is treated and livestock concentrate on the improved forage resources. You should identify the role of grazing management in relating to success of brush management and include changes required in fencing, waterings, etc. These are legitimate costs associated with the program and should be used in the economic assessment.

It is also important to be able to respond with livestock numbers in the correct posttreatment time frame to optimize treatment benefits. Economic performance of any brush management effort will be related to effective harvest of additional forage resources from the treated area.

Economic Analysis

The planning process for brush management should include an appropriate "planning horizon" - the time period for which the plan is intended, and an acceptable rate of return on investments in the treatments. It should be noted that the nature of brush management and animal production as biological functions impose time constraints on investment recovery periods. This is to say that short planning horizons (1-5 years) will not allow satisfactory financial performance of most brush management alternatives. We recommend planning periods of at least as long as there are still effects of treatments, and longer if maintenance practices will extend initial treatment life. Planning horizons of 15 years are common for many brush management analyses.

Since investments and returns in brush management programs are spread over several to many years, we strongly recommend the use of "net present value" (NPV) economic analyses. This technique takes into account the time value of money; allowing planners to compare alternative improvement scenarios on an equal basis by discounting costs and benefits from the treatment to a present day value.

In order to use the NPV method, you should select a discount rate (the rate of return you want the treatment program to pay back on your investment over the planning horizon) that considers opportunities for alternate investments as well as a risk factor associated with brush management compared to alternate investments (Whitson et al. 1979).

Once all benefits and costs are determined, annual net cash flows can be estimated for each year of the planning period. These net cash flows can then be discounted at the selected rate to yield their annual net present values and summed to produce the accumulated net present value of the entire string of investments and benefits over the planning horizon. An internal rate of return (IRR) can also be calculated. The IRR is the discount rate over the planning period that produces an accumulated net present value of zero. A zero net present value means that the improvement scenario has paid for all costs associated with its application over the planning horizon and yielded a rate of return on your investment equal to the discount rate you used in the analysis.

This entire process of economic analysis of improvement practices using NPV has been computerized in a program called ECON by our Ranching System Group. ECON will be available through the Extension Service computer software catalog in 1990 as a "stand alone" package. It will also be an integral part of the GLA software mentioned earlier.

Alternative Selection

After economic analysis, the most appropriate alternative for meeting objectives based on economic efficiency of plans can be selected. This strategic plan should then be the basis for developing tactical and operational plans, and contingency plans to provide for circumstances that occur outside of the "normal" conditions developed within the strategic planning process.

Installing and Monitoring Plans

As your plans are implemented, they should be evaluated to measure actual performance and this data used to feed back into the planning process to "fine tune" your ability to predict responses, costs, etc. This provides for a planning continuum that will contribute to improved plans over time. The better your plans, the greater the likelihood for success in your operations.

Literature Cited

Hamilton, W.T. 1979. Range management for quality wildlife. Rangelands. 1(4):149-151.

Hamilton, W.T. 1981. Producing quality range. Proc. International Rancher's Roundup. Tex. Agr. Ext. Ser. p. 159-165.

Hamilton, W.T., L.M. Kitchen, and C.J. Scifres. 1981. Height replacement of selected woody species following burning or shredding. Tex. Agr. Exp. Sta. Bull. 1361. 9 pp.

Hamilton, W.T., J.W. Stuth, J.R. Conner, and D.A. Riegel. 1989. FORAGE: a computerized forage inventory system. Tex. Agr. Exp. Sta. MP 1683. 110 pp.

Scifres, C.J. 1980. Brush management - principles and practices for Texas and the southwest. Tex. A&M Univ. Press. 360 pp.

Scifres, C.J., and B.H. Koerth. 1986. Habitat alterations in mixed brush from variable rate patterns. Wild. Soc. Bull. 14:146-150.

Scifres, C.J., and W.T. Hamilton. 1989. Factors affecting economic performance of herbicides. Chapter VII *in* Scifres, et al. Management of South Texas mixed brush with herbicides. Tex. Agr. Exp. Sta. 1623. 66 pp.

Scifres, C.J., W.T. Hamilton, J.R. Conner, J.M. Inglis, G.A. Rasmussen, R.P. Smith, J.W. Stuth, and T.G. Welch. 1985. Integrated brush management system for South Texas: development and implementation. Tex. Agr. Exp. Sta. Bull. 1493. 71 pp.

Stuth, J.W., J.R. Conner, W.T. Hamilton, D.A. Riegel, B.G. Lyons, B.R. Myrick, and M.J. Couch. 1990. A resource systems planning model for integrated resource management. J. Biogeography (In press).

Whitson, R.E., W.T. Hamilton, and C.J. Scifres. 1979. Techniques and considerations for economic analysis of brush control alternatives. Tex. Agr. Exp. Sta. Dept. of Range Sci. TR 79-1. 30 pp.
Whitson, R.E., and C.J. Scifres. 1980. Economic considerations of alternatives for improving honey-mesquite infested rangeland. Tex. Agr. Exp. Sta. B-1307. 185 pp.

Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of Congress of May 8, 1914, as amended, and June 30, 1914, in cooperation with the United States Department of Agriculture. Zerle L. Carpenter, Director, Texas Agricultural Extension Service, The Texas A&M University System.
400—4-91

RS